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1 SCOPE

1.1 Identification

This document has been produced by the Avionic Systems Group of BAE SYSTEMS as deliverable item D19 “Definition of Airborne Equipment Architecture” for the MA-AFAS programme. It should be read in conjunction with the Interface Control Document that forms deliverable item D24 of the MA-AFAS programme.

The document describes the system architecture for the MA-AFAS airborne trials equipment and identifies the main hardware and software configuration items for the system.

1.2 System Overview

The More Autonomous Aircraft in the Future Air Traffic Management System (MA-AFAS) project is part of a larger European undertaking, that of reducing delays by improving means for aircraft movement control in the European airspace. It aims to transform European research results into practical operational Air Traffic Management (ATM) procedures with the potential to radically improve the European ATM scenario in the near term (from 2005 onwards).

The MA-AFAS project objective is to validate airborne equipment and procedures within the Air – Ground control loop. There are three major activities. Firstly, an Operational Concept has been described in MA-AFAS D9. Secondly, the Operational Concepts were translated into an overall system requirements specification for the ground and airborne equipment, MA-AFAS D13. A requirements specification for the airborne equipment, MA-AFAS D18, was derived from the overall systems requirements. This document represents the first stage of the system design for the airborne equipment and can be traced directly to the content of MA-AFAS D18.

Upon completion of the design and development of the airborne equipment, the operational concepts of MA-AFAS D9 will be validated in a series of simulator and flight trials. The results of the trials will be made available so that a Minimum Operational Performance Standard can be developed by a body such as EUROCAE.

1.3 Document Overview

The majority of the data that was used to generate this document is held within a database created and maintained using the Dynamic Object Orientated Requirements System (DOORS) tool. As such, the database is considered to hold the Master data and this document is an extraction of the data in a MIL-STD-498 format.

The structure of this document follows the guidelines for a System/Sub-system Design Description document as defined within MIL-STD-498.

Section One provides an introduction to the document and an overview of the system requirements.

Section Two contains a list of documents that have been referenced from this document.

Section Three describes the decisions that have influenced the architectural and software design for the system. It also contains requirements that have been derived from the requirements identified in MA-AFAS D18.

Section Four describes the architectural design of the system and identifies the hardware and software configuration items. It has been generated by exporting selected information from a system model that is being maintained using the AxiomSys Structured Analysis design tool. This section also includes a series of descriptions of how the system is expected to be used for different operations. The exported data is held within a separate Word file in order to ease document maintenance.

Section Five contains traceability tables. The first table shows where the requirements identified in MA-AFAS D19 are addressed within the system design described by this document. The second table contains the traceabilty information between D18 and D19. Both tables have been generated using DOORS and are held in separate WORD files for maintenance purposes.

Section Six contains supplementary notes for the document. This includes a glossary of terms and a list of abbreviations used within the document.

1.4 Special Usage

Where the word “System” is used unqualified and capitalised in this document, it refers to a single enclosure that contains the Flight Management Unit (FMU) and the Communications Management Unit (CMU).

Where a numerical figure is contained in round brackets, e.g. (300), as part of a requirement statement, then that figure should be considered a provisional value and hence subject to change.

2 REFERENCED DOCUMENTS

2.1 MA-AFAS Documents

MA-AFAS ANNEX: The More Autonomous Aircraft in the Future Air Traffic Management System. Version 1, Date 4/11/99. GRD1-1999-10516, Annex 1, Description of Work.

MA-AFAS SDP: Software Development Plan for MA-AFAS. BAE Systems. 560/78432.

MA-AFAS D9: ATM Operational Concept. Version 1, 27 October 2000.

MA-AFAS D13: Definition of ATM MA-AFAS Airborne and Ground Functions.

MA-AFAS D14: MA-AFAS Operational Services and Environment Definition.

MA-AFAS D18: Airborne Systems Requirement Specification.

2.2 Standards

2.2.1 ARINC Standards

ARINC 424: Navigation System Database, Supplement 15, February 2000.

ARINC 429: Mark 33 Digital Information Transfer System (DITS) , Part 1 – Functional Description and Word Formats, Version 15, Date 9/95, Part 2 – Discrete Data Words, Version 15, Date 3/96, Part 3 – File Data Transfer Techniques, Version 17, Date 5/99

ARINC 600-12: Air Transport Avionics Equipment Interfaces.

ARINC 615-3: Specification for a Data Loader, Issue 3, August 1992.

ARINC 701-1: Flight Control Computer System, Version 1, April 1983.

ARINC 702A: Advanced Flight Management Computer System, Version 1, Date 2/00

ARINC 725-2: Electronic Flight Instruments, November 1984.

ARINC 739A-1: Multi-Purpose Control And Display Unit, December 1998.

ARINC 755-1: Multi-mode Receiver.

ARINC 756-2: GNSS Navigation and Landing Unit.

ARINC 758-1: Communications Management Unit.

2.2.2 Documentation Standards

MIL-STD-498: Software Development and Documentation, Date 5 December 1994.

2.2.3 Other Standards

ODIAC AGC-ORD-01: Operational Requirements for Air/Ground Cooperative Air Traffic Services, Version 1-0, Dated 03-11-00, produced by Operational Development of Integrated surveillance and Air/ground data Communications.

ATN SARPS: ICAO 9705/2, Manual of Technical Provisions for the Aeronautical Telecommunication Network, 2nd edition 1999.

BASELINE 1: Safety and Interoperability of Air Traffic Services Communication. RTCA SC-189/Eurocae WG-53 Position Paper.

GNSS SARPS: Draft SARPS for GNSS.

ADS-B MOPS: Minimum Operation Performance Specification for ADS-B. EUROCAE/ED 102, November 2000.

CDTI MOPS: Minimum Operation Performance Standards for Computer Display of Traffic Information. RTCA Special Committee, Draft Issue 25-v2.

ANO: Air Navigation, The Order and the Regulations. CAP 393, Section 2.

FIS-B DESCRIPTION: FIS-B Service Description. NEAN Update Program.

TIS-B DESCRIPTION: TIS-B Service Description. NEAN Update Program.

ED-99: User Requirements for Aerodrome Mapping Information

3 DESIGN DECISIONS

3.1 Operating States and Modes

MA-AFAS D18 identifies four states for the overall aircraft equipment. This includes a single operational state. This does not allow the different operating states of the System, e.g. taxi or flight, to be identified. The following state transition diagram extends the number of states so that all of the operating states and the associated transitions are shown. Each of the states and the transitions are described in the following paragraphs.

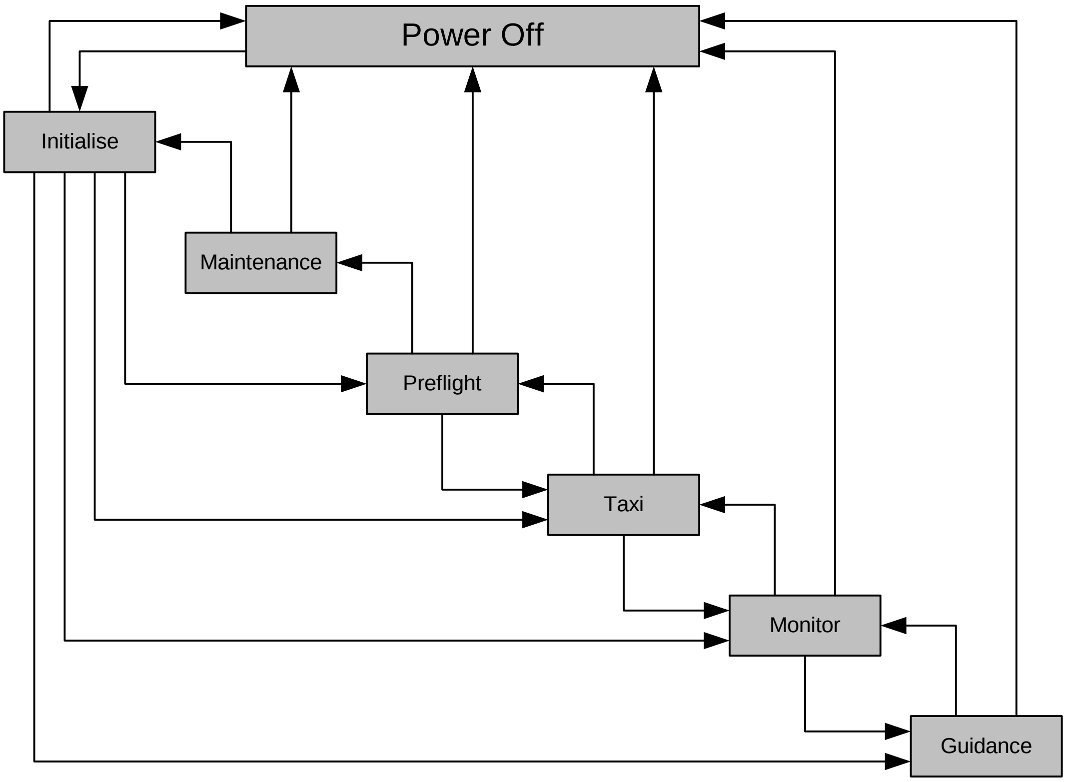

Figure 1 System State Transition Diagram

3.1.1 Power Off State

The power off state can be reached from any other state when power is removed from the System. Under normal operating conditions, it is expected that power will only be removed from the System when it is in either the Maintenance or Preflight states. When power is applied to System after a normal shutdown, the System will execute a "cold" boot. In this situation, the System will enter the Preflight state upon completion of the initialisation processing.

The Power Off state shown in the state transition diagram is the same as the Off state in the state transition diagram contained within Figure 1 of MA-AFAS D18.

When power is applied to the System, it shall enter the Initialise state.

[Analysis / TBD] [D19-53]

3.1.2 Initialise State

The Initialise state is a transitory state that must be passed through before the System can be considered operational. In this state, the System begins by performing a series of Power On Self Tests. When these are complete, it will also determine what state the System was in when power was last removed so that it can implement a "warm" boot process if appropriate. Finally, the System reads configuration data from a Hard Disk Drive and creates the various databases that are required.

Once the initialisation processing is complete, the System status and any necessary recovery data, e.g. active trajectory or traffic information, shall be written to an area of store on the Hard Disk Drive at time intervals of not greater than 30 seconds so that in the event of a power failure, the System can resume processing with minimal input from the pilot.

[Demonstration / TBD] [D19-380]

NOTE: The rate at which information is written to the HDD will be dependent upon the rate at which the individual data items are updated internally. So traffic information and trajectory information need only be stored at a relatively slow rate while aircraft state data must be stored at a higher rate.

The ARINC 702-A characteristic specifies that an FMS should continue normal operation during power interruptions of up to 200ms. For the MA-AFAS trials, the System power supply will not have this capability. This requirement will only be necessary for production versions of the equipment.

A production standard version of the System shall continue normal operation if the duration of a power interruption is less than 200ms.

[Measurement / TBD] [D19-481]

The ARINC 702-A characteristic indicates that an FMS should treat all power interruptions of less than 10 seconds as transient and the FMS should implement a "warm" boot in order to recover the system state prior to the power interruption. While this requirement is essential for a production standard FMS, it is not an essential requirement for the MA-AFAS trials equipment.

If the time since power was removed is greater than 10 seconds, then a "cold" boot process shall be initiated.

[Demonstration / TBD] [D19-480]

Upon completion of a "cold" boot process where data and code transfers have been completed successfully, the system shall enter the Preflight state.

[Analysis / TBD] [D19-57]

For power interruption intervals of less than 10 seconds but greater than 200 milliseconds, the System state prior to the power interruption shall be restored with no input required from the pilot provided that all navigation systems are operable.

[Demonstration / TBD] [D19-482]

For the trials equipment, the time since power was removed will be estimated by examining the time stamp of the last data record that was written to the HDD prior to the power interrruption. The accuracy of the time estimate will be dependent upon the rate at which the data records are written. It is proposed that a system status record is written at a rate of 1Hz giving an accuracy of +/-1 second.

3.1.3 Preflight State

The Preflight State provides facilities that enable the pilot to plan a flight and then negotiate with the ATC. Entry to this state indicates that the System has successfully completed the boot up process. Any problems encountered during the boot up sequence will be displayed as text messages on the MCDU. The System will move to the Maintenance state or Taxi state only upon pilot command.

The System shall transition from the Preflight state to the Maintenance state only on pilot command.

[Demonstration / TBD] [D19-505]

The transition from the Preflight state to the Maintenance state shall require a password to be entered.

[Demonstration / TBD] [D19-497]

Ideally, any attempt to transition to the Maintenance state should be disabled if the aircraft is in flight, as indicated by the absence of a "Weight On Wheels" signal. In the short term, this additional lock-out will not be implemented because it will prevent maintenance activities being performed in the air during the MA-AFAS trials.

The transition from the Preflight state to the Taxi state shall occur only upon pilot command subject to the condition that all navigation systems are operable.

[Inspection / TBD] [D19-498]

3.1.4 Maintenance State

Within the Maintenance state, there are two sub-states, a basic state and an enhanced state. The two sub-states are differentiated by the presence of a data loading device. When a device is not connected, only System configuration functions will be available to the user. When a data loader is connected to the System, a number of additional functions will be enabled so that data uploads and downloads can be performed.

In order to exit from the Maintenance state, the System must be re-initialised. This can be achieved by two independent means. Either the power can be removed from the System for a time interval of greater than 10 seconds or the pilot can request that the System returns directly to the Initialise state.

It shall be possible for the pilot to cause a re-initialisation of the System from the Maintenance state.

[Demonstration / TBD] [D19-490]

3.1.5 Taxi State

The taxi state corresponds to the periods of time when the aircraft is on the ground but not at a gate. This phase of the flight is entered initially when the aircraft is pushed back from the gate and secondly when the aircraft lands. While the System is in this state, the pilot can still update the trajectory details in response to requests from the ATC.

The entry condition requires that a single robust signal is derived from existing signals, such as the "Weight On Wheels" signal. The exit from the Taxi state to the Monitor state during the take-off sequence can also be captured using a "Weight On Wheels" signal. While weight remains on the wheels, the aircraft can be assumed to be on the ground. Where an aircraft configuration does not provide a "Weight On Wheels", then a substitute signal can be generated by monitoring the aircraft speed. The aircraft can be assumed to be on the ground if its air speed is less than the take-off speed.

One potential problem with using just the "Weight On Wheels" signal is that it is subject to noise. In order to improve its robustness, this should be combined with other aircraft information such as the airspeed in order to create a single composite "Aircraft On Ground" signal.

The System shall generate a single internal signal, "Aircraft On Ground", that indicates whether the aircraft is on the ground or in the air using as a minimum, the "Weight On Wheels" signal and the aircraft air speed.

[Measurement / TBD] [D19-514]

The System shall transition from the Taxi state to the Monitor state when Take-Off occurs, i.e. the “Aircraft On Ground” signal is removed.

[Demonstration / TBD] [D19-60]

3.1.6 Monitor State

In this state, the System is not actively guiding the aircraft. The aircraft is assumed to be either under manual control or autopilot control. It is assumed that the pilot has generated a trajectory at this stage so that deviations from this trajectory can be displayed. While the System is in this state, the pilot can still update the trajectory details in response to requests from the ATC.

A transition from the Monitor state to the Guidance state shall occur when the FMS is selected by the pilot to guide the aircraft subject to the condition that all navigation systems are operable.

[Demonstration / TBD] [D19-382]

The System shall transition from the Monitor state to the Taxi state when the aircraft lands as indicated by the generation of a “Aircraft On Ground” signal.

[Demonstration / TBD] [D19-506]

3.1.7 Guidance State

In this state, the FMS is responsible for generating the guidance commands for the autopilot so that the aircraft follows a specified trajectory or tactical command. While the System is in this state, the pilot can still update the trajectory details in response to requests from the ATC.

A typical FMS has several guidance modes, e.g. RNAV, VNAV. The MA-AFAS 4D trajectory guidance functions begin when any of these modes is selected.

A transition from the Guidance state to the Monitor state shall occur when the FMS guidance is disengaged by the pilot.

[Demonstration / TBD] [D19-492]

3.2 Capability

3.2.1 System Initialisation

The details of the initialisation process remain TBD.

3.2.2 HMI

3.2.2.1 Overview

The pilot interfaces to the MA-AFAS trials equipment comprise a Cursor Control Device, a Multi-purpose Control and Display Unit (MCDU), an Electronic Flight Instrument System (EFIS) for the navigation display unit (NDU) and optionally, a Head Up Display (HUD).

In scenarios where both the MCDU and the NDU can provide control, the MCDU shall be treated as the master controller and a synchronisation message shall be sent between the systems.

[Analysis / TBD] [D19-393]

3.2.2.2 Parameter Units

It is important for the HMI to present data in a consistent manner and for the same set of units to be used across all menu pages. While the System may perform all of its internal calculations using a single set of consistent units, e.g. the SI system, it is not necessary for the same restrictions to be applied to the displayed data. It is more important that the data is presented in units with which the pilot is familiar.

Horizontal distances shall be displayed in metres for ground movement displays and nautical miles for all other displays.

[Analysis / TBD] [D19-831]

For horizontal distances greater than 10 miles, the distance shall be displayed in miles to the nearest integer value.

[Inspection / TBD] [D19-1807]

For horizontal distances less than 10 miles, the distance shall be displayed to the nearest one tenth of a mile.

[Inspection / TBD] [D19-1808]

The aircraft ground speed shall be displayed in knots to the nearest integer value.

[Analysis / TBD] [D19-832]

The true airspeed of the aircraft shall be displayed in knots to the nearest integer value.

[Analysis / TBD] [D19-833]

The vertical speed of an aircraft shall be displayed in feet per minute to the nearest integer value.

[Analysis / TBD] [D19-834]

The aircraft heading and track shall be displayed in degrees to the nearest integer value.

[Analysis / TBD] [D19-835]

Latitudes shall be displayed as degrees and minutes North or South of the equator.

[Analysis / TBD] [D19-836]

Longitudes shall be displayed as degrees and minutes East or West of the Greenwich meridian.

[Analysis / TBD] [D19-837]

Altitudes shall be displayed in feet to the nearest integer value.

[Analysis / TBD] [D19-838]

3.2.2.3 MCDU

3.2.2.3.1 Physical Characteristics

The MCDU provides a colour display of alphanumeric data. It incorporates an alphanumeric keyboard for data entry, data editing and for system control. Dedicated function keys and line selection keys allow easy operator control of flight management functions.

The physical characteristics of the MCDU shall be compliant with paragraph 2 of ARINC 739A-1.

[Inspection / TBD] [D19-797]

3.2.2.3.2 Display Requirements

The HMI design treats the display screen as though it has two independent display areas, a main display area and a scratchpad area. The main display area comprises a title line and 12 lines of either menu options or displayed information. The scratchpad is used to display messages to the pilot and also to reflect keypad inputs.

The presentation style and behaviour of all displayed information on the MCDU shall follow the guidelines laid down in Attachment 10 of ARINC 739A, "MCDU Display Considerations".

[Similarity / TBD] [D19-516]

The presentation style and behaviour of all displayed information on the MCDU shall follow the guidelines laid down in HMI Design Document generated by NLR.

[Similarity / TBD] [D19-1641]

3.2.2.3.3 Function Keys

The MCDU keypad includes a number of dedicated function keys that provide quick access to specific parts of the menu structure. In some cases, the behaviour of these buttons will need to reflect the current state of the System or a recent event.

The menu behaviour resulting from a button press on a special function key shall be consistent with the behaviour specified in paragraph 3.3.1 of ARINC 739A-1.

[Similarity / TBD] [D19-1642]

3.2.2.3.4 Line Select Keys

The line select keys (LSKs) are used to manipulate data within the menus and also to control the information that is displayed on the screen. There are a total of 12 LSKs, six on either side of the display screen. The result of pressing an LSK depends upon what information, if any, is displayed next to the key.

The behaviour of the System with regard to a Line Key selection shall be consistent with the behaviour specified in paragraph 3.4 of ARINC 739A-1.

[Similarity / TBD] [D19-1643]

3.2.2.3.5 Scratchpad

The scratchpad is used to hold inputs from the pilot that have been entered with the alphanumeric keypad and also to display messages to the pilot. Any messages will take priority over pilot entries and so when a message is received, any existing scratchpad data must be stored until all messages have been cleared. This behaviour is described in more detail within the ARINC characteristic 739A-1.

The behaviour of the System with regard to the scratchpad shall be consistent with paragraph 3.4.5 of ARINC 739A-1.

[Similarity / TBD] [D19-808]

3.2.2.3.6 Lamps

The MCDU includes a set of lamps that can be used to signal specific events or conditions. For the MA-AFAS trials, only the "MSG" and "ATC" lamps will be activated.

The “MSG” lamp shall be lit whenever an alert message or an advisory message has been received by the MCDU that has not been acknowledged by the pilot.

[Demonstration / TBD] [D19-807]

The “ATC” lamp shall be lit whenever a CPDLC message has been received from an ATC that has not been acknowledged by the pilot.

[Demonstration / TBD] [D19-1554]

3.2.2.4 Navigation Display Unit

3.2.2.4.1 Overview

The HMI design treats the navigation display screen as though it has three independent display areas, a main display area, a menu bar and a message bar. The primary control for the display is provided via a Display Control Panel. A cursor control device is also available for interaction with the displayed data and the menu bar.

3.2.2.4.2 Display Control Panel

The display panel provides a manual control device for the navigation display unit. It provides a display mode selection capability and a range scale selection capability. The range scale selector is normally annotated for use with airborne display formats. For the MA-AFAS trials, the interpretation of the annotated values will differ for the ground movement displays.

While the TAXI display mode is selected, the display range scale shall be interpreted as 1/40 of the annotated range scale.

[Demonstration / TBD] [D19-903]

A request for a display mode change, e.g. change of map scale or a change to the displayed data, shall occur within 1s of the request being made.

[Measurement / TBD] [D19-904]

3.2.2.4.3 Cursor Control Device

The Cursor Control Device (CCD) will be a trackball. The CCD will be positioned in the cockpit aft of the MCDU and in close reach of the pilot. The CCD will be equipped with two select buttons.

The behaviour of the cursor and the display in response to a cursor button selection shall be consistent with the behaviour described in the NLR HMI design document.

[Demonstration / TBD] [D19-1645]

3.2.2.4.4 General Display Attributes

3.2.2.4.4.1 Use Of Colour

The EMD MOPS states that the extreme brightness that is possible within the flight deck can cause washout and drastically alter the appearance and discriminability of colour. As a result, it is recommended that no more than seven colours are used on a display with high information content. Additional colours such as grey or brown can be used but only for infilling items with low display priority.

The use of colour shall be consistent with the guidance provided in Appendix E of the EMD MOPS.

[Inspection / TBD] [D19-1644]

3.2.2.4.5 Lateral Display Formats

This section will be expanded when more information is available from the NLR HMI design document.

3.2.2.4.6 Vertical Display Format

This section will be expanded when more information is available from the NLR HMI design document.

3.2.2.4.7 Taxi Display Formats

For the MA-AFAS trials equipment, the Taxi management functions are considered to be primarily an HMI activity within the system design. The display functions have access to the central data store in order to obtain the relevant airport information, traffic information and aircraft positional information. All communications with the ground controller and ATC will be facilitated through a communications display manager.

This section will be expanded when more information is available from the NLR HMI design document.

3.2.2.4.8 Menu Bar

In order to provide flexibility in the menu structures during the development of the System, the software design should aim to separate the menu control functionality from the menu structures. This allows the menu structures and the associated linking across menus to be developed independently of the generic control process.

The menu controller shall create a menu structure at initialisation using information stored in a file on the System hard disk drive.

[Demonstration / TBD] [D19-392]

3.2.2.4.9 Message Bar

The message bar is used primarily to display messages received over the datalink to the pilot.

3.2.2.5 Head Up Display

It is unlikely that a HUD will be available for use during the time scales of the MA-AFAS programme and so the design should include hooks for its later inclusion only.

3.2.2.6 Alert Handling

The alert definitions used throughout this specification follow those in Table 1 of ARINC 726. For completeness, the ARINC definitions are repeated in paragraph 6.3 of this document.

3.2.2.6.1 Alert Management

All situation awareness alerts generated by the System whilst the aircraft is in under direct ATC control shall be treated as Information alerts.

[Analysis / TBD] [D19-983]

The FMU will be capable of triggering a level 1 alert on the AWS. This comprises a single chime. The rate at which the chime is sounded must be slower than the rate specified in ARINC 726 for a level 2 alert so that no confusion arises over the level of the alert. A level 2 alert is indicated by a single chime that is repeated at 15 second intervals until cancelled by the pilot, therefore the MA-AFAS trials equipment must issue individual alerts at a rate that is significantly different from this.

The System shall issue alerts associated with the Conflict Detection function at a maximum rate of 1 per 30 seconds.

[Measurement / TBD] [D19-984]

The crew shall be able to cancel/acknowledge alerts via an entry into the MCDU or a menu selection on the navigation display unit.

[Demonstration / TBD] [D19-986]

It shall be possible to inhibit the display of information messages generated by the FMU at any flight phase.

[Demonstration / TBD] [D19-987]

It shall be possible to inhibit the display of advisory alert messages generated by the FMU at any flight phase.

[Demonstration / TBD] [D19-988]

3.2.2.6.2 MCDU

Alert messages are displayed within the scratchpad area of the MCDU with colour being used to differentiate between the different levels of alert.

When there is more than one message awaiting display to the pilot, the messages shall be presented in priority order.

[Demonstration / TBD] [D19-1056]

The priority associated with each message will be determined using the message urgency and the time at which was received. If two messages have the same urgency, then the messages will be displayed in time order.

An information message shall be displayed in white text within the scratchpad area.

[Inspection / TBD] [D19-993]

An advisory alert message shall be displayed in amber text within the scratchpad area.

[Inspection / TBD] [D19-994]

An abnormal alert message shall be displayed in amber text within the scratchpad area.

[Inspection / TBD] [D19-995]

3.2.2.6.3 Navigation Display Unit

Since the navigation display unit lies in the primary field of view of the pilot, the generation of many low level alert messages on this display surface would be a distraction to the pilot and so only advisory or higher level alerts will be presented.

All advisory and abnormal alerts shall be displayed in the message bar in amber text.

[Inspection / TBD] [D19-997]

All warnings shall be displayed in the message bar in red text.

[Inspection / TBD] [D19-998]

3.2.3 4D Trajectory Generation

The Trajectory generation functions are treated as a set of library functions that can be accessed by the different processes within the system. This simplifies the design because the pilot can generate one or more different trajectories for the flight and store these in the data base. It also allows the pilot to create trajectories that incorporate passing, crossing or spacing manoeuvres as directed by the ATC. The ASA functions can also use the generation functions to create new trajectories that prevent conflicts within FFAS. These conflict resolution strategies are made available for display to the pilot and hence for selection as the current active trajectory.

3.2.4 Aircraft Guidance

The guidance functions are primarily responsible for monitoring the 4D position of the aircraft against the active trajectory and for generating demands for the Autopilot to ensure that the aircraft remains within the limits of that trajectory. The first part of the monitoring process requires that an aircraft state vector be generated from the aircraft sensor inputs. The state information is then made available to the other processing tasks within the FMS. The state information is also used to compute deviations from the active trajectory so that when the FMS is controlling the autopilot, the FMS can update the autopilot demands as necessary to keep the aircraft on course.

The MA-AFAS FMS also provides support to the pilot to simplify the implementation of strategic and tactical commands. When the ATC sends commands to the aircraft, the pilot can choose how to implement these commands. For simple commands, such as speed, heading or altitude changes, the pilot could transfer control of the aircraft from the FMS to the autopilot and implement these commands directly. This is the most likely option when the commands are received by voice. If the commands are received over a datalink however, then the MA-AFAS avionics software is capable of implementing the commands directly. When more complex commands have been sent by ATC, the MA-AFAS avioncs provides the tools to interpret the command and display the impact on the trajectory. In general, it will not be possible for the pilot to implement any of the complex commands such as passing, crossing and spacing manoeuvres without assistance from the FMS.

The operation of the aircraft guidance functions shall take precedence over all other functions.

[Analysis / TBD] [D19-880]

3.2.4.1 Monitoring

The monitoring functions are primarily responsible for monitoring the 4D position of the aircraft against the currently active trajectory. When a spacing manoeuvre is selected for implementation using the FMS, the monitoring functions are also responsible for checking the separation between the aircraft and the target aircraft. When a tactical command is selected for implementation using the FMS, the monitoring functions are responsible for the reporting the deviation from the original trajectory that result from the implementation of the tactical command.

A trajectory progress monitoring process shall be automatically initiated upon activation of a trajectory by the pilot.

[Analysis / TBD] [D19-893]

The monitoring process is responsible for computing the deviations of the aircraft's actual 4D position from the predicted 4D position in the active trajectory and for comparing these against the tolerances specified for the current airspace. During a spacing manoeuvre the cross track error and altitude of the target aircraft are also checked to ensure that the target aircraft is not deviating from the previously agreed course. The speed of the target aircraft is monitored to ensure that the own aircraft will not be exceeding its own operational capability whilst following the target aircraft.

The monitoring functions shall be performed at a rate of approximately 2Hz.

[Analysis / TBD] [D19-1197]

This rate is based upon the experience gained from the AATMS/AFMS/EFMS programmes.

Due to the nature of prioritised multi-tasking operating systems, the exact rate of execution cannot be guaranteed as the point at which a higher priority task relinquishes the processor can vary.

Because of possible time lags in the System, caused by higher priority tasks, it is necessary for each time dependent task to compute the time that has elapsed since it was last activated. The processing tasks cannot assume that they will be activated at constant time intervals.

Each time dependant monitor function shall compute its own activation rate.

[Analysis / TBD] [D19-1535]

3.2.4.1.1 Trajectory Tolerances

The trajectory tolerances for each cleared point in the active trajectory are used to generate a hyperpipe which describes the boundaries that the aircraft is cleared to fly within.

The Required Navigational Performance (RNP) of the airspace the aircraft will be travelling through shall be used to define the lateral tolerance for each point in the active trajectory within that airspace.

[Analysis / TBD] [D19-886]

These tolerances shall be reduced by the error represented by the current Actual Navigation Performance (ANP) of the aircraft navigation systems.

[Analysis / TBD] [D19-887]

The Required Vertical Navigation Performance (RVNP) of the airspace the aircraft will be travelling through shall be used to define the altitude tolerance for each point in the active trajectory within that airspace.

[Analysis / TBD] [D19-890]

The Required Time Navigation Performance (RTNP) of the airspace the aircraft will be travelling through shall be used to define the time tolerance for each point in the active trajectory within that airspace.

[Analysis / TBD] [D19-891]

The hyperpipe shall be defined by applying the tolerances of each point in the active trajectory to its corresponding point in the active trajectory thereby creating a set of maximum and minimum limits for each point in the active trajectory.

[Analysis / TBD] [D19-1052]

The hyperpipe for a trajectory shall be generated when the trajectory is activated.

[Analysis / TBD] [D19-1058]

The hyperpipe reflects the clearances that have been agreed with the ATC and cannot be altered without the approval of the ATC. While the guidance functions may modify parts of the active trajectory detail within the limits of the hyperpipe, the hyperpipe information can not be changed because the guidance functions do not have the authority to modify the hyperpipe.

The tolerance limits for a position between two trajectory points shall be calculated by linear interpolation.

[Analysis / TBD] [D19-884]

3.2.4.1.2 Trajectory Position Prediction

In order to maintain the aircraft within the hyperpipe limits during the flight, it is necessary to predict how the aircraft will react to the actual environmental conditions instead of the predicted ones.

The method of predicting the trajectory position is based upon the experience gained during the AATMS/AFMS/EFMS programmes.

The monitoring function shall predict the aircraft position at 10 second intervals for the next 600 seconds ahead of the current aircraft position.

[Analysis / TBD] [D19-899]

3.2.4.1.3 Trajectory Guidance Closed Loop Monitoring

In order to maintain the aircraft within the hyperpipe, a predictive correction algorithm will be used that determines the correction(s) that must be made to the active trajectory if the aircraft will breach the hyperpipe within the next 600 seconds.

A System Informational Alert shall be generated if the System predicts that the aircraft will breach the hyperpipe within the next 600 seconds.

[Demonstration / TBD] [D19-1008]

If a breach has been predicted, then the constraints used to construct the active trajectory will be reduced to only the remaining constraints. Then, one or more new constraints are calculated and added to the start such that when the aircraft is controlled using the regenerated trajectory it will be guided back onto the route without violating the negotiated clearance. This is described in more detail within Technote MAT0001-1D.

If the System detects that the aircraft will breach the hyperpipe within the next 600 seconds, then a new trajectory shall be generated to correct the deviation.

[Analysis / TBD] [D19-1011]

The 4D positions in the regenerated trajectory shall be compared with the bounds of the cleared trajectory as defined by the hyperpipe.

[Analysis / TBD] [D19-1012]

A System Advisory Alert shall be generated if the System detects that the regenerated trajectory will breach the hyperpipe.

[Demonstration / TBD] [D19-1013]

If the regenerated trajectory does not breach the hyperpipe, then the regenerated trajectory shall be set as the active trajectory.

[Demonstration / TBD] [D19-1014]

3.2.4.1.4 Trajectory Monitoring

The aircraft's 4D position relative to the hyperpipe will be monitored to check if a fault has occurred and whether the end of the cleared trajectory is about to be reached.

The monitoring function shall compare the current aircraft position to the hyperpipe.

[Analysis / TBD] [D19-894]

A System Advisory Alert shall be generated if the aircraft manoeuvres outside the hyperpipe.

[Demonstration / TBD] [D19-895]

A System Advisory Alert shall be generated if the 4D predicted aircraft position at (300) seconds ahead of the current aircraft position is beyond the end of the hyperpipe.

[Demonstration / TBD] [D19-1010]

This time limit has been selected as a best estimate of the maximum time required for the Pilot to obtain new clearances from ATC.

3.2.4.1.5 Spacing Monitoring

When a spacing manoeuvre is selected for implementation using the FMS, a trajectory is generated that will guide the aircraft to behind and within the separation distance of the target, to 'acquire' the target. Once this trajectory has been activated by the Pilot, it will become the new active trajectory. Once the target has been 'acquired', the separation between the own and target aircraft is maintained until the manoeuvre is terminated.

The aircraft's 4D position relative to the target aircraft will be monitored to check for deviations from the specified separation. The cross track error, altitude rate and speed of the target aircraft will be monitored for any unexpected changes and for variations that will cause the own aircraft's operational limits to be exceeded.

When performing a spacing manoeuvre, a Spacing Alert shall be generated if the longitudinal separation between the own aircraft and target aircraft is outside the defined tolerance.

[Demonstration / TBD] [D19-854]

When performing a spacing manoeuvre, a Spacing Alert shall be generated if the horizontal separation between the own aircraft and target aircraft is less than the specified separation.

[Demonstration / TBD] [D19-1871]

When performing a spacing manoeuvre with a lateral offset specified, a Spacing Alert shall be generated if the lateral offset is outside its tolerance.

[Demonstration / TBD] [D19-855]

When performing a spacing manoeuvre with a vertical offset specified, a Spacing Alert shall be generated if the vertical offset is outside its tolerance.

[Demonstration / TBD] [D19-856]

Simple monitoring of the separation between the two aircraft does not lead to very robust spacing manoeuvre algorithm because no corrective actions are taken until the tolerance limits have been exceeded. In order to improve the performance, the behaviour of the separation over time will be also be monitored so that a separation trend vector can be computed. By combining the current separation and the trend vector, the separation at any time ahead can be estimated. If the predicted separation at a time ahead exceeds the tolerance limits, then any necessary corrective action can be taken immediately so that the aircraft is maintained at the correct separation. The prediction time needs to be chosen so that the aircraft has sufficient time to react to any changes in the commands sent to the autopilot. A time of 120 seconds has been selected as the best estimate of the time necessary for aircraft to make the necessary course correction and return to a steady state.

When performing a spacing manoeuvre, the separation deviation shall be calculated by taking the difference between the required separation and the actual separation.

[Analysis / TBD] [D19-857]

When performing a spacing manoeuvre, the separation trend shall be calculated from the separation deviation by taking the difference between this separation deviation and the previous and differentiating over the time period between the calculating of the separation deviation.

[Analysis / TBD] [D19-858]

When performing a spacing manoeuvre, the separation deviation and trend shall be used to estimate the separation for a time (120) seconds in the future.

[Analysis / TBD] [D19-859]

When performing a spacing manoeuvre, a Spacing Alert shall be generated if the separation distance is predicted to be lost within the next (120) seconds.

[Analysis / TBD] [D19-860]

During a spacing manoeuvre, the aircraft must react to changes in the speed of the target aircraft so that the specified separation is not lost. In order to achieve this, the speed of the target aircraft will be monitored. The monitoring process will check for any sudden or unexpected variation and provide corrections as necessary. The monitoring process will also check that the speed of the target aircraft remains within the operational limits of the own aircraft.

When performing a spacing manoeuvre, the calibrated airspeed of the target aircraft shall be monitored.

[Analysis / TBD] [D19-848]

If the calibrated airspeed of the target aircraft is not available, then the groundspeed of the target aircraft shall be converted to calibrated airspeed.

[Demonstration / TBD] [D19-849]

When performing a spacing manoeuvre, a Spacing Alert shall be generated if the calibrated airspeed of the target aircraft approaches within 30kts of the minimum normal operating calibrated airspeed of the own aircraft in the current flight configuration.

[Measurement / TBD] [D19-861]

When performing a spacing manoeuvre, a Spacing Alert shall be generated if the calibrated airspeed of the target aircraft approaches within 30kts of the maximum normal operating calibrated airspeed of the own aircraft in the current flight configuration.

[Measurement / TBD] [D19-862]

The cross track error of the target aircraft will be monitored for sudden variation or exceeding of the own aircraft's operational limits as specified by the own aircraft's limits definition held within the System.

When performing a spacing manoeuvre the position of the target aircraft shall be monitored.
(To do :- Need to replace with calculation of cross track error.)

[Analysis / TBD] [D19-850]

When performing a spacing manoeuvre a Spacing Alert shall be generated if the cross track error of the target aircraft is greater than twice the associated airspace’s RNP for the corresponding point on the aircraft’s trajectory.

[Measurement / TBD] [D19-863]

The altitude rate of the target aircraft will be monitored for sudden variation or exceeding of the own aircraft's operational limits as specified by the own aircraft's limits definition held within the System.

When performing a spacing manoeuvre the altitude rate of the target aircraft shall be monitored.

[Analysis / TBD] [D19-851]

When performing a spacing manoeuvre if the altitude rate of the target aircraft is not available the altitude shall be monitored and the altitude rate calculated.

[Demonstration / TBD] [D19-852]

When performing a level flight spacing manoeuvre a Spacing Alert shall be generated if the altitude rate of the target aircraft changes by ±200ft/min.

[Measurement / TBD] [D19-864]

When performing an in descent spacing manoeuvre a Spacing Alert shall not be generated if the altitude rate of the target aircraft changes by ±200ft/min.

[Measurement / TBD] [D19-865]

When a Spacing Alert is generated a System Advisory Alert shall be generated.

[Demonstration / TBD] [D19-1155]

3.2.4.1.6 Tactical Command Monitoring

The guidance of the aircraft to a trajectory can be interrupted by a request to perform a tactical command. These requests can take the form of heading, altitude and speed changes.

It is assumed that only one request type will be active at a time.

When performing a Tactical Command if the active trajectory is regenerated it is activated automatically, but the new Autopilot demands will not take effect until the Tactical Command has been stopped i.e. the Tactical Command guidance parameters plus the previous trajectory guidance parameters will override the active trajectory guidance parameters. This is to give the Pilot an indication of what effect the Tactical Command is having on his flight plan and to show the best policy for returning to the flight plan.

[Analysis / TBD] [D19-910]

When performing a Tactical Command the aircraft is monitored against the currently active trajectory.

[Analysis / TBD] [D19-901]

3.2.4.2 Guiding

The guiding functions are primarily responsible for generating the demands for the Autopilot. There are three types of demands used to control the Autopilot; LNAV, VNAV and THR/SPD. Basically LNAV is controlled by Heading or Bank Angle, VNAV is controlled by Altitude and THR/SPD is controlled by Speed or Mach, and Throttle. The other parameters that can be controlled are Bank Angle Limit, Acceleration, the Rate of Change of Mach, Throttle N1 (Altitude Rate is controlled via Throttle and Throttle N1 changes, the Throttle and Throttle N1 are calculated to give the required speed and altitude rate). Naturally controlling the aircraft with only one type of demand have an affect on the other two, e.g. heading changes will cause a loss of altitude, altitude changes will cause a loss in speed, etc..., so for optimal performance it is necessary to control all three at once. A Profile Mode usually consisting of Level, Climb and Descent is used to show which demands have preference e.g. in Level LNAV and THR/SPD have preference over VNAV, in Climb or Descent LNAV and VNAV have preference over THR/SPD, etc...

When a spacing manoeuvre is selected for implementation using the FMS the guiding functions are responsible for maintaining the separation between the aircraft and the target aircraft.

When a tactical command is selected for implementation using the FMS the guiding functions are responsible for generating the demands for the Autopilot that implement the command.

The aircraft guidance functions shall use the active trajectory as the basis for generating the aircraft guidance commands.

[Analysis / TBD] [D19-881]

3.2.4.2.1 Trajectory Guiding

The active trajectory that is used to generate the aircraft guidance commands is generated using a prediction of the environmental conditions that the aircraft will encounter. Obviously as this is a prediction the actual conditions that the aircraft will encounter will be different and need to be corrected for.
This is done in two ways:-
Firstly, the aircraft guidance commands generated from the active trajectory are corrected for the difference between the actual and predicted environmental conditions.
Secondly, the progress of the aircraft is monitored and predictions are forecast on whether or not the aircraft will remain within the hyperpipe (see the Trajectory Guidance Closed Loop Monitoring section in this document). If it is predicted that the aircraft will not remain within the hyperpipe the active trajectory is regenerated using the actual environmental conditions blended with the predicted environmental conditions.

The guiding function shall correct the aircraft guidance commands generated for the differences between the actual environmental conditions, contained within the Aircraft State, and the predicted environmental conditions, contained within the active trajectory.

[Analysis / TBD] [D19-882]

3.2.4.2.2 Spacing Guiding

When the aircraft has manoeuvred to be behind the target aircraft, the target aircraft shall be monitored and the speed of the aircraft adjusted to maintain specified longitudinal separation (specified as a relative distance or a relative time) within the specified tolerance.

[Demonstration / TBD] [D19-737]

If the optional lateral offsets have been specified then when the aircraft has manoeuvred to be behind the target aircraft, the target aircraft shall be monitored and the aircraft guidance commands adjusted to maintain specified lateral offset within a TBD tolerance (e.g. ±100m).

[Demonstration / TBD] [D19-741]

If the optional vertical offsets have been specified then when the aircraft has manoeuvred to be behind the target aircraft, the target aircraft shall be monitored and the aircraft guidance commands adjusted to maintain specified vertical offset within a TBD tolerance (e.g. ±200m).

[Demonstration / TBD] [D19-742]

Only the parameters associated with maintain longitudinal separation and the optional lateral and vertical offsets shall be adjusted.

[Demonstration / TBD] [D19-743]

All other parameters shall be maintained as previously indicated by the trajectory being performed.

[Demonstration / TBD] [D19-763]

When an In Descent spacing manoeuvre is selected for implementation using the FMS the guiding functions are responsible for maintaining the own aircraft's descent profile, but are not responsible for maintaining the own aircraft's heading. This is the responsibility of ATC, they will command the target aircraft to change to a new heading when required and then command the trailing aircraft when to change to a new heading to follow. Depending upon the separation distance it is possible for the target aircraft to have been commanded to change it's heading several times before the trailing aircraft is commanded to change it's heading to follow.

This is as described in D14 Section 3.1.1.5.1.

During In Descent Spacing it is possible for ATC to command Heading Changes via Tactical Commands these shall be followed whilst maintaining longitudinal separation and optional lateral and/or vertical offsets.

[Demonstration / TBD] [D19-744]

When a Spacing Alert occurs then the maintaining of the longitudinal separation shall be stopped.

[Demonstration / TBD] [D19-765]

When a Spacing Alert occurs then the aircraft shall be guided to the previously generated trajectory until otherwise commanded by the Pilot/ATC.

[Demonstration / TBD] [D19-767]

When an error is detected the Pilot cannot take any action until commanded by ATC except in case of vital emergency.

This is described in D14 Section 3.1.1.8 and 3.1.2.9.

3.2.4.2.3 Tactical Command Guiding

When a tactical command is selected for implementation using the FMS the guiding functions are responsible for performing the tactical command whilst still controlling the aircraft using the active trajectory, e.g. when a Speed tactical command is requested the guidance functions will implement the new speed specified whilst still performing the LNAV and VNAV control as specified by the active trajectory, i.e. if the aircraft is in a Climb or Descent Profile Mode the Thrust and Thrust N1 calculated will have to be adjusted to allow for the new selected Speed and the required Altitude Rate from the active trajectory.

This is described in D14 Section 3.3.1.10.2.1 and sub-sections.

When a tactical command is received the aircraft shall override the indicated parameter(s) and any associated parameter(s) whilst maintaining all other parameters as previously indicated by the trajectory being performed.

[Analysis / TBD] [D19-875]

3.2.4.3 Precision Approach

The precision approach functions do not appear explicitly in the FMS System design because the FMS will not be certified to a level sufficient to support this capability. The precision approach functions will be provided by other aircraft equipment such as GBAS, SBAS, MLS and ILS. The prime responsibility of the FMS with regard to precision approach activities is to alert the pilot to the availability of other systems if the FMS is currently controlling the aircraft.

If the pilot has selected the FMS to provide aircraft guidance and the aircraft enters airspace that supports GBAS, then an advisory alert shall be generated.

[Demonstration / TBD] [D19-1833]

If the pilot has selected the FMS to provide aircraft guidance and the aircraft enters airspace that supports SBAS, then an advisory alert shall be generated.

[Demonstration / TBD] [D19-1834]

If the pilot has selected the FMS to provide aircraft guidance and the aircraft enters a runway approach equiped with MLS, then an advisory alert shall be generated.

[Demonstration / TBD] [D19-1835]

If the pilot has selected the FMS to provide aircraft guidance and the aircraft enters a runway approach equiped with ILS, then an advisory alert shall be generated.

[Demonstration / TBD] [D19-1836]

3.2.5 Airborne Separation Assurance

3.2.5.1 Overview

The system design separates the ASA capabilities into two distinct parts; operations in managed air space (MAS) and operations in free flight air space (FFAS).

In MAS, the responsibility for separation assurance lies with the ATC unless they have delegated some responsibility to the aircraft. The partial delegation typically requires the aircraft to maintain a safe distance or a safe time from a nominated aircraft which is typically the focus point for a manoeuvre such as a passing, crossing or spacing manoeuvre. For spacing manoeuvres, the separation can also be specified as a time behind the target aircraft. During this partial delegation phase, the responsibility for maintaining a safe separation from any other aircraft remains with the ATC. The generation and monitoring of manoeuvres under partial delegation forms one part of the aircraft guidance functions and occurs only in response to a tactical command.

In FFAS, the aircraft is solely responsible for separation assurance with any other aircraft in FFAS. The ATC is not expected to have any direct involvement other than possibly a policing role. In order to achieve this, the ASA capability for FFAS includes three main tasks.

The first task is the generation of a traffic surveillance database. The traffic database is used as the basis of the information that is displayed on any CDTI and for identifying potential conflicts.

The second task is the Conflict Detection process. This is a generic process that can be applied to any nominated trajectory. Whenever a new trajectory has been generated, it can be compared with the known traffic movements in order to identify potential conflicts. During the initial flight planning stages, it will not normally be necessary for the aircraft to do this because the conflict detection and resolution will be the responsibility of the ATC. When the aircraft is airborne and approaching an area of FFAS, the pilot will select autonomous operations and the Conflict Detection and Resolution algorithms will be run on a periodic basis.

An alert message will only be generated in response to the detection of a potential conflict if the aircraft is in FFAS or if the alerts have been activated by the pilot. The latter situation is required for the proposed procedures for transitions from MAS to FFAS. There are no plans to provide conflict detection capabilities on board the aircraft during ground movements.

The final task is conflict resolution. When potential conflicts have been identified, the resolution algorithm creates additional constraints for the trajectory generation process in order to create a trajectory that avoids the conflict. While the aircraft is in FFAS, the conflict and the resolved trajectory are presented to the pilot so that he can take appropriate action. It is expected that the pilot will activate the proposed resolution trajectory as the new active trajectory.

For transitions into FFAS, the aircraft needs to co-ordinate its movements within the MAS with ATC so that its entry point into FFAS does not cause conflicts. Once the aircraft is within the ADS-B range of its proposed entry point to FFAS, its conflict detection process should be activated by the pilot. If the proposed entry point will cause a conflict with aircraft already in FFAS, it will be necessary to negotiate a new entry point with the ATC.

For transitions from FFAS to MAS, the aircraft must reach an exit point agreed with ATC at a specified time. The responsibility for conflict detection and resolution upon exit from FFAS returns to ATC and the generation of conflict alerts by the aircraft equipment will be suppressed.

3.2.5.2 Conflict Detection and Resolution

3.2.5.2.1 Overview

The Conflict Detection & Resolution functions can be separated naturally into conflict detection functions and conflict resolution functions. This split is based both on what the functions are required to do and when they are activated.

The Conflict Detection process must operate on an almost continual basis because the contents of the surveillance database will be updated continually. Since it is not practical to run the Conflict Detection algorithm whenever a change to the surveillance database occurs, it has been decided to activate the processing at regular time intervals. Within each time interval, a snapshot of the surveillance data is taken and the conflict detection process is applied to each item within the database.

The Conflict Resolution process will only be activated upon completion of a Conflict Detection processing cycle. The processing is not activated as soon as a conflict is detected because additional conflicts may exist with traffic items that have not been tested. The Conflict Resolution processing will only operate if one or more conflicts was found in the preceding Conflict Detection processing cycle.

The Conflict Detection & Resolution function will ensure that any generated trajectory will not include a FFAS boundary crossing.

3.2.5.2.2 Conflict Detection

The design of the conflict detection algorithms uses the concept of a Protected Airspace Zone (PAZ) in accordance with the Application of Airborne Conflict Management document. This zone is used to define an area surrounding the aircraft which, under normal conditions, will be free of other traffic. A conflict is therefore defined as the penetration of the aircraft PAZ by another traffic object in the surveillance database.

The Conflict Detection function can be activated in one of two ways. It can be invoked by the Trajectory Generation process when a proposed trajectory has been generated. When the pilot has selected autonomous operations, the Conflict Detection function is activated at regular time intervals to compare the active trajectory against all traffic objects.

Although D18 specifies that the Conflict Detection process should be activated whenever a new object has been added to the surveillance database or when surveillance data is received for a traffic object with a Virtual Conflict Time (VCT) of less than 5 minutes, this is not considered to be practical. An alternative approach that activates the processing at regular intervals is preferred. This is described in detail within a separate document - Conflict Detection and Resolution Technical Note.

The precise definition of the Virtual Conflict Time has still to be decided. In the short term, a very conservative statistic will be used. This is defined as the distance between the ownship PAZ and a traffic object divided by the sum of their groundspeeds.

When Autonomous Operations have been selected by the pilot, the System shall activate the Conflict Detection function at 30 second time intervals.

[Analysis / TBD] [D19-1024]

When the Conflict Detector function is initiated at regular time intervals, the subset of traffic requested from the surveillance database will vary on a cyclic basis. This is shown in the Table 1 - Traffic Request Cycle from the Conflict Detection and Resolution Technical Note.

The Conflict Detection function shall use both 'state only' data and 'state and intent' data.

[Analysis / TBD] [D19-1030]

The active trajectory shall be compared to the trajectories of each traffic object within the surveillance database in order to identify those objects whose trajectories will cross or come into close proximity of the ownship within the look-ahead time.

[Analysis / TBD] [D19-1814]

The precise value of the look-ahead time has still to be decided but it is likely to be close to 15 minutes.

The Conflict Detection function shall take account of positional errors, both across and along track of both aircraft.

[Analysis / TBD] [D19-942]

Each conflict that is found by the Conflict Detection function will be stored in a conflict database in chronological order. The reference time for sorting the conflicts will be the predicted time until the conflict occurs.

If a conflict is found within the look-ahead time the conflict shall be registered in the conflict database.

[Analysis / TBD] [D19-1031]

The Conflict Detection function shall use the predicted time of the conflict to enable the conflict information to be stored in chronological order.

[Analysis / TBD] [D19-1032]

The Conflict Detection function is responsible for alerting the pilot whenever a potential conflict has been detected. The type of alert will depend upon the predicted time until conflict occurs.

If a conflict is found with a conflict time of less than 2 minutes then an advisory conflict alert shall be generated.

[Demonstration / TBD] [D19-1179]

If a conflict is found with a conflict time of greater than 2 minutes then an information conflict alert shall be generated.

[Demonstration / TBD] [D19-1180]

3.2.5.2.3 Conflict Resolution

The Conflict Resolution function will generate a proposed trajectory that reduces the likelihood of occurrence for any conflict that has been detected. This proposed trajectory will be presented to the pilot who will be able to accept, reject or modify the proposed trajectory.

The Conflict Resolution function will make use of two different algorithms in order to compute a resolution trajectory.

- Priority Rules Based; This method is characterised by the fact that only one of the two conflicting aircraft is manoeuvring to solve the conflict. In this situation, other ‘rules of the air’ exist that define which aircraft has priority over the other in a conflict situation. Once the priority has been determined the aircraft having priority is not required to manoeuvre as long as the conflict situation exists. The aircraft not having priority should initiate a manoeuvre which solves the conflict.
- Cooperative; This method is characterised by the fact that the two aircraft which are in conflict both take action by manoeuvring in order to solve the conflict.

The priority rules based method uses both state and intent data, giving a long term outlook of up to 20 minutes.

The cooperative method uses state data only, giving a short term outlook of up to 5 minutes.

The Conflict Resolution function, in conjunction with the trajectory generator, shall be capable of generating a proposed trajectory that prevents occurrence of detected conflicts.

[Analysis / TBD] [D19-957]

One of the constraints on the Conflict Resolution algorithms is that the resolution trajectory must not cross the boundaries of the FFAS. If this was allowed, then the ATC would need to become involved and the aircraft operation would not be autonomous. When the resolution trajectory has been computed, then this will be compared with the FFAS boundary information to ensure that the boundary is not crossed. If a boundary crossing is detected, then a new trajectory must be computed.

The Conflict Resolution function shall ensure that any resolution trajectory presented to the pilot does not cross the FFAS boundary.

[Analysis / TBD] [D19-1511]

If it is not possible to find a resolution trajectory without crossing the FFAS boundary, then an advisory alert shall be generated.

[Analysis / TBD] [D19-1510]

The process of conflict resolution is an iterative one. The process begins by resolving the most immediate conflict. The Conflict Detection function is then applied to this trajectory to ensure that the proposed trajectory does not introduce further conflicts. If more conflicts are created, then these are added to the conflict database and the resolution process begins again. The processing ends when a resolution trajectory is found that eliminates all conflicts.

The Conflict Resolution function shall utilise the Conflict Detection function to verify that a proposed resolution trajectory does not conflict with any other conflicts currently known.

[Analysis / TBD] [D19-954]

The Conflict Resolution function shall utilise the Conflict Detection function to verify that a proposed resolution trajectory does not involve a FFAS boundary crossing.

[Analysis / TBD] [D19-958]

The resolution trajectory generated by the Conflict Resolution process will be presented to the Pilot for approval, modification or rejection. If the Pilot rejects the resolution trajectory then the Conflict Resolution process will be repeated. Any resolution trajectory will only be valid for a limited time and so the processing includes an allowance for a pilot decision time. If the Pilot does not respond within the Pilot Decision Time then the Conflict Resolution process will need to be repeated. If the Pilot requests a modification to the resolution trajectory then the Conflict Resolution process will be repeated with the additional Pilot requested constraint.

The computation of a resolution trajectory shall include an allowance for a Pilot Decision Time.

[Demonstration / TBD] [D19-960]

If a resolution trajectory has been generated but the pilot has either rejected the resolution trajectory or there is no response within the Pilot Decision Time, then the Conflict Resolution process shall be repeated.

[Demonstration / TBD] [D19-1039]

If a resolution trajectory has been generated and the Pilot has requested a modification, then the Conflict Resolution process shall be repeated with the additional Pilot requested constraint.

[Demonstration / TBD] [D19-1040]

When using the Cooperative conflict resolution method, the Conflict Resolution function will result in an avoidance manoeuvre being generated. This avoidance manoeuvre will be converted to a Trajectory Change Point that will be passed to the Trajectory Generator. This TCP will be accepted automatically by the system and so implemented without recourse to the Pilot.

The Cooperative conflict resolution method shall generate an avoidance manoeuvre.

[Analysis / TBD] [D19-1042]

The avoidance manoeuvre shall be converted to a Trajectory Change Point..

[Analysis / TBD] [D19-1043]

The Trajectory Change Point shall be passed to the Trajectory Generator for implementation.

[Analysis / TBD] [D19-1480]

When using the Priority Rules Based conflict resolution method, the Conflict Resolution function will result in a conflict free trajectory that will be presented to the Pilot for acceptance. If the ownship is the lower priority aircraft in conflict then a conflict free trajectory will be generated, i.e. higher priority traffic will assume the aircraft with lower priority will move. The relative priorities between aircraft will be applied by using the Extended visual Flight Rules (EFR).

The Priority Rules Based conflict resolution method shall use the relative priorities between the ownship and conflicting traffic, as determined by the Extended visual Flight Rules (EFR), as detailed in Table 2 of D18.

[Analysis / TBD] [D19-962]

If all traffic objects are of a lower priority then the preferred trajectory shall be sent to the Trajectory Generator.

[Demonstration / TBD] [D19-1045]

If a higher priority traffic object exists, the lower priority aircraft shall generate a list of avoiding manoeuvres.

[Demonstration / TBD] [D19-1002]

The list of avoiding manoeuvres shall be searched for the optimum solution which will be presented to the Pilot for acceptance.

[Analysis / TBD] [D19-1005]

3.2.6 Data Management

The System design distributes the management of the various databases within the System to those functions that are responsible for the data generation wherever this is possible. In practice, the pilot is the ultimate user of the information and so all information must be available to him via the HMI.

The HMI requires its own database functions for handling configuration information, company route information, airport map information and the navigation database. The navigation database is also used by the Trajectory Generation functions and a separate group of data access functions are defined for the Trajectory Generator.

The primary source of the meteorological data used by the aircraft system is the AOC. Within the design, the AOC functions have been made responsible for the maintenance of the Meteo database. The Trajectory Generation functions are the only ones that use this data and so it includes all of the necessary access functions.

The AOC function also includes its own internal database functions for maintaining the information that is sent from the AOC to the pilot.

The FIS function includes its own internal database functions for maintaining records of broadcast information. This includes ATIS, RVR and SIGMET records.

A separate function is responsible for the maintenance of the traffic surveillance database. The information from ADS and TIS broadcasts is fused into single records and held within this function. Access to the information is provided through a set of filter functions.

The database can be considered to comprise static and dynamic components. Static databses are those that can not be changed during the flight. This includes the navigation database, company route database and configuration database. Updates to the static components of the database can only occur while the system is in the maintenance state. At all other times, this data is treated as 'read-only'. The static databases are created from data files held on the data storage device when the System is in the Initialise state. All other databases are created in volatile memory at the same time but are initially empty.

Downloads from the system can be performed only when a data loading device is connected and the system is in either the Maintenance state or the Preflight state.

The system design includes a data storage device that will be used to hold data files that have been loaded through the Data Loader. During the Initialisation phase, the system shall read the contents of these files and create the database in virtual memory.

[Demonstration / TBD] [D19-410]

An error message shall be generated if, during the generation of the database, either a file is not found or a file read error occurs.

[Demonstration / TBD] [D19-411]

3.2.6.1 Configuration Database

In order to maximise the flexibility of the System for trials purposes, it is intended that during the Initialise state, a single configuration file will be read from the HDD. This file will contain the information necessary to allow the complete System to be initialised. The configuration file will contain the names of files on the HDD that contain information that is specific to different parts of the system, e.g. menu data files. The configuration file will also contain information that will affect the behaviour of the System while it is in other operating states.

It is intended that the menu structures for the MCDU and Navigation Display Unit be completely configurable off-line. In order to meet this aim, the menu structures must be loaded while the System is in the Initialise state. The menu data files will be held on the Hard Disk Drive that forms an essential part of the System architecture.

The configuration database shall contain the names of the menu data files from which the menus will be built.

[Analysis / TBD] [D19-1330]

The Flight Management functions will incorporate an aircraft performance model. While the equations that are used within the model are largely independent of the aircraft type, the behaviour of the equations will be dependent upon the aircraft type. The parameters appropriate to a single aircraft will be held in a single file that can be loaded during the initialisation phase.

The configuration database shall contain the name of the aircraft performance data file.

[Inspection / TBD] [D19-1333]

3.2.7 Context Management

The Context Management (CM) service is an ATS application which enables an ATS Provider system to become aware of an aircraft's datalink capabilities and provides an exchange of application name, address, and version number for each application and version number of an application supported by the aircraft and the ATS provider. In addition BASELINE 1 ground systems require that the aircraft provide flight plan information. The CM messages have no function related to the direct control of the aircraft by an ATS Provider.

The ODIAC DLL service specified in D18 represents a particular way of using the CM functions specified in the ATN SARPS. In order to meet the D18 requirements, some but not all of the message set identified in the ATN SARPS needs to be implemented.In particular, the System must be able to initiate a CM logon and handle the response message from the ground system.

The System shall be capable of creating a CMLogonRequest message as defined in the ATN SARPS.

[Analysis / TBD] [D19-1649]

The System shall be capable of decoding a CMLogonResponse message as defined in the ATN SARPS.

[Analysis / TBD] [D19-1650]

Paragraph 7.3.4.1 of BASELINE 1 specifies that at least four sets of ground system addresses and the associated application information should be stored within the aircraft system. This corresponds to information from the CDA, NDA and two DDAs.

The System shall be capable of storing logon information for at least 4 ground systems.

[Measurement / TBD] [D19-1652]

3.2.8 Controller Pilot Datalink Communications

The CPDLC system allows data link communication between aircraft and ATC ground systems.

The communication is nominally between pilots and controllers although it may be between automated systems in the aircraft and on the ground with or without pilot/controller interaction.

The following defines some of the terms used to describe the CPDLC links.

CPDLC connection : A data link connection between an instance of an ASE and a ground facility.

CPDLC dialogue connection : A CPDLC connection over which CPDLC messages, which form CPDLC message dialogues, may be exchanged.

CPDLC message dialogues : The exchange of CPDLC messages and CPDLC message responses where the CPDLC message response is determined by the CPDLC message elements contained within the CPDLC message.

CDA CPDLC dialogue connection : A CPDLC dialogue connection associated with the CDA.

NDA CPDLC connection : A CPDLC connection associated with the NDA.

DDA CPDLC dialogue connection : A CPDLC dialogue connection associated with the DDA.

Note : A CPDLC message response may be sent over a CPDLC connection even though it does not form part of a CPDLC message dialogue, and the CPDLC connection is not a CPDLC dialogue connection. In this case the CPDLC message response is a standard response to the service primitive and not a specific response to the CPDLC message.

The following terms have been used to describe CPDLC messages.

uplink LACK : A valid uplink CPDLC message which contains the following CPDLC message element :
UM227 LOGICAL ACKNOWLEDGEMENT

uplink STANDBY : A valid uplink CPDLC message which contains the following CPDLC message element :
UM1 STANDBY

uplink ERROR : A valid uplink CPDLC message which contains one of the following CPDLC message elements :
UM159 ERROR
UM162 SERVICE UNAVAILABLE
UM233 USE OF LOGICAL ACKNOWLEDGEMENT PROHIBITED
UM234 FLIGHT PLAN NOT HELD

uplink OPERATIONAL : A valid uplink CPDLC message which is not one of the following :
uplink LACK
uplink STANDBY
uplink ERROR

downlink LACK : A valid downlink CPDLC message whcih contains the following CPDLC message element :
DM100 LOGICAL ACKNOWLEDGEMENT

downlink STANDBY : A valid downlink CPDLC message which contains the following CPDLC message element :
DM2 STANDBY

downlink ERROR : A valid downlink CPDLC message which contains one of the following CPDLC message elements :

DM62 ERROR
DM63 NOT CURRENT DATA AUTHORITY
DM107 NOT AUTHORIZED NEXT DATA AUTHORITY

downlink OPERATIONAL : A valid uplink CPDLC message which is not one of the following :
downlink LACK
downlink STANDBY
downlink ERROR

The CPDLC system communicates via an ATN stack to the ATC ground system.

The interface between the CPDLC system and the ATN stack is defined as an abstract service interface.

Communication from the CPDLC system to the ATN stack is achieved by invoking a service with a set of parameters.

CPDLC-Start-Rsp	
Parameter	Description
Reject Reason	This parameter is used to provide a reason for rejecting a CPDLC Connection. This parameter will conform to the ASN.1 abstract syntax ATCDownlinkMessage.
Result	This parameter is used to indicate whether a requested CPDLC Connection is accepted or rejected. This parameter will contain the abstract value “accepted” or “rejected”.

CPDLC-Message-Req	
Parameter	Description
CPDLC Message	This parameter is used to provide the CPDLC message to be transmitted. This parameter will conform to the ASN.1 abstract syntax ATCDownlinkMessage.

CPDLC-End-Rsp	
Parameter	Description
CPDLC Message	This parameter is used to provide the CPDLC message to be transmitted. This parameter will conform to the ASN.1 abstract syntax ATCDownlinkMessage.
Result	This parameter indicates whether a requested CPDLC Connection termination is accepted or rejected. This parameter will contain the abstract value “accepted” or “rejected”.

CPDLC-User-Abort-Req	
Parameter	Description
Reason	This parameter is used to indicate the reason for aborting the CPDLC Connection. This parameter will conform to the ASN.1 abstract syntax CPDLCUserAbortReason.

DSC-Start-Req	
Parameter	Description
Facility Designation	This parameter is used to indicate the ground facility to which the service primitive is to be transmitted. This parameter will conform to the abstract syntax 4 to 8 character facility designation.
CPDLC Message	This parameter is used to provide the CPDLC message to be transmitted. This parameter will conform to the ASN.1 abstract syntax ATCDownlinkMessage.
Class Of Communication	This parameter is used to indicate the required class of communication. This parameter will contain one of the abstract values “A” to “H”.

DSC-End-Req	
Parameter	Description
CPDLC Message	This parameter is used to provide the CPDLC message to be transmitted. This parameter will conform to the ASN.1 abstract syntax ATCDownlinkMessage.

Communication from the ANT stack to the CPDLC system is achieved by receipt of a service primitive which contains a set of parameters.

CPDLC-Start-Ind	
Parameter	Description
Calling Peer Identifier	This parameter is used to indicate the ground facility from which the service primitive came. This parameter will conform to the abstract syntax 4 to 8 character facility designation.
CPDLC Message	This parameter is used to provide the CPDLC message to be transmitted. This parameter will conform to the ASN.1 abstract syntax ATCDownlinkMessage.
Class Of Communication	This parameter is used to indicate the required class of communication. This parameter will contain one of the abstract values “A” to “H”.

CPDLC-Message-Ind	
Parameter	Description
CPDLC Message	This parameter is used to indicate the CPDLC message received. This parameter will conform to the ASN.1 abstract syntax ATCUplinkMessage.

DSC-End-Ind	
Parameter	Description
CPDLC Message	This parameter is used to indicate the CPDLC message received. This parameter will conform to the ASN.1 abstract syntax ATCUplinkMessage.

CPDLC-User-Abort-Ind	
Parameter	Description
Reason	This parameter is used to indicate the reason for aborting the CPDLC Connection. This parameter will conform to the ASN.1 abstract syntax CPDLCUserAbortReason.

CPDLC-Provider-Abort-Ind	
Parameter	Description
Reason	This parameter is used to indicate the reason for aborting the CPDLC Connection. This parameter will conform to the ASN.1 abstract syntax CPDLCProviderAbortReason.

3.2.8.1 CPDLC System States

The CPDLC system will have two modes of operation INHIBITED mode and ENABLED mode.

The CPDLC system will power up in the INHIBITED mode and re enter this mode when commanded by the pilot, after any power cycle resulting in a cold start or after the end of the flight (doors open for 10 minutes).

In the INHIBITED mode any attempt to initiate a CPDLC Connection from the ground will be rejected with "AIRCREW HAS INHIBITED CPDLC." and any attempt to initiate a CPDLC Connection for DSC will be blocked.

If there are existing CPDLC Connections with ground facilities when the CPDLC system enters the INHIBITED mode, they will be aborted with the commanded termination reason.

The CPDLC system shall enter the ENABLED state after a successful CM logon with any ground facility and will then process CPDLC Connection requests.

[TBD / TBD] [D19-1772]

The CPDLC system shall have the following states.

INHIBITED
ENABLED

[TBD / TBD] [D19-1076]

The CPDLC system shall start in the INHIBITED state.

[TBD / TBD] [D19-1078]

The CPDLC system shall enter the ENABLED state when a successful context management logon is performed with a ground facility.

[TBD / TBD] [D19-1080]

The CPDLC system shall reenter the INHIBITED state after a power cycle, resulting in a cold start.

[TBD / TBD] [D19-1079]

The CPDLC system shall reenter the INHIBITED state at the end of flight.

[TBD / TBD] [D19-1488]

Note : End of Flight is defined as any passenger door being open for 10 minutes or more.

The CPDLC system shall re-enter the INHIBITED state when commanded by the pilot.

[TBD / TBD] [D19-1081]

When the CPDLC system is commanded into the INHIBITED state the system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req service for the each CPDLC connection with :

1.1 - The reason parameter set to commanded-termination.

[TBD / TBD] [D19-1082]

3.2.8.2 Data Authorities

The CPDLC system will support CPDLC connections with three types of data authority.

The Current Data Authority (CDA) is the air traffic control centre which is currently in control of the aircraft. The CPDLC system will allow full message exchange with the CDA.

The Next Data Authority (NDA) is the air traffic control centre which will be in control of the aircraft after a handover has taken place. The CPDLC system will allow no message exchange with the NDA. The CPDLC connection with the NDA is allowed to ensure that, at the time of handover, there will be no gap in data link connection.

The Downstream Data Authority (DDA) is an air traffic control centre on the aircraft's route which will be in control of the aircraft at some future point in time. The CPDLC system will allow limited message exchange with the DDA in order to allow downstream clearances to be obtained. A DDA CPDLC dialogue connection is allowed with the NDA but not with the CDA.

Note : A data authority represents one air traffic control centre within which there may be many air traffic control sectors.

The CPDLC system shall support CPDLC connections with the following data authorities.

Current Data Authority (CDA)

Next Data Authority (NDA)
Downstream Data Authority (DDA)

[TBD / TBD] [D19-1308]

The CPDLC system shall allow a CPDLC dialogue connection with the CDA.

[TBD / TBD] [D19-1313]

The CPDLC system shall allow only one CDA CPDLC dialogue connection at any instance.

[TBD / TBD] [D19-1307]

The CPDLC system shall allow only one NDA CPDLC connection at any instance.

[TBD / TBD] [D19-1309]

The CPDLC system shall allow a CPDLC dialogue connection with the DDA.

[TBD / TBD] [D19-1315]

The CPDLC system shall allow only one DDA CPDLC dialogue connection at any instance.

[TBD / TBD] [D19-1310]

The CPDLC system shall not permit the creation of a DDA CPDLC dialogue connection with the same ground facility for which a CDA CPDLC dialogue connection exists.

[TBD / TBD] [D19-1311]

If a CDA CPDLC dialogue connection is established with a ground facility for which a DDA CPDLC dialogue connection exists then the system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req service for the DDA CPDLC dialogue connection with no reason parameter.

[TBD / TBD] [D19-1312]

The CPDLC system shall not allow a CPDLC dialogue connection with the NDA.

[TBD / TBD] [D19-1314]

3.2.8.3 Message Identification Numbers

The purpose of the CPDLC system is to allow communication (nominally) between the pilot and a controller.

When a CPDLC connection is established over which messages may be exchanged (CPDLC dialogue connection) the system allows two types of message exchange : the sending of messages to the controller and the receipt of responses to those messages (CPDLC downlink message dialogue); and the receipt of messages from the controller and the sending of responses to those messages (CPDLC uplink message dialogue).

To keep track of these message exchanges the CPDLC system uses message ids.

When a message is sent from the pilot the id is allocated from a set of ids associated with the CPDLC dialogue connection over which the messages are being sent. This opens a CPDLC downlink message dialogue which is nominally closed when the required response is received (or immediately if no response is required).

For a message received from the controller the message id associated with the message (allocated by the ground system) is used. This opens a CPDLC uplink message dialogue which is nominally closed when the required response is sent (or immediately if no response is required).

Each CPDLC dialogue connection shall be associated with a set of CPDLC dialogue downlink message identification numbers with the range 0 to 63.

[TBD / TBD] [D19-1318]

Each CPDLC downlink message sent over a CPDLC dialogue connection shall be allocated one of the CPDLC dialogue downlink message identification numbers.

[TBD / TBD] [D19-1317]

CPDLC dialogue downlink message identification numbers shall be allocated sequentially from the set of CPDLC dialogue downlink message identification numbers until all CPDLC dialogue downlink message identification numbers have been allocated once.

[TBD / TBD] [D19-1354]

CPDLC dialogue downlink message identification numbers shall be allocated sequentially from the set of CPDLC dialogue downlink message identification numbers starting with the number 0.

[TBD / TBD] [D19-1875]

When all CPDLC dialogue downlink message identification numbers have been allocated once they shall be reallocated in the order in which they were deallocated.

[TBD / TBD] [D19-1876]

Note : This should help ensure that CPDLC connections are not unnecessarily aborted. Aborts could occur if a deallocated identification number is reused when the ground system is still maintaining the association of the identification number with the original message (i.e. the ground system has not yet deallocated the identification number).

If a CPDLC dialogue downlink message identification number cannot be allocated then the CPDLC system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req for the CPDLC dialogue connection with :

1.1 - The reason parameter set to no message identification numbers available.

[TBD / TBD] [D19-1463]

Each CPDLC downlink message sent over a CPDLC connection dialogue shall open a CPDLC downlink message dialogue.

[N/A / N/A] [D19-1320]

CPDLC dialogue downlink message identification numbers shall not be allocated to another CPDLC downlink message until the CPDLC downlink message dialogue for the asssociated message has been closed.

[TBD / TBD] [D19-1319]

A CPDLC downlink message dialogue shall be closed when :

1 - The closure response is received.
2 - The associated CPDLC dialogue connection is terminated.
3 - The tcs timer has expired.

[TBD / TBD] [D19-1353]

Each CPDLC downlink message sent over a CPDLC connection which is not a CPDLC dialogue connection shall use the message identification number 0.

[TBD / TBD] [D19-1496]

Note : In this case as there is no message exchange allowed, the CPDLC system does not need to track the message. Any arbitrary message identification number could be allocated - there is no special significance to the value 0.

Each CPDLC uplink message received over a CPDLC dialogue connection shall open a CPDLC uplink message dialogue.

[TBD / TBD] [D19-1355]

A CPDLC uplink message dialogue shall be closed when :

1 - The closure response is sent.
2 - The associated CPDLC dialogue connection is terminated.
3 - The ttr timer has expired.

[TBD / TBD] [D19-1356]

3.2.8.4 Logical Acknowledgement

In order to determine whether a message has been successfully delivered the CPDLC system uses a logical acknowledgement mechanism in which the receiving system automatically acknowledges the receipt of a valid message.

When a message is sent from the pilot over a CPDLC dialogue connection a logical ackonwledgement may be requested from the ground CPDLC system. Conversely when a CPDLC message is received from the controller over a CPDLC dialogue connection a logical acknowledgement may be requested from the air CPDLC system.

The use of LACKs gives increased confidence that a CPDLC message has been delivered and improved reporting of failures if it has not been delivered. Therefore, all CPDLC dialogue connections will default to requiring LACKs for downlink messages when sent (CPDLC connections which are not CPDLC dialogues connections may not use the LACK facility). However, some ground systems may not support the LACK facility and send a CPDLC message which inhibits the LACK facility for that particular CPDLC connection.

A CPDLC downlink message sent over a CPDLC dialogue connection shall require a logical acknowledgement unless the use of logical acknowledgements has been prohibited on that particular CPDLC dialogue connection or the CPDLC downlink message belongs to one of the sets of downlink ERROR messages, downlink LACK messages or downlink STANDBY messages.

[TBD / TBD] [D19-1517]

A CPDLC downlink message sent over a CPDLC connection which is not a CPDLC dialogue connection shall not require a logical acknowledgement.

[TBD / TBD] [D19-1518]

3.2.8.5 Date and Time

In order to determine the message latency for a CPDLC dialogue connection, each CPDLC message includes a timestamp which shows the date and time of the message transmission.

All CPDLC downlink messages shall include a timestamp consisting of a date and a time.

[TBD / TBD] [D19-1523]

The timestamp for a CPDLC downlink message constructed by the pilot shall be the date and time at which the pilot triggers the message for transmission.

[TBD / TBD] [D19-1524]

Note : This may be the point at which the pilot presses a "send" key if one is required, or the point at which he presses the last data entry key if the message is sent automatically upon completion.

The timestamp for a CPDLC downlink message which is constructed without pilot intervention shall be the date and time at which the generating system triggers the message for transmission.

[TBD / TBD] [D19-1526]

3.2.8.6 Class of Communication

When establishing a communication link this parameter allows the establisher to specify the quality of service expected from the communication link. This quality of service is specifed in terms of the end to end transit delay at 95% probability.

The class of communication parameter, when specified by the CPDLC system, shall be one of the values 'B' to 'H'.

[TBD / TBD] [D19-1885]

The meaning of each type of class of communication value is given in the table below.

Class of Communication	End to End Transport Delay (at 95% probability)	ATSC Value
‘A’	Reserved	5
‘B’	4.5	5
‘C’	7.2	8
‘D’	13.5	14
‘E’	18	18
‘F’	27	27
‘G’	50	50
‘H’	100	100
Not Specified	No Preference	100

3.2.8.7 Timers

In order to detect failures in the transmission of messages and/or responses or the failure of a system to respond in a timely manner, the CPDLC system will use a series of timers.

For each downlink CPDLC message sent on a CPDLC dialogue connection, the following timers shall be enabled :

1 - If an uplink LACK response is required, Technical Response Timer (trs)
2 - If an uplink OPERATIONAL response is required, Operational Response Timer (tos)
3 - If an uplink OPERATIONAL response is required, Termination Timer (tts)
4 - If an uplink OPERATIONAL response is required, Closure Timer (tcs)

[TBD / TBD] [D19-1170]

The trs timer shall expire at T(trs) seconds.

[TBD / TBD] [D19-1171]

The tos timer shall expire at T(tos) seconds.

[TBD / TBD] [D19-1172]

The tts timer shall expire at T(tts) seconds.

[TBD / TBD] [D19-1173]

The tcs timer shall expire at T(tcs) seconds.

[TBD / TBD] [D19-1174]

The trs timer shall be disabled when :

1 - An uplink LACK response is received for the associated message.
2 - An uplink ERROR response is received for the associated message.
3 - An uplink STANDBY response is received for the associated message.
4 - An uplink OPERATIONAL response is received for the associated message.

[TBD / TBD] [D19-1175]

The tos timer shall be disabled when :

1 - An uplink ERROR response is received for the associated message.
2 - An uplink STANDBY response is received for the associated message.
3 - An uplink OPERATIONAL response is received for the associated message.

[TBD / TBD] [D19-1176]

The tts timer shall be disabled when

1 - An uplink ERROR response is received for the associated message.
2 - An uplink OPERATIONAL response is received for the associated message.

[TBD / TBD] [D19-1177]

The tcs timer shall be disabled when

1 - An uplink ERROR response is received for the associated message.
2 - An uplink OPERATIONAL response is received for the associated message.

[TBD / TBD] [D19-1181]

The tts timer shall be reset when

1 - An uplink STANDBY response is received for the associated message.

[TBD / TBD] [D19-1182]

The tcs timer shall be reset when

1 - An uplink STANDBY response is received for the associated message.

[TBD / TBD] [D19-1183]

For each uplink CPDLC message received from a CPDLC dialogue connection, the following timers shall be enabled.

1 - If a downlink OPERATIONAL response is required, Operational Response Timer (tor).
2 - If a downlink OPERATIONAL response is required, Termination Timer (ttr).

[TBD / TBD] [D19-1184]

The tor timer shall expire at T(tor) seconds

[TBD / TBD] [D19-1185]

The ttr timer shall expire at T(ttr) seconds.

[TBD / TBD] [D19-1186]

In normal operation the tor timer shall be disabled when

1 - A downlink ERROR response is sent for the associated message.
2 - A downlink OPERATIONAL response is sent for the associated message.

[TBD / TBD] [D19-1187]

In normal operation the ttr timer shall be disabled when

1 - A downlink ERROR response is sent for the associated message.
2 - A downlink OPERATIONAL response is sent for the associated message.

[TBD / TBD] [D19-1188]

The tor timer shall be reset when

1 - A downlink STANDBY response is sent for the associated message.

[TBD / TBD] [D19-1189]

The ttr timer shall be reset when

1 - A downlink STANDBY response is sent for the associated message.

[TBD / TBD] [D19-1190]

When the trs timer expires the system shall

1 - Disable the tos timer for the associated message.
2 - Disable the tts timer for the associated message.
3 - Issue an informational alert to the pilot.

[TBD / TBD] [D19-1191]

Note : Any future STANDBY or OPERATIONAL responses to the associated message will be rejected by sending an ERROR response (um159 + “MESSAGE LATE”). This is handled as part of the message validation.

When the tos timer expires the system shall

1 - Issue an informational alert to the pilot.

[TBD / TBD] [D19-1192]

When the tts timer expires the system shall

1 - Issue an informational alert to the pilot.

[TBD / TBD] [D19-1193]

Note : Any future STANDBY or OPERATIONAL responses to the associated message will be rejected by sending an ERROR response (um159 + “MESSAGE LATE”). This is handled as part of the message validation.

When the tcs timer expires the system shall

1 - Close the CPDLC message dialogue for the associated message.

[TBD / TBD] [D19-1194]

When the tor timer expires the system shall

1 - Issue an informational alert to the pilot.

[TBD / TBD] [D19-1195]

When the ttr timer expires the system shall

1 - Issue an informational alert to the pilot.

2 - If the associated message was received in a CPDLC-End-Ind service primitive then :

2.1 - Invoke the CPDLC-End-Rsp service for the CDA CPDLC dialogue connection with :

2.1.1 - The result parameter set to rejected.

2.1.2 - The CPDLC message parameter with the CPDLC message elements :

2.1.2.1 - DM62 ERROR with insufficient-resources.

2.1.2.2 - DM98 “DIALOGUE TIMEOUT." TBD

3 - If the associated message was not received in a CPDLC-End-Ind service primitive then :

2.1 - Invoke the CPDLC-Message-Req service for the TBD CPDLC dialogue connection with :

2.1.1 - The CPDLC message parameter with the CPDLC message elements :

2.1.1.1 - DM62 ERROR with insufficient-resources.

2.1.1.2 - DM98 “DIALOGUE TIMEOUT." TBD

[TBD / TBD] [D19-1196]

The following values are suggested for the timers.

Timer Timeout	Recommended Value (seconds)
T(trs)	20
T(tos)	100
T(tts)	120 + ATSC Value
T(tcs)	240 + ATSC Value
T(tor)	100
T(ttr)	120

3.2.8.8 Message Attributes

In order to determine message queuing priority, alerting requirements and response requirements each message will have three associated attributes: Urgency, Alert, Response.

Each CPDLC message element shall have an associated message element urgency attribute with the precedence as shown in the following table.

[TBD / TBD] [D19-1206]

Type	Description	Precedence
D	Distress	1
U	Urgent	2
N	Normal	3
L	Low	4

Each CPDLC message element shall have an associated message element alert attribute with the precedence as shown in the following table.

[TBD / TBD] [D19-1225]

Type	Description	Precedence
H	High	1
M	Medium	2
L	Low	3
N	None	4

Each uplink CPDLC message element shall have an associated message element response attribute with the precedence as shown in the following table.

[TBD / TBD] [D19-1226]

Type	Description	Precedence
WU	Wilco/Unable	1
AN	Affirm/Negative	2
R	Roger/Unable	3
Y	Yes	4
N	No	5

Each downlink CPDLC message element shall have an associated message element response attribute with the precedence as shown in the following table.

[TBD / TBD] [D19-1227]

Type	Description	Precedence
Y	Yes	1
N	No	2

For each CPDLC message, the System shall determine a message urgency attribute which shall be the highest precedence message element urgency attribute for the given CPDLC message.

[TBD / TBD] [D19-1228]

For each CPDLC message, the System shall determine a message alert attribute which shall be the highest precedence message element alert attribute for the given CPDLC message.

[TBD / TBD] [D19-1229]

For each CPDLC message, the System shall determine a message response attribute which shall be the highest precedence message element response attribute for the given CPDLC message.

[TBD / TBD] [D19-1230]

3.2.8.9 Message Responses

Once the message response attribute has been determined for a message, this is used to determine the valid response for the message and the message closure response (the response which closes the message dialogue).

The message response attribute for a downlink CPDLC message shall determine the valid responses as shown in the table below.

[TBD / TBD] [D19-1233]

Response Attribute	Valid Response
Y	uplink LACK, if required uplink ERROR uplink STANDBY uplink OPERATIONAL
N	uplink LACK, if required uplink ERROR

The message response attribute for an uplink CPDLC message shall determine the valid responses as shown in the table below.

[TBD / TBD] [D19-1245]

Response Attribute	Valid Response
WU	DM0 WILCO DM1 UNABLE downlink STANDBY downlink LACK, if required downlink ERROR
AN	DM4 AFFIRM DM5 NEGATIVE downlink STANDBY downlink LACK, if required downlink ERROR
R	DM3 ROGER DM1 UNABLE downlink STANDY downlink LACK, if required downlink ERROR
Y	downlink LACK, if required downlink ERROR downlink STANDBY downlink OPERATIONAL
N	None unless LACK required, in which case : downlink LACK downlink ERROR

The message response attribute for a downlink CPDLC message shall determine the closure responses as shown in the table below.

[TBD / TBD] [D19-1265]

Response Attribute	Closure Response
Y	uplink ERROR uplink OPERATIONAL excluding : UM2 REQUEST DEFERRED
N	Automatic closure unless LACK required, in which case : uplink LACK uplink ERROR

The message response attribute for an uplink CPDLC message shall determine the closure responses as shown in the table below.

[TBD / TBD] [D19-1276]

Response Attribute	Closure Response
WU	DM0 WILCO DM1 UNABLE downlink ERROR
AN	DM4 AFFIRM DM5 NEGATIVE downlink ERROR
R	DM3 ROGER DM1 UNABLE downlinkERROR
Y	downlink ERROR downlink OPERATIONAL
N	None unless LACK required, in which case : downlink LACK downlink ERROR

3.2.8.10 Receipt of Service Primitives

3.2.8.10.1 Receipt of a CPDLC-Start-Ind Service Primitive

Receipt of this service primitive indicates a request for a CPDLC ground facility to establish a CPDLC connection. This is used to establish CPDLC connections with the CDA and NDA.

If the CPDLC system is in the INHIBITED state then the CPDLC connection will be rejected.

If the CPDLC system is in the ENABLED state then the processing of the service primitive is dependent upon CPDLC system's current connections with the CDA and NDA.

The CPDLC system shall invoke the CPDLC-Start-Rsp service within 0.5 seconds of receiving the CPDLC-Start-Ind service primitive.

[TBD / TBD] [D19-1089]

If the CPDLC system is in the INHIBITED state the system shall perform the following sequence :

1 - Invoke the CPDLC-Start-Rsp service for the CPDLC-Start-Ind CPDLC connection with :

1.1 - The result parameter set to rejected.

1.2 - The reject reason parameter with :

1.2.1 - The Message Id set to 0.

1.2.2 - The CPDLC message elements :

1.2.2.1 - DM98 FREE TEXT => “AIRCREW HAS INHIBITED CPDLC”

2 - Discard any CPDLC message contained within the CPDLC-Start-Ind.

[TBD / TBD] [D19-1090]

If the system is in the ENABLED state and no CPDLC connection exists with the CDA or the NDA then the system shall perform the following sequence :

1 - Invoke the CPDLC-Start-Rsp service with :

1.1 - The result parameter set to accepted.

2 - Create a CDA CPDLC dialogue connection associated with the CPDLC-Start-Ind ASE and

facility designation.

3 - If the CPDLC-Start-Ind contains a CPDLC message then :

3.1 - Invoke the CPDLC-Message-Req service for the CDA CPDLC dialogue connection with :

3.1.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

3.1.2 - The Reference Number set to the CPDLC message, message id.

3.1.3 - The CPDLC message elements :

3.1.3.1 - DM63 NOT CURRENT DATA AUTHORITY

3.2 - Discard the CPDLC message.

4 - Invoke the CPDLC-Message-Req service with :

4.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

4.2 - The CPDLC message elements :

4.2.1 - DM99 CURRENT DATA AUTHORITY

[TBD / TBD] [D19-1091]

If the system is in the ENABLED state and a CPDLC connection exists with the CDA and the CPDLC-Start-Ind service primitive is from the CDA then the system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req service for the CDA CPDLC dialogue connection with no reason parameter.

2 - Create a CDA CPDLC dialogue connection associated with the CPDLC-Start-Ind ASE and facility designation.

3 - Invoke the CPDLC-Start-Rsp service for the CDA CPDLC dialogue connection with :

3.1 - The result parameter set to accepted.

4 - If the CPDLC-Start-Ind contains a CPDLC message then :

4.1 - Invoke the CPDLC-Message-Req service for the CDA CPDLC dialogue connection with :

4.1.1 - The CPDLC message parameter with :

4.1.1.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

4.1.1.2 - The Reference Number set to the CPDLC message, message id.

4.1.1.3 - The CPDLC message elements :

4.1.1.3.1 - DM63 NOT CURRENT DATA AUTHORITY

4.2 - Discard the CPDLC message.

5 - Invoke the CPDLC-Message-Req service for the CDA CPDLC dialogue connection with :

5.1 - The CPDLC message parameter with :

5.1.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

5.1.2 - The CPDLC message elements :

5.1.2.1 - DM99 CURRENT DATA AUTHORITY

[TBD / TBD] [D19-1092]

If the system is in the ENABLED state and an NDA facility designation has been defined and no CPDLC connection exists with the NDA and the CPDLC-Start-Ind service primitive is from the defined NDA facility then the system shall perform the following sequence :

1 - Create the NDA CPDLC connection associated with the CPDLC-Start-Ind ASE and facility designation.

2 - Invoke the CPDLC-Start-Rsp service for the NDA CPDLC connection with :

2.1 - The result parameter set to accepted.

3 - Discard any CPDLC message contained within the CPDLC-Start-Ind.

[TBD / TBD] [D19-1093]

If the system is in the ENABLED state and a CPDLC connection exists with the NDA and the CPDLC-Start-Ind service primitive is from the NDA then the system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req service for NDA CPDLC connection.

2 - Create the NDA CPDLC connection associated with the CPDLC-Start-Ind ASE and facility designation.

3 - Invoke the CPDLC-Start-Rsp service for the NDA CPDLC connection with :

3.1 - The result parameter set to accepted.

4 - Discard any CPDLC message contained within the CPDLC-Start-Ind.

[TBD / TBD] [D19-1094]

If the system is in the ENABLED state, and a CPDLC connection exists with the CDA, and either an NDA facility designation has been defined or a CPDLC connection exists with the NDA, and the CPDLC-Start-Ind service primitive is not from the CDA, the defined NDA facility or the NDA then the system shall perform the following sequence :

1 - Invoke the CPDLC-Start-Rsp service for the CPDLC-Start-Ind CPDLC connection with :

1.1 - The result parameter set to rejected.

1.2 - The reject reason parameter with :

1.2.1 - The Message Id set to 0.

1.2.2 - If the CPDLC-Start-Ind contains a CPDLC message then :

1.2.2.1 - The Reference Number set to the CPDLC message,

message id.

1.2.3 - The CPDLC message elements :

1.2.3.1 - DM107 NOT AUTHORIZED NEXT DATA AUTHORITY

2 - Discard any CPDLC message contained within the CPDLC-Start-Ind.

[TBD / TBD] [D19-1095]

3.2.8.10.2 Receipt of a CPDLC-Start-Cnf Service Primitive

Under Basline 1 the CPDLC system is not allowed to initiate a CPDLC connection with the CDA or with the NDA. The CPDLC system is not therefore permitted to invoke the CPDLC-Start-Req service and cannot therefore receive a CPDLC-Start-Cnf service primitive.

3.2.8.10.3 Receipt of a CPDLC-Message-Ind Service Primitive

Receipt of this service primitive indicates that a CPDLC message has been received from a CPDLC ground system.

The CPDLC system will only allow a CPDLC message to be processed if it is from either the CDA or the DDA.

If the CPDLC-Message-Ind service primitive is from the CDA or the DDA then the system shall :

1 - Process any CPDLC message contained within the CPDLC-Message-Ind.

[TBD / TBD] [D19-1099]

If the CPDLC-Message-Ind service primitive is not from the CDA or the DDA then the system shall perform the following sequence :

1- Invoke the CPDLC-Message-Req for the CPDLC-Message-Ind CPDLC connection with :

1.1 - The CPDLC message parameter with :

1.1.1 - The Message Id set to 0.

1.1.2 - The CPDLC message parameter with the CPDLC message elements :

1.1.2.1 - DM63 NOT CURRENT DATA AUTHORITY

2 - Discard any CPDLC message contained within the CPDLC-Message-Ind.

[TBD / TBD] [D19-1100]

3.2.8.10.4 Receipt of a CPDLC-End-Ind Service Primitive

Receipt of this service primitive indicates a request by the CPDLC ground systems to terminate the CDA CPDLC dialogue connection.

If the CPDLC-End-Ind is not from the CDA then the CPDLC system shall perform the following sequence :

1 - Invoke the CPDLC-End-Rsp service for the CPDLC-End-Ind CPDLC connection with :

1.1 - The result parameter set to rejected.

1.2 - The CPDLC message parameter with :

1.2.1 - The Message Id set to 0.

1.2.2 - The CPDLC message elements :

1.2.2.1 - DM63 NOT CURRENT DATA AUTHORITY

2 - Discard any CPDLC message within the CPDLC-End-Ind.

[TBD / TBD] [D19-1110]

If the CPDCL-End-Ind service primitive is from the CDA and does not contain a CPDLC message then the system shall perform the following sequence :

1 - Invoke the CPDLC-End-Rsp for the CDA CPDLC dialogue connection with

1.1 - The result parameter set to accepted.

[TBD / TBD] [D19-1111]

If the CPDLC-End-Ind service primitive is from the CDA and contains a CPDLC message that does not require a response then the system shall perform the following sequence :

1 - Validate the CPDLC message.

2 - If the CPDLC message does not contain any errors then :

2.1 - Process the CPDLC message.

3 - Invoke the CPDLC-End-Rsp for the CDA CDPLC dialogue connection with :

3.1 - The result parameter set to accepted.

[TBD / TBD] [D19-1112]

If the CPDLC-End-Ind service primitive is from the CDA and contains a CPDLC message that requires a LACK response only then the system shall perform the following sequence :

1 - Validate the CPDLC message.

2 - If the CPDLC message does not contain any errors then :

2.1 - Invoke the CPDLC-Message-Req service for the CDA CPDLC dialogue connection with :

2.1.1 - The CPDLC message parameter with :

2.1.1.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

2.1.1.2 - The Reference Number set to the CPDLC message, message id.

2.1.1.3 - The CPDLC message elements :

2.1.1.3.1 - DM100 LOGICAL ACKNOWLEDGEMENT.

2.2 - Process the CPDLC message.

[TBD / TBD] [D19-1132]

Note : Handling of the above case when the CPDLC message contains errors is specified in the section on message validation.

If the CPDLC-End-Ind service primitive is from the CDA and contains a CPDLC message that requires any response, other than just a LACK response, then the system shall perform the following sequence :

1 - Validate the CPDLC message.

2 - If the CPDLC message does not contain any errors then :

2.1 - If the CPDLC message requires a LACK then :

2.1.1 - Invoke the CPDLC-Message-Req service for the CDA CPDLC dialogue connection with :

2.1.1.1 - The CPDLC message parameter with :

2.1.1.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

2.1.1.2 - The Reference Number set to the CPDLC message, message id.

2.1.1.3 - The CPDLC message elements :

2.1.1.3.1 - DM100 LOGICAL ACKNOWLEDGEMENT.

2.2 - Process the CPDLC message.

[TBD / TBD] [D19-1872]

Note : Handling of the above case when the CPDLC message contains errors is specified in the section on message validation.

3.2.8.10.5 Receipt of a DSC-Start-Cnf Service Primitive

Receipt of this service primitive indicates whether a request to establish a DDA CDPLC dialogue connection has been accepted or rejected by the CDPLC ground facility.

On receipt of the DSC-Start-Cnf service primitive from the DDA then the CPDLC system shall perform the following sequence :

1 - Convert the DDA CPDLC connection associated with the DSC-Start-Cnf ASE to a DDA CPDLC dialogue connection.

[TBD / TBD] [D19-1465]

3.2.8.10.6 Receipt of the DSC-End-Cnf Service Primitive

Receipt of this service primitive indicates whether a request to terminate the DDA CPDLC dialogue connection has been accepted or rejected by the CPDLC ground facility.

On receipt of a DSC-End-Cnf service primitive with the result parameter set to accepted then the CPDLC system shall perform the following sequence :

1 - Terminate the DDA CPDLC dialogue connection.

[TBD / TBD] [D19-1540]

On receipt of a DSC-End-Cnf service primitive with the result parameter set to rejected then the CPDLC system shall perform the following sequence :

1 - Re-enable the invocation of services with the DDA CPDLC dialogue connection.

2 - If the DSC-End-Cnf contains a CPDLC message then :

2.1 - Validate the CPDLC message.

2.2 - If the CPDLC message is valid then :

2.2.1 - Process the CPDLC message.

[TBD / TBD] [D19-1541]

3.2.8.10.7 Receipt of a CPDLC-User-Abort-Ind Service Primitive

Receipt of this service primitive indicates that the CPDLC physical connection has been terminated by the CPDLC ground system.

On receipt of a CPDLC-User-Abort-Ind service primitive from the CDA then the CPDLC system shall perform the following sequence :

1 - Terminate the CDA CPDLC dialogue connection.

2 - If a CPDLC connection exists with the NDA then :

2.1 - Invoke the CPDLC-User-Abort-Req service for the NDA CPDLC connection with
:

2.1.1 - The reason parameter set to current-data-authority-abort.

[TBD / TBD] [D19-1457]

On receipt of a CPDLC-User-Abort-ind service primitive from the NDA then the CPDLC system shall perform the following sequence :

1 - Terminate the NDA CPDLC dialogue connection.

[TBD / TBD] [D19-1459]

On receipt of a CPDLC-User-Abort service primitive from the DDA then the CPDLC system shall perform the following sequence :

1 - Terminate the DDA CPDLC dialogue connection.

[TBD / TBD] [D19-1461]

3.2.8.10.8 Receipt of a CPDLC-Provider-Abort Service Primitive

Receipt of this service primitive indicates that the CPDLC physical connection has been terminated by the service provider.

On receipt of a CPDLC-Provider-Abort-Ind service primitive from the CDA then the CPDLC system shall perform the following sequence :

1 - Terminate the CDA CPDLC dialogue connection.

2 - If a CPDLC connection exists with the NDA then :

2.1 - Invoke the CPDLC-User-Abort-Req service for the NDA CPDLC connection with
:

3.1.1 - The reason parameter set to current-data-authority-abort.

[TBD / TBD] [D19-1458]

On receipt of a CPDLC-Provider-Abort-ind service primitive from the NDA then the CPDLC system shall perform the following sequence :

1 - Terminate the NDA CPDLC connection.

[TBD / TBD] [D19-1460]

On receipt of a CPDLC-Provider-Abort service primitive from the DDA then the CPDLC system shall perform the following sequence :

1 - Terminate the DDA CPDLC dialogue connection.

[TBD / TBD] [D19-1462]

3.2.8.11 Receipt of HMI Input

3.2.8.11.1 Invoking the CPDLC-Start-Req service.

This service is used to establish a CPDLC connection between the CPDLC air system and a CPDLC ground facility.

Under Basline 1 the CPDLC system is not allowed to initiate a CPDLC connection with the CDA or with the NDA so use of this service is not permitted.

The CPDLC system shall not be permitted to invoke the CPDLC-Start-Req service.

[TBD / TBD] [D19-1087]

3.2.8.11.2 Invoking the CPDLC-Message-Req service.

This service is used to send a CPDLC message from the CPDLC air user to the CPDLC ground facility.

This service is only allowed to communicate with the CDA or DDA ground facilities.

On receipt of a downlink message to the CDA from the HMI the CPDLC system shall perform the following sequence.

1 - Invoke the CPDLC-Message-Req for the CDA CPDLC dialogue connection with :

1.1 - The CPDLC message parameter with :

1.1.1 - The Message Id selected from the set of CDA CPDLC dialogue connection message ids.

1.1.2 - The CPDLC message elements set to the downlink message, CPDLC message elements.

[TBD / TBD] [D19-1543]

On receipt of a downlink message to the DDA from the HMI the CPDLC system shall perform the following sequence.

1 - Invoke the CPDLC-Message-Req for the DDA CPDLC dialogue connection with :

1.1 - The CPDLC message parameter with :

1.1.1 - The Message Id selected from the set of DDA CPDLC dialogue connection message ids.

1.1.2 - The CPDLC message elements set to the downlink message, CPDLC message elements.

[TBD / TBD] [D19-1547]

On receipt of an uplink response message to the CDA from the HMI which is not a response to a CPDLC message received in a CPDLC-End-Ind the CPDLC system shall perform the following sequence.

1 - Invoke the CPDLC-Message-Req for the CDA CPDLC dialogue connection with :

1.1 The CPDLC message parameter with :

1.1.1 - The Message Id selected from the set of CDA CPDLC dialogue connection message ids.

1.1.2 - The Reference Number set to the uplink response message, reference number.

1.1.3 - The CPDLC message elements set to the uplink response message, CPDLC message elements.

[TBD / TBD] [D19-1546]

On receipt of an uplink response message to the DDA from the HMI the CPDLC system shall perform the following sequence.

1 - Invoke the CPDLC-Message-Req for the DDA CPDLC dialogue connection with :

1.1 - The CPDLC message parameter with :

1.1.1 - The Message Id selected from the set of DDA CPDLC dialogue connection message ids.

1.1.2 - The Reference Number set to the uplink response message, reference number.

1.1.3 - The CPDLC message elements set to the uplink response message, CPDLC message elements.

[TBD / TBD] [D19-1548]

3.2.8.11.3 Invoking the CPDLC-End-Rsp Service

This service is used to respond to a CPDLC ground facility request to terminate the CDA CPDLC dialogue connection.

On receipt of an uplink response message to the CDA which is a response to a CPDLC message received in a CPDLC-End-Ind and where the uplink reponse message contains the CPDLC message element :

DM2 STANDBY

then the system shall perform the following sequence :

1 - Invoke the CPDLC-Message-Req for the CDA CPDLC dialogue connection with :

1.1 - The CPDLC message parameter with :

1.1.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

1.1.2 - The Reference Number set to the HMI input CPDLC message, reference number.

1.1.3 - The CPDLC message elements set to the HMI input CPDLC message, CPDLC message elements.
[TBD / TBD] [D19-1122]

On receipt of an uplink response message to the CDA which is a response to a CPDLC message received in a CPDLC-End-Ind and where the uplink CPDLC message response attribute is one of

WU
AN
R

and where the HMI input contains one of the CPDLC message elements

DM0 WILCO
DM3 ROGER
DM4 AFFIRM

then the system shall perform the following sequence :

1 - Invoke the CPDLC-End-Rsp for the CDA CPDLC dialogue connection with :

1.1 - The result parameter set to accepted.

1.2 - The CPDLC message parameter with :

1.2.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

1.2.2 - The Reference Number set to the HMI input CPDLC message, reference number.

1.2.3 - The CPDLC message elements set to the HMI input CPDLC message, CPDLC message elements.
[TBD / TBD] [D19-1124]

On receipt of an uplink response message to the CDA which is a response to a CPDLC message received in a CPDLC-End-Ind and where the uplink CPDLC message response attribute is one of

WU
AN
R

and the HMI input contains one of the following CPDLC message elements

DM1 UNABLE

DM5 NEGATIVE

then the system shall perform the following sequence :

1- Invoke the CPDLC-End-Rsp for the CDA CPDLC connection dialogue with :

1.1 - The result parameter set to rejected.

1.2 - The CPDLC message parameter with :

1.2.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

1.2.2 - The Reference Number set to the HMI input CPDLC message, reference number.

1.2.3 - The CPDLC message elements set to the HMI input CPDLC message, CPDLC message elements.

[TBD / TBD] [D19-1125]

On receipt of an uplink response message to the CDA which is a response to a CPDLC message received in a CPDLC-End-Ind and where the uplink CPDLC message response attribute is Y and the HMI input does not contain the CPDLC message element :

DM2 STANDBY

then the system shall perform the following sequence :

1 - Invoke the CPDLC-End-Rsp for the CDA CPDLC dialogue connection with :

1.1 - The results parameter set to accepted.

1.2 - The CPDLC message parameter with :

1.2.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

1.2.2 - The Reference Number set to the HMI input CPDLC message, reference number.

1.2.3 - The CPDLC message elements set to the HMI input CPDLC message, CPDLC message elements.

[TBD / TBD] [D19-1126]

3.2.8.11.4 Invoking the DSC-Start-Req Service

This service is used to request the establishment of a DDA CPDLC dialogue connection.

This service will send a DSC-Start-Req service primitive to the CPDLC ground system to initiate a DDA CPDLC dialogue connection.

If a DSC start request is received from the HMI and the CPDLC system does not have a DDA CPDLC connection then the system shall perform the following sequence :

1 - Create a DDA CPDLC connection associated with the DSC-Start-Req ASE and facility designation.

2 - Invoke the DSC-Start-Req service for the DDA CPDLC connection.

[TBD / TBD] [D19-1464]

3.2.8.11.5 Invoking the DSC-End-Req Service

This service is used to request the termination of a DDA CPDLC dialogue connection.

If a DSC end request is received from the HMI then the system shall perform the following sequence :

1 - Invoke the DSC-End-Req service for the DDA CPDLC dialogue connection.

2 - Disable the invocation of services with the DDA CPDLC dialogue connection except the CPDLC-User-Abort-Req service.

[TBD / TBD] [D19-1538]

3.2.8.11.6 Invoking the CPDLC-User-Abort-Req Service

This service is used to abnormally terminate a CPDLC connection.

On receipt of an abort request for the CDA from the HMI then the CPDLC system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req for the CDA CPDLC dialogue connection with :

1.1 - No reason parameter.

[TBD / TBD] [D19-1550]

On receipt of an abort request for the NDA from the HMI then the CPDLC system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req for the NDA CPDLC connection with :

1.1 - No reason parameter.

[TBD / TBD] [D19-1551]

On receipt of an abort request for the DDA from the HMI then the CPDLC system shall perform the following sequence :

1 - Invoke the CPDLC-User-Abort-Req for the DDA CPDLC dialogue connection with :

1.1 - No reason parameter.

[TBD / TBD] [D19-1552]

3.2.8.12 Transfer of Data Authority

When the CDA CPDLC dialogue connection has been terminated by accepting a CPDLC-End-Req then any NDA CPDLC connection is automatically upgraded to become the CDA CPDLC dialogue connection. If no NDA CPDLC connection exists then data link communication with the controller will be lost and communication must revert to voice.

Upon sending a CPDLC-End-Rsp service primitive with the result parameter set to accepted then the system shall perform the following sequence :

1 - If an NDA CPDLC connection exists then :

1.1 - Terminate the CDA CPDLC dialogue connection.

1.2 - Create a CDA CPDLC dialogue connection associated with the NDA CPDLC connection ASE and facility designation.

1.3 - Terminate the NDA CPDLC connection and delete the NDA facility designation definition.

1.2 - Invoke the CPDLC-Message-Req service for the CDA CPDLC dialogue connection with :

1.2.1 - The CPDLC message parameter with :

1.2.1.1 - The Message Id selected from the CDA CPDLC dialogue connection message ids.

1.2.1.2 - The CPDLC message elements :

1.2.1.2.1 - DM99 CURRENT DATA AUTHORITY

2 - If no NDA CPDLC connection exists but the NDA facility designation is defined then :

2.1 - Terminate the CDA CPDLC dialogue connection.

2.1 - Delete the NDA facility designation definition.

3 - If no NDA CPDLC connections exists and no NDA facility designation is defined then :

3.1 - Terminate the CDA CPDLC dialogue connection.

[TBD / TBD] [D19-1129]

3.2.8.13 Abort Processing

Upon invoking the CPDLC-User-Abort-Req service some housekeeping functions must be performed to tidy up the CPDLC connections.

If the CPDLC system invokes the CPDLC-User-Abort-Req service with the CDA then the CPDLC system shall perform the following sequence :

1 - Terminate the CDA CPDLC dialogue connection.

2 - If an NDA CPDLC connection exists then :

2.1 - Invoke the CPDLC-User-Abort-Req service for the NDA CPDLC connection with :

2.1.1 - The reason parameter set to current-data-authority-abort.

[TBD / TBD] [D19-1455]

If the CPDLC system invokes the CPDLC-User-Abort-Req service with the NDA then the CPDLC system shall perform the following sequence :

1 - Terminate the NDA CPDLC connection.

[TBD / TBD] [D19-1527]

If the CPDLC system invokes the CPDLC-User-Abort-Req service with the NDA and the reason parameter is set to current-data-authority-abort or no-longer-next-data-authority then the system shall perform the following sequence :

1 - Delete any NDA facility designation defintion.

[TBD / TBD] [D19-1456]

3.2.8.14 Message Element Processing

Some CPDLC message elements have specific effects on the CPDLC air system. The following defines the specific processing required for each of these CPDLC message elements.

3.2.8.14.1 Receipt of UM160 NEXT DATA AUTHORITY

This CPDLC message element defines the NDA facility designation.

If the uplink CPDLC message is from the CDA and contains the CDPLC message element UM160 NEXT DATA AUTHORITY then the system shall perform the following sequence :

1 - If there is an NDA CPDLC connection then :

1.1 - Invoke the CPDLC-User-Abort service for the NDA CPDLC connection with :

1.1.1 - The reason parameter set to no-longer-next-data-authority.

2 - If the CPDLC message element UM160 NEXT DATA AUTHORITY indicates “NULL” for the NDA then

2.1 - Delete the NDA facility designation definition.

3 - If the CPDLC message element UM160 NEXT DATA AUTHORITY indicates a facility designation for the NDA then :

3.1 - Set the NDA facility designation definition to the facility designation indicated in the CPDLC message element UM160 NEXT DATA AUTHORITY.

[TBD / TBD] [D19-1115]

3.2.8.14.2 Receipt of UM233 USE OF LOGICAL ACKNOWLEDGEMENT PROHIBITED

This CPDLC message element prohibits the CPDLC air system from requesting a LACK on the CPDLC dialogue connection.

If the uplink CPDLC message is from the CDA or the DDA and contains the CDPLC message element UM233 USE OF LOGICAL ACKNOWLEDGEMENT PROHIBITED then the system shall perform the following sequence :

1 - Prohibit any downlink CPDLC message on the CPDLC dialogue connection from requiring a LACK.

[TBD / TBD] [D19-1117]

3.2.8.14.3 Receipt of a Voice Change Instruction

These CPDLC message elements initiate the handover sequence between the CDA and the NDA.

Voice Change Instructions shall consist of one of the following CPDLC message elements

UM117 CONTACT
UM120 MONITOR

[TBD / TBD] [D19-1119]

If the uplink CPDLC message is from the CDA and contains a voice change instruction and the facility designation in the voice change instruction is the same as the CDA CPDLC dialogue connection facility designation then the system shall perform the following sequence :

1 - Prohibit the sending of any downlink CPDLC message for the CDA CPDLC dialogue connection except the response to the CPDLC message that contains the voice change instruction.

[TBD / TBD] [D19-1120]

If the uplink CPDLC message is from the CDA and contains a voice change instruction and the facility designation in the voice change instruction is the same as the defined NDA facility designation or the NDA CPDLC connection facility designation then the system shall perform the following sequence :

1 - Close all CPDLC message dialogues for the CDA CPDLC dialogue connection except the CPDLC message dialogue for the CPDLC message which contains the voice change instruction.

2 - Prohibit the sending of any downlink CPDLC message for the CDA CPDLC connection except the response to the CPDLC message that contains the voice change instruction.

[TBD / TBD] [D19-1135]

If the uplink CPDLC message is from the CDA and contains a voice change instruction and the facility designation in the voice change instruction is not the same as the CDA CPDLC dialogue connection facility designation and is not the same as the defined NDA facility designation or the NDA CPDLC connection facility designation then the system shall perform the following sequence :

1 - Close all CPDLC message dialogues for the CDA CPDLC dialogue connection except the CPDLC message dialogue for the CPDLC message which contains the voice change instruction.

2 - Prohibit the sending of any downlink CPDLC message for the CDA CPDLC dialogue connection except the response to the CPDLC message that contains the voice change instruction.

3 - Issue an informational alert to the pilot to warn him that the voice change facility designation is not the same as the defined NDA facility designation.

[TBD / TBD] [D19-1134]

3.2.8.15 Responding to a Voice Change Instruction

Once a handover sequence has been started by the receipt of a voice change instruction the sending of further downlink CPDLC messages is disabled. Upon responding negatively to a voice change instruction the sending of downlink CPDLC message is re-enabled.

On sending a response to an uplink CPDLC message dialogue for a CPDLC message that contained a voice change instruction where the response contains one of the following CPDLC message elements :

DM1 UNABLE

then the system shall perform the following sequence :

1- Allow the sending of downlink CPDLC messages for the CPDLC dialogue.

[TBD / TBD] [D19-1137]

3.2.8.16 Uplink Message Validation

If multiple errors exist in a single uplink CPDLC message then only the sequence associated with the highest precedence error shall be performed.

[TBD / TBD] [D19-1140]

Duplicate Message Identification Number (Precedence 1)

If an uplink CPDLC message is received with a message identification number identical to that of a message identification number currently in use then the system shall perform the following actions.

1 - Invoke the CPDLC-User-Abort-Req service with duplicate-message-identification-number.

[TBD / TBD] [D19-1141]

Invalid Message Response (Precedence 2)

If an uplink CPDLC response message is received for a downlink CPDLC message which had a message response attribute of N and which required a LACK and it does not contain one of the valid response CPDLC message elements then the system shall perform the following actions

1 - Invoke the CPDLC-User-Abort-Req service with invalid-response.

[TBD / TBD] [D19-1142]

Incorrect Message Reference Number (Precedence 3)

If an uplink CPDLC message is received with a message reference number which is not identical to any message identification number currently in use the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with unrecognized-msg-reference-number.

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1148]

Timer Expired (Precedence 4)

If an uplink CPDLC message is received with a message reference number which matches an allocated CPDLC downlink message identification number for the CPDLC connection and for which the tts timer or trs timer has expired then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with TBD

1.1.2 - DM98 free text => "MESSAGE LATE. USE VOICE."

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1198]

Invalid Message Element Combination (Precedence 5)

If an uplink CPDLC message is received with one of the following combinations of CPDLC message elements

A UM227 LOGICAL ACKNOWLEDGEMENT with any other CPDLC message element.

A UM160 NEXT DATA AUTHORITY with any other CPDLC message element.

More than two CPDLC message elements which require route-clearance data.

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with invalid-message-element-combination.

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1150]

Invalid Message Elements (Precedence 6)

If an uplink CPDLC message is received with one or more of the following CPDLC uplink message elements

UM33
UM40
UM41
UM178

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with invalid-message-element.

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1151]

Logical Acknowledgement not Required (Precedence 7)

If an uplink CPDLC response message is received with the following CPDLC message element :

UM227 LOGICAL ACKNOWLEDGEMENT

when the downlink CPDLC message did not require a LACK then the system shall perform the following sequence :

1 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1152]

Incorrect Time Stamp (Precedence 8)

If an uplink CPDLC message is received with a timestamp which is in the future or more than three times the ATSC Value, associated with the class of communication associated with the CPDLC connection, in the past then the system shall perform the following actions

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with TBD.

2 - Discard the uplink CPDLC message.

3 - Issue an informational alert to the pilot.

[TBD / TBD] [D19-1153]

Unsupported Message Elements (Precedence 9)

If an uplink CPDLC message is received with a CPDLC message element which is not supported then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “MESSAGE NOT SUPPORTED. USE VOICE”

2 - Discard the uplink CPDLC message.

3 - Issue an informational alert to the pilot.

[TBD / TBD] [D19-1154]

Free Text Element Constraint (Precedence 10)

If an uplink CPDLC message is received with one or more FREE TEXT CPDLC message elements which contain more than 80 characters then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “INVALID FREE TEXT ELEMENT LENGTH." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1158]

Unit Name (Precedence 11)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

The [UnitName] shall always include the optional [FacilityName] data type.

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1159]

Frequence (Precedence 11)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

The ASN.1 values contained in the data type frequencyVHF shall correspond to the voice channel designators for VHF channels separated by 8.33khz and 25khz spacing, as specified by the relevant provisions in ICAO Annex 10, Volume V, Chapter 4.1 (bis).

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1160]

Speed (Precedence 12)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

The data element [speed] shall contain one of two data types :

speedmach
speedindicated

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1161]

ATS Route Designator (Precedence 13)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following conventions :

The first [ATSroutedesignator] in [routeinformation] shall be preceded by a [publishedidentifier].

Any [ATSroutedesignator] shall be followed by a [publishedidentifier] indicating the point at which the airplane is to leave the airway, or by an intersecting [ATSroutedesignator].

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1162]

Level (Precedence 14)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

The data element [level] shall always contain the data type levelFlightLevel or levelFeet.

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1163]

Vertical Rate (Precedence 15)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

The data element [VerticalRate] shall always contain the data type verticalRateEnglish.

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1164]

Distance (Precedence 16)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

The data element [DistanceSpecified] shall always contain the data type distanceSpecifiedNm.

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1165]

Direction (Precedence 17)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

The data element [Direction] shall always contain either the ‘0’, ‘1’. or '2' enumerated values (i.e. ‘left’, ‘right’, and either side, respectively).

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1166]

String Characters (Precedence 18)

If an uplink CPDLC message is received with one or more CPDLC message elements which do not conform to the following convention :

Data elements defined in the SARPS ASN.1 syntax as IA5String shall include only the following characters :

Uppercase alpha characters : A through Z
Numerics : 0 through 9
Space : " "
Symbols : ! " # % & ( ) * + , - . : ; < = > ? [ ] / '

then the system shall perform the following sequence :

1 - Send a downlink ERROR message with :

1.1 - The CPDLC message elements :

1.1.1 - DM62 ERROR with insufficient-resources.

1.1.2 - DM98 “???." TBD

2 - Discard the uplink CPDLC message.

[TBD / TBD] [D19-1167]

3.2.8.17 Sending a Downlink Error Message

If the uplink CPDLC message does not contain one of the following CPDLC message elements :

UM227 LOGICAL ACKNOWLEDGEMENT
UM234 FLIGHT PLAN NOT HELD
UM162 SERVICE UNAVAILABLE
UM159 ERROR

and the uplink CPDLC message was received in a CPDLC-End-Ind service primitive and the CPDLC message response attribute is one of :

WU
AN
R
Y
N with LOGICAL ACKNOWLEDGEMENT required

then the system shall perform the following sequence :

1 - Invoke the CPDLC-End-Rsp service with :

1.1 - The result parameter set to rejected.

1.2 - The CPDLC message parameter with :

1.2.1 - The Message Id selected from the CDA CPDLC dialogue connection, message ids.

1.2.2 - The Reference Number set to the uplink CPDLC message, message id.

1.2.3 - The CPDLC message elements as required.
[TBD / TBD] [D19-1145]

If the uplink CPDLC message does not contain one of the following CPDLC message elements :

UM227 LOGICAL ACKNOWLEDGEMENT
UM234 FLIGHT PLAN NOT HELD
UM162 SERVICE UNAVAILABLE
UM159 ERROR

and the uplink CPDLC message was not received in a CPDLC-End-Ind service primitive then the system shall perform the following sequence :

1 - Invoke the CPDLC-Message-Req service with :

1.1 - The CPDLC message parameter with :

1.1.1 - The Message Id selected from the CDA/DDA TBD CPDLC dialogue connection, message ids.

1.1.2 - If the uplink CPDLC message response attribute is one of :

WU
AN
R
Y
N with LOGICAL ACKNOWLEDGEMENT required

then :

1.1.2.1 - The Reference Number set to the uplink CPDLC message, message id.

1.1.3 - The CPDLC message elements as required.
[TBD / TBD] [D19-1147]

3.2.9 AOC Functions

The system design described in Section 4 treats the Airborne AOC functions as essentially a standalone application within the FMS software. The application is responsible for decoding all AOC messages received over GACS and for maintaining an internal database of these messages.

The pilot can only interact with the AOC application through the MCDU. The AOC messages are considered to be a lower priority than any ATC messages and therefore no support for viewing this information will be provided on the navigation display. On the MCDU, the pilot will be able to view lists of different report types and from these select individual reports for display. The HMI will alos provide the capability to print any of these reports using the cockpit printer.

The AOC represents the primary source of meteorological information for the aircraft. Therefore, the AOC application will be responsible for maintaining a Meteo database. The information held within the database will be used by the Trajectory Generation functions in order to improve the accuracy of the calculations.

The AOC application will receive inputs form various aircraft equipment so that OOOI messages can be transmitted at the appropriate time. For the MA-AFAS trials, it is known that an ACMS will not be available on board the BAC 1-11. In order to provide the appropriate signals therefore, some of the ACMS functionality will be emulated on a PC and the signals will be input to the System over an Ethernet link. The following signals will be emulated:

- Parking Brakes On.
- Cabin Doors Open.

Additional signals will be added as necessary.

3.2.10 Flight Information Services

Until the FIS-B service description and implementation are finalised, the current design assumes that the FIS-B service will operate in the manner described in the NUP FIS-B Service Description. This is essentially a broadcast service but some aircraft requests can be handled.

NUP FIS-B states that Option 3 (which allows the aircraft to request specific FIS-B information to be broadcast to it) will not be implemented during the first phase(s) of NUP. However, this is seen by MA-AFAS as crucial to a future operational FIS-B service so it has been decided to implement it. It is acknowledged that it is unlikely that flight trials will be able to use this capability in the time frame of MA-AFAS, but the functionality will have been developed and tested in ground simulation, paving the way for early adoption of this aspect of the service if and when it becomes available

The System shall be capable of receiving and processing Flight Information Service (FIS) uplink messages that are compliant with the NUP FIS-B Service Description Options 1, 2, and 3.

[Demonstration / TBD] [D19-473]

The System shall be capable of creating and transmitting Flight Information Service (FIS) downlink messages that are compliant with the NUP FIS-B Service Description Options 3.

[Demonstration / TBD] [D19-583]

3.2.11 Built In Test

3.2.11.1 Initialisation Tests

The scope of the initialisation tests for the MA-AFAS trials equipment is TBD. It will be largely dependent upon the test facilities provided by the COTS hardware.

The initialisation tests shall only be performed when power is first applied to the system.

[Analysis / TBD] [D19-416]

ARINC 702A does not specifiy a time limit within which the initialisation of the System should be complete, only that it should be as fast as possible. Since the checks at this stage should include interface checks and the MCDU does not begin testing for sub-systems for at least 13s after the application of power, then the initialisation will take longer than this. Assuming that all of the sub-systems used by the FMS take similar amounts of time to reach operational status, then is only sensible to specify an upper time limit for initialisation that is larger than this time but which is not over long.

The initialisation tests shall complete within 20s.

[Measurement / TBD] [D19-417]

3.2.11.2 Interruptive Tests

Currently, there are no plans to provide an interruptive test capability for the MA-AFAS trials equipment.

3.2.11.3 Parallel Tests

Currently, there are no plans to provide a parallel test capability for the MA-AFAS trials equipment.

3.3 External Interface Requirements

The architecture design described in section Four is for the MA-AFAS trials implementation. It assumes that there are several types of interface to the core processing capabilities. During the development and test phases of the equipment, it is likely that some of the interface modules will be simulated by putting information directly onto the VME. The architecture diagrams shown in this document are not intended to show how this will be achieved. Modifications to the architecture will be addressed in the appropriate test documents.

The interfaces to the majority of the aircraft equipment is assumed to be via an ARINC 429 bus. The architecture diagram shows separate processing modules for input processing and output processing. It has been assumed that the pilot interfaces with the system through a set of display devices or input devices which are linked to the FMS via appropriate 429 buses.

The FMS design also includes an Ethernet interface module to provide communications with a standard PC. This can be used for simulation purposes or as an interface unit to a printing device.

The FMS also includes an interface module that can translate the discrete signals received from other aircraft equipment or generate discrete signals for use by other equipment.

3.3.1 Cockpit Systems

3.3.1.1 Data Loading Device

The data loading device is used to transfer data files from an external storage device onto an internal storage device, in this case, a hard disk drive. During the initialisation of the System, the data files are opened for reading and their contents used to create the various databases that will be used by the System while it is in the normal operation state. Loading of data files will only be possible while the System is in the maintenance state.

It shall be possible to load company route data files from an external storage device onto the data storage device via the Data Loader.

[Demonstration / TBD] [D19-461]

3.3.1.2 Data Storage Device

The System design requires an internal storage device to provide an area of non-volatile memory. This storage area is required to hold initialisation files for the System. For the MA-AFAS trials, this will be a Hard Disk Drive (HDD).

3.3.1.3 Printer

The cockpit printer enables the pilot to print information that has been transmitted to the aircraft that is not easily displayed on any of the available display surfaces. This is typically the case with information that is sent to the aircraft by the AOC. This can include load sheet information or meterological information.

ARINC 702A allows for a printer connection either by Ethernet or by ARINC 429 links.

For the MA-AFAS trials, the System shall include an ARINC 429 interface with the cockpit printer.

[Inspection / TBD] [D19-1659]

3.3.2 Pilot Interfaces

3.3.2.1 MCDU

The MA-AFAS system will incorporate a MCDU that is compliant with the recommendations of ARINC 739A.

The System shall include an ARINC 429 Interface driver for controlling the MCDU that is compliant with section 3.7 of ARINC 739A.

[Inspection / TBD] [D19-673]

3.3.2.2 EFI Display Control Panel

The display control panel provides a set of manual switches for controlling the display content and format of the EFI navigation screen.

The System shall include a ARINC 429 input channel for receiving the outputs from the Display Control Panel.

[Inspection / TBD] [D19-1689]

The System shall be capable of decoding ARINC 420 labels 271, 272 and 273 from the DCP.

[Analysis / TBD] [D19-1690]

3.3.2.3 EFI

For the MA-AFAS trials, the EFIS display unit on the BAC 1-11 does not have an ARINC 429 interface. The display unit requires RGB inputs.

The BAC 1-11 display unit has the following characteristics:
a) 1152 by 900 pixel resolution.
b) Horizontal Frequency 61.8kHz.
c) Vertical Frequency 66Hz.

The System shall include a graphical display driver for the BAC 1-11 display unit.

[Inspection / TBD] [D19-1653]

3.3.2.4 Cursor

For the MA-AFAS trials, the cursive device will be a rollerball with two buttons, a "Select" button and a "Menu" button.

The System shall include a single RS232 interface for handling cursor inputs.

[Inspection / TBD] [D19-1665]

3.3.2.5 Head Up Display

The MA-AFAS trials equipment will not be capable of driving a Head Up Display.

3.3.2.6 Primary Flight Display

An ARINC 702A standard FMS is not required to provide any inputs directly to a Primary Flight Display Unit. Therefore, the MA-AFAS FMS trials equipment will not be capable of sending data to the Primary Flight Display Unit.

3.3.2.7 Aircrew Warning System

An ARINC 702A standard FMS is only required to provide a single discrete output to the Aircrew Warning System. There is no requirement for an ARINC 429 link. Therefore, the MA-AFAS FMS will only include a mechanism for generating a discrete signal to trigger the generation of an aural alert.

3.3.3 Aircraft Systems

3.3.3.1 Air Data Computer

The System shall include an ARINC 429 interface for receiving information from the Digital Air Data Computer that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1634]

The System shall be capable of decoding ARINC 429 labels 203, 205, 206, 210 and 213 from the ADC.

[Analysis / TBD] [D19-1667]

3.3.3.2 Attitude and Heading Reference System

The System shall include an ARINC 429 interface for receiving information from the Attitude and Heading Reference System that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1669]

The System shall be capable of decoding ARINC 429 labels 320, 324, 325, 335, 336, 337, 364, 365, 373 and 374 from the AHRS.

[Analysis / TBD] [D19-1668]

3.3.3.3 Inertial Reference System

The System shall include an ARINC 429 interface for receiving information from the Inertial Reference System that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1674]

The System shall be capable of decoding ARINC 429 labels 310 to 317 inclusive, 320 to 327 inclusive, 330 to 337 inclusive and 364 to 367 inclusive from the IRS.

[Analysis / TBD] [D19-1679]

3.3.3.4 Global Navigation Satellite System

The System shall include an ARINC 429 interface for receiving information from the Global Navigation Satellite System that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1639]

The System shall be capable of decoding ARINC 429 labels 076, 101, 102, 103, 110, 111, 112, 120, 121, 130, 133, 136, 140, 141, 150, 165, 166, 174, 247, 273 and 355 from the GNSS.

[Analysis / TBD] [D19-1680]

3.3.3.5 Flight Control System

The System shall include an ARINC 429 interface for receiving information from the Flight Control System that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1635]

The System shall include an ARINC 429 interface for sending information to the Flight Control System that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1685]

The System shall be capable of encoding and sending ARINC 429 labels 121, 361, 362, 363, 364, 365, 366, 367, 370, 372 and 373 to the AFCS.

[Analysis / TBD] [D19-1686]

3.3.3.6 Engine Management System

The System shall include an ARINC 429 interface for receiving information from the Engine Management System that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1637]

The System shall be capable of decoding ARINC 429 labels 245 and 246 from the EMS.

[Analysis / TBD] [D19-1670]

The System shall include an ARINC 429 interface for sending information to the Engine Management System (Auto-Throttle) that is fitted to the BAC 1-11.

[Inspection / TBD] [D19-1687]

The System shall be capable of encoding and transmitting ARINC 429 labels 363 and 366 to the EMS.

[Analysis / TBD] [D19-1688]

3.3.3.7 Fuel Quantity Data System

The BAC 1-11 that will be used in the MA-AFAS trials does not include an FQDS that generates outputs which are accessible to the FMS. It will be necessary for this system to be emulated within the software.

3.3.3.8 Weight And Balance System

The BAC 1-11 that will be used in the MA-AFAS trials does not include a WBS that generates outputs which are accessible to the FMS. The aircraft mass can only be input by the pilot using the MCDU.

3.3.3.9 Aircraft Condition Monitoring System

The BAC 1-11 that will be used in the MA-AFAS trials does not include an ACMS. Any inputs from this system that are required by the AOC functions will be emulated on a PC and transmitted to the System over an Ethernet link.

3.3.3.10 Other Navigation Equipment

An ARINC 702A standard FMS should be capable of receiving data from all of the navigation equipment that is fitted to the aircraft, e.g. ILS, DME, etc.. For the MA-AFAS trials, the processing of this data is not critical. The primary emphasis is on the GNSS output. Therefore, for the MA-AFAS trials equipment, the interfaces and associated processing for ILS and DME will not be supported.

3.3.3.11 Weather Radar System

For the MA-AFAS trials, there are no plans to display weather information on the navigation display unit. Therefore, the System design does not include an input channel for weather information.

3.3.4 CMU

The communications links to and from the ground are provided by VDL mode 2 and VDL mode 4 interface modules. These are linked to the FMS via a Communications Management Unit (CMU). The CMU handles the different VHF link formats so that the FMS sees only the transferred messages. The CMU is linked to the VDL mode 2 transponder over ARINC 429 links and to the VDL mode 4 transponder over an RS422 link.

The System shall include an ARINC 429 interface for receiving information from the Communications Management Unit that forms part of the MA-AFAS Avionics equipment.

[Inspection / TBD] [D19-1681]

The System shall include an ARINC 429 interface for transmitting information to the Communications Management Unit that forms part of the MA-AFAS Avionics equipment.

[Inspection / TBD] [D19-1682]

3.4 Internal Interface Requirements

The system design separates the communications requirements into two parts, an FMS component and a CMU component. The CMU is responsible for managing the reception and transmission of signals in different formats, e.g. VDL mode 2 and VDL mode 4. The FMS communications functions represent the high level functions required to support the FMS operation but which are independent of the physical reception and transmission modes.

The design assumes that the CMU and FMS communicate across a pair of ARINC 429 buses even though physically they share a common VME backplane in the proposed MA-AFAS trials equipment fit. It is proposed that physical ARINC 429 buses are used so that information can be gained on bus loading and the effects of data transfer delays. This will enable an assessment of the suitability of the ARINC 429 interface for real production systems. During the MA-AFAS trials, the quantity of data to be transferred will be significantly less than in the 2015 scenario described in the MA-AFAS OSED so the loading risks can be assessed with little risk to the programme. In the event that there is a problem with delays, even at the MA-AFAS loading levels, the VME backplane can be used as a fallback mechanism for transfer.

The internal interface between the CMU and FMS components shall be via ARINC 429 links even though they share a common VME backplane.

[Inspection / TBD] [D19-111]

3.5 Internal Data Requirements

3.5.1 Aircraft State Information

3.5.1.1 Content

The aircraft state information contains data that is collected from a range of sensors on board the aircraft. This data is collated by the progress monitoring functions within the Aircraft Guidance functions.The information is held in a single central store so that it can be accessed by parts of the System other than the Aircraft Guidance functions.

The content of the store shall be updated at intervals of not greater than 1 second.
[Measurement / TBD] [D19-681]

The aircraft state information shall include a UTC time stamp.
[Inspection / TBD] [D19-1806]

The aircraft state information shall include the barometric altitude of the aircraft.
[Inspection / TBD] [D19-682]

The aircraft state information shall include the estimated altitude of the aircraft derived from radar altimetry if this is available.
[Inspection / TBD] [D19-683]

The aircraft state information shall include the estimated altitude rate of the aircraft.
[Inspection / TBD] [D19-684]

The aircraft state information shall include the estimated Latitude and Longitude co-ordinates of the aircraft.
[Inspection / TBD] [D19-686]

The aircraft state information shall include the estimated error in the position co-ordinates of the aircraft.
[Inspection / TBD] [D19-690]

The aircraft state information shall include the estimated error in the altitude of the aircraft.
[Inspection / TBD] [D19-1810]

The aircraft state information shall incude the estimated speed of the aircraft including; ground speed, indicated air speed, calibrated air speed and Mach.
[Inspection / TBD] [D19-691]

The aircraft state information shall include the aircraft heading and attitude data.
[Inspection / TBD] [D19-693]

The aircraft state information shall include the measured outside air pressure, air temperature, wind speed and wind direction.
[Inspection / TBD] [D19-694]

3.5.1.2 Access

A variety of access methods are required for the aircraft state data. Although some processing functions will require the complete data set, the majority will only need access to small parts of the data.

The System shall support an access function that provides the current position estimate of the aircraft and the estimated error in that position estimate.

[Inspection / TBD] [D19-687]

The System shall support an access function that provides the current altitude of the aircraft.

[Inspection / TBD] [D19-688]

The System shall support an access function that provides the current speed of the aircraft. This includes the Ground Speed, Indicated Air Speed, Calibrated Air Speed and Mach Number.

[Inspection / TBD] [D19-689]

The System shall support an access function that provides a copy of all of the aircraft state data that is held in the store.

[Inspection / TBD] [D19-692]

3.5.2 Surveillance Database

3.5.2.1 Content

The surveillance database differs from the other databases in that it is very dynamic. New information is continually being received and incorporated into the database.

The System shall maintain a database of other traffic.

[Analysis / TBD] [D19-638]

The surveillance database shall be capable of handling 2044 independent traffic objects.

[Analysis / TBD] [D19-639]

The surveillance database shall contain state information for each traffic object.

[Analysis / TBD] [D19-622]

The state information for a traffic object shall include position in Latitude and Longitude co-ordinates.

[Analysis / TBD] [D19-623]

The state information for a traffic object shall include its altitude.

[Analysis / TBD] [D19-624]

The state information for a traffic object shall include its speed.

[Analysis / TBD] [D19-625]

The state information for a traffic object shall include its heading.

[Analysis / TBD] [D19-626]

It shall be possible to store intent data for each traffic object.

[Analysis / TBD] [D19-627]

The intent data shall include four positions, specified as latitude, longitude and altitude, and the associated estimated time of arrival at that position.

[Analysis / TBD] [D19-1812]

The surveillance database shall contain the time at which the information associated with each traffic object was last updated.

[Analysis / TBD] [D19-640]

3.5.2.2 Data Fusion

The surveillance database requires that a sophisticated data fusion process is applied so that information from both TIS-B and ADS-B transmissions is combined into a single coherent data set.

The surveillance database shall include a fusion function to provide a best estimate of the current state of each object using information extracted from both TIS-B and ADS-B transmissions.

[Analysis / TBD] [D19-641]

The System shall compute and store a Virtual Conflict Time for each traffic object in the surveillance database.

[Analysis / TBD] [D19-645]

The definition of the Virtual Conflict Time has still to be agreed. The provisional definition is the distance between the ownship PAZ and a traffic object divided by the sum of their groundspeeds.

When an object passes beyond the RF horizon, its information shall be removed from the surveillance database.

[Analysis / TBD] [D19-642]

After receipt of new information for a traffic object, the closure vector and closure rate shall be computed.

[Demonstration / TBD] [D19-643]

When the aircraft is in FFAS, an advisory alert shall be generated if the TIS/ADS data for a traffic object that is also in FFAS and has a virtual collision time of less than 8 minutes has not been updated in the last 3 minutes.

[Measurement / TBD] [D19-644]

3.5.2.3 Access

All of the access functions require that a filter is applied to the complete set of traffic objects in order to identify a subset that meet specified requirements.

The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie within a specified range of the current aircraft position.

[Demonstration / TBD] [D19-629]

The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie within a specified range of a selected position, e.g. an airport.

[Demonstration / TBD] [D19-630]

The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie within a specified altitude range of the current aircraft position.

[Demonstration / TBD] [D19-631]

The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie below a specified altitude.

[Demonstration / TBD] [D19-632]

The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie above a specified altitude.

[Demonstration / TBD] [D19-633]

The System shall support a data access request that creates a list of all of traffic objects with their associated state data that have a virtual collision time that lies between specified limits.

[Demonstration / TBD] [D19-635]

The System shall support a data access request that creates a copy of all of the information stored for a specified traffic object.

[Demonstration / TBD] [D19-634]

3.5.3 Navigation Database

3.5.3.1 Content

The navigation database shall be based upon the data record types that are described in ARINC 424-15.

[Analysis / TBD] [D19-422]

The MA-AFAS trials programme will not involve helicopters and so records relating specifically to helicopters (HA, HC, HD, HE, HF, HS and HV record types) can be ignored within the development of the navigation database.

3.5.3.2 Access

3.5.3.2.1 AS Records

AS records contain information that details the Minimum Off Route Altitudes as a function of Latitude and Longitude.

The System shall provide an access function that returns Minimum Off Route Altitude for any specified latitude and longitude co-ordinates.

[Measurement / TBD] [D19-604]

3.5.3.2.2 D Records

D records contain details of VHF NavAids such as VOR and DME stations. For MA-AFAS trials, the information is used for display purposes only.

The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of a specified VHF NavAid station.

[Measurement / TBD] [D19-559]

The System shall provide an access function that creates a copy of all reference information held within the database for a specified VHF NavAid station.

[Measurement / TBD] [D19-560]

The System shall provide an access function that creates a list of all of the VNF NavAids that are within a selected distance of a specified latitude and longitude position.

[Measurement / TBD] [D19-561]

3.5.3.2.3 DB Records

DB records contain details of all enroute on-airway and off-airway Non-Directional Beacons (NDBs) that are listed in an airport specific record (PN). For MA-AFAS trials, the information is used for display purposes only.

The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of a specified NDB.

[Measurement / TBD] [D19-564]

The System shall provide an access function that creates a copy of all reference information held within the database for a specified NDB.

[Measurement / TBD] [D19-565]

The System shall provide an access function that creates a list of all of the NDBs that are within a selected distance of a specified latitude and longitude position.

[Measurement / TBD] [D19-566]

3.5.3.2.4 EA Records

EA records contain information about waypoints that are used by multiple airports. The use of a separate record type for common waypoints prevents duplication within the database.

The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates along with the waypoint type for a selected waypoint within the vicinity of a specified airport.

[Measurement / TBD] [D19-570]

The System shall provide an access function that creates a copy of all reference information held within the PA record for a specified airport.

[Measurement / TBD] [D19-571]

3.5.3.2.5 EM Records

EM records contain details of all markers and locators associated with all types of airway localiser.

The System shall provide an access function that creates a copy of all marker information held within the database for a selected localiser.

[Measurement / TBD] [D19-592]

3.5.3.2.6 EP Records

EP records contain information about holding patterns that have been recommended for inclusion on aeronautical charts by the official government authority. The list of holding patterns includes both terminal and enroute holding patterns.

The System shall provide an access function that creates a copy of all reference information held within the database for a specified holding pattern.

[Measurement / TBD] [D19-574]

3.5.3.2.7 ER Records

Each ER record contains information about a single airway or other established route.

The System shall provide an access function that creates a copy of all reference information held within the database for a specified airway.

[Measurement / TBD] [D19-577]

3.5.3.2.8 ET Records

ET Records contain details of the preferred routes and other predefined routes.

The System shall provide an access function that creates a copy of all route information held within the database for a specified preferred route.

[Measurement / TBD] [D19-732]

3.5.3.2.9 EU Records

EU Records contain altitude and time restrictions for airways.

The System shall provide an access function that creates a copy of all restriction information held within the database for a specified airway.

[Measurement / TBD] [D19-607]

3.5.3.2.10 EV Records

EV records contain details of the communications information for enroute airways.

The System shall provide an access function that creates a copy of all communications information held within the database for a specified airway.

[Measurement / TBD] [D19-614]

3.5.3.2.11 PA Records

PA records contain reference information about airports.

The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of the airport reference position.

[Measurement / TBD] [D19-539]

The System shall provide an access function that creates a copy of all reference information held within the database for a specified airport.

[Measurement / TBD] [D19-540]

3.5.3.2.12 PB Records

PB records contain information about passenger gates at airports.

The System shall provide an access function that generates a list of all of the passenger gates at a specified airport.

[Measurement / TBD] [D19-535]

The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of a selected gate at a specified airport.

[Measurement / TBD] [D19-536]

The System shall provide an access function that creates a copy of any notes that are held in the database for a selected gate at a specified airport.

[Measurement / TBD] [D19-537]

3.5.3.2.13 PC Records

PC records contains information about waypoints within the vicinity of an airport.

The System shall provide an access function that generates a list of all of the waypoints within the vicinity of a specified airport.

[Measurement / TBD] [D19-545]

The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates along with the waypoint type for a selected waypoint within the vicinity of a specified airport.

[Measurement / TBD] [D19-546]

The System shall provide an access function that creates a copy of all reference information held within the database for a specified waypoint.

[Measurement / TBD] [D19-547]

3.5.3.2.14 PD Records

PD records contain information about SIDs.

The System shall provide an access function that generates a list of all of the SIDs from a specified airport.

[Measurement / TBD] [D19-549]

The System shall provide an access function that creates a copy of all of the detailed procedural information for a selected SID from a specified airport.

[Measurement / TBD] [D19-550]

3.5.3.2.15 PE Records

PE records contain information about STARs.

The System shall provide an access function that generates a list of all of the STARs to a specified airport.

[Measurement / TBD] [D19-552]

The System shall provide an access function that creates a copy of all of the detailed procedural information for a selected STAR to a specified airport.

[Measurement / TBD] [D19-553]

3.5.3.2.16 PF Records

PE records contain information about Approaches to airports.

The System shall provide an access function that generates a list of all of the Approaches to a specified airport.

[Measurement / TBD] [D19-555]

The System shall provide an access function that creates a copy of all of the detailed procedural information for a selected Approach to a specified airport.

[Measurement / TBD] [D19-556]

3.5.3.2.17 PG Records

PG records contain detailed information about runways at airports.

The System shall provide an access function that generates a list of all of the runways at a specified airport.

[Measurement / TBD] [D19-542]

The System shall provide an access function that creates a copy of all reference information held within the database for a selected runway at a specified airport.

[Measurement / TBD] [D19-543]

3.5.3.2.18 PI Records

PI records contain information about the glide slopes associated with localisers at each airport.

The System shall provide an access function that generates a list of all of the localisers at a specified airport.

[Measurement / TBD] [D19-581]

The System shall provide an access function that creates a copy of all reference information held within the database for a selected localiser at a specified airport.

[Measurement / TBD] [D19-582]

3.5.3.2.19 PL Records

PL records contain detailed information about all Microwave landing Systems at airports.

The System shall provide an access function that generates a list of all of the Microwave Landing Systems at a specified airport.

[Measurement / TBD] [D19-610]

The System shall provide an access function that creates a copy of all reference information held within the database for a selected Microwave Landing System at a specified airport.

[Measurement / TBD] [D19-611]

3.5.3.2.20 PM Records

PM records contain details of all markers and locators associated with all types of airport localiser.

The System shall provide an access function that creates a copy of all marker information held within the database for a selected localiser at a specified airport.

[Measurement / TBD] [D19-586]

3.5.3.2.21 PN Records

PN records contain details on Non directional beacons associated with an airport.

The System shall provide an access function that generates a list of all of the Navaids at a specified airport.

[Measurement / TBD] [D19-707]

The System shall provide an access function that creates a copy of all information held within the database for a selected beacon at a specified airport.

[Measurement / TBD] [D19-700]

3.5.3.2.22 PS Records

PS Records contain details of the sector altitudes for all SIDs, STARs and Approaches.

The System shall provide an access function that generates a list of all of the Minimum Sector Altitudes at a specified airport.

[Measurement / TBD] [D19-736]

The System shall provide an access function that creates a copy of all reference information held within the database for a selected Minimum Sector Altitude at a specified airport.

[Measurement / TBD] [D19-739]

3.5.3.2.23 PV Records

PV records contain details of the communications capabilities at an airport.

The System shall provide an access function that generates a list of all of the Navaids at a specified airport.

[Measurement / TBD] [D19-706]

The System shall provide an access function that creates a copy of all communications information held within the database for a specified airport.

[Measurement / TBD] [D19-589]

3.5.3.2.24 TC Records

TC records contain details of cruising levels for IFR flights.

3.5.3.2.25 TG Records

TG records contain details on all geographical cross reference entries that are required to create a link to the Preferred Route Identifiers.

3.5.3.2.26 UC Records

UC records contain details of the vertical and lateral boundaries of Controlled Airspaces.

NOTE: For the purposes of this design document, it is assumed that the boundaries of a FFAS will be defined using a UC record structure.

The System shall provide an access function that creates a copy of all boundary information held within the database for a specified controlled airspace.

[Measurement / TBD] [D19-617]

The System shall provide an access function that determines the current airspace for a given position and altitude.

[Demonstration / TBD] [D19-1804]

The System shall provide an access function that creates a copy of the RNP for the current airspace.

[Demonstration / TBD] [D19-1805]

3.5.3.2.27 UF Records

UF records contain details of the vertical and lateral boundaries of Flight Information Regions.

The System shall provide an access function that creates a copy of all boundary information held within the database for a specified FIR or UIR.

[Measurement / TBD] [D19-598]

3.5.3.2.28 UR Records

UR records contain details of the vertical and lateral boundaries of Restricted Airspaces.

The System shall provide an access function that creates a copy of all boundary information held within the database for a specified airspace.

[Measurement / TBD] [D19-601]

3.5.4 Company Routes Database

3.5.4.1 Content

The system design includes a hard disk drive that will be used to hold data files that have been loaded through the Data Loader.

During the Initialisation phase, the system shall read the contents of these files and create the company route database in virtual memory.

[Demonstration / TBD] [D19-580]

MA-AFAS D18 places unnecessary restrictions on the maximum size of the company route database. The restrictions have been taken from the requirements specification document for the CMA-900 FMS which has a more limited memory capacity than the MA-AFAS equipment. It is proposed that these restrictions be interpreted as follows.

The System shall be capable of storing at least 400 company routes, each containing 128 way points.

[Measurement / TBD] [D19-453]

The structure used for defining a single segment of a company route shall contain the information described in ARINC 424-15 for company routes.

[Analysis / TBD] [D19-455]

The total memory storage allocation for company routes shall not exceed 2MB.

[Measurement / TBD] [D19-454]

3.5.4.2 Access

There will be typically two types of access to this database. The first is an HMI access. In this case, the pilot will specify a departure airport and will want a list of company routes that originate at that airport. In the second, the fine detail of a company route is required in order to generate a 4D trajectory.

The System shall be capable of generating a list of company routes that originate from a specified airport.

[Measurement / TBD] [D19-457]

The System shall be capable of generating a list of route segments that make up a single company route.

[Measurement / TBD] [D19-458]

3.5.5 Computed Trajectories

3.5.5.1 Content

The active trajectory information contains a list of trajectory change points that have been computed by the Trajectory Generation functions in order to meet a set of route constraints. This data is held in a single central store so that it can be accessed any part of the System that requires active trajectory information.

The System shall be capable of storing four trajectories and their associated constraint lists.

[Measurement / TBD] [D19-650]

The trajectory detail shall include the departure airport.

[Inspection / TBD] [D19-651]

The trajectory detail shall include the destination airport.

[Inspection / TBD] [D19-652]

The trajectory detail shall include a list of alternate airports.

[Inspection / TBD] [D19-653]

3.5.5.2 Access

A variety of access functions to the trajectory data are required. In most cases, the access is always to the active trajectory.

The System shall provide an access function that identifies the departure airport for the active trajectory.

[Demonstration / TBD] [D19-656]

The System shall provide an access function that identifies the destination airport for the active trajectory.

[Demonstration / TBD] [D19-657]

The System shall provide an access function that creates a list of alternate airports for the active trajectory.

[Demonstration / TBD] [D19-658]

The System shall provide an access function that creates a copy of the active trajectory.

[Demonstration / TBD] [D19-1811]

The System shall provide an access function that creates a copy of the constraint list for the active trajectory.

[Demonstration / TBD] [D19-1894]

3.5.6 Performance Database

3.5.6.1 Content

The ARINC 702A-1 standard does not specify a definitive set of data to be held in the database. It identifies a superset of parameters from which only a subset is likely to be used for any particular model. Since one of the partners (Eurocontrol) on the MA-AFAS programme have defined a generic aircraft performance model and have populated the associated database for a large number of aircraft types, it has been decided to make use of this model during the MA-AFAS trials. The performance parameters used by this model are similar to the ones identified in ARINC 702A-1.

The performance model for the aircraft shall be based upon the generic aircraft model defined by Eurocontrol in the document "User Manual for the Base of Aircraft Data (BADA)".

[Analysis / TBD] [D19-446]

The performance parameters for each aircraft used within the MA-AFAS trials shall be taken from the Eurocontrol BADA database.

[Inspection / TBD] [D19-447]

3.5.6.2 Access

The performance data for each aircraft can be broken down naturally into several distinct groups. Since each group of data is normally used to complete a performance calculation, there is no need to provide access functions for individual items within the database.

The System shall support a data access request that generates a copy of all of the aircraft mass related information.

[Measurement / TBD] [D19-522]

The System shall support a data access request that generates a copy of all of the aircraft speed related information.

[Measurement / TBD] [D19-523]

The System shall support a data access request that generates a copy of all of the aircraft lift related information.

[Measurement / TBD] [D19-524]

The System shall support a data access request that generates a copy of all of the aircraft engine related information.

[Measurement / TBD] [D19-525]

The System shall support a data access request that generates a copy of all of the aircraft fuel usage rate related information.

[Measurement / TBD] [D19-526]

3.5.7 Meteorological Database

3.5.7.1 Content

The Meteo Data base is required to follow the syntax of the Meteo data defined in WMO Technical Regulations, WMO No. 49 Vol. II which dictates the format of the data within the wider MA-AFAS System, its supporting sub-systems and the Domain of its Operational Concept.

Each data file contains meteorological information for a set of latitude and longitude positions defined on a regular grid. The forecast sea level pressure is provided at each grid point. In addition, the forecast air temperature, wind speed and wind direction are provided at each grid point for a set of altitudes.

The meteorological database shall be created while the System is in the initialisation state using data files that are stored on the hard disk drive.

[Demonstration / TBD] [D19-430]

The meteorological record for each altitude at each grid point shall contain the forecast estimates of the air temperature, wind speed and wind direction.

[Analysis / TBD] [D19-437]

An estimate of the air pressure at sea level shall be provided for each grid point.

[Analysis / TBD] [D19-439]

Each set of measurements shall include a time window for which the forecast data can be assumed to be reliable.

[Analysis / TBD] [D19-438]

3.5.7.2 Access

Since the meteorological data sets represents samples over a relatively coarse grid, it is necessary to apply some form of interpolation in order to obtain more useful estimates of the air data parameters at any intermediate positions and altitudes.

The System shall apply linear interpolation in 3 dimensions in order to estimate the air temperature at any arbitrary position and altitude that lies within the boundaries of a data file.

[Analysis / TBD] [D19-432]

If the location is within 50km of the current aircraft position and within 1000m of the current aircraft altitude, then the temperature estimate shall be blended with the measured air temperature at the aircraft.

[Analysis / TBD] [D19-433]

In this context, blending refers to the linear combination of the measured temperature at the aircraft and the estimated temperature. The weighting applied to the measured temperature shall be the current aircraft distance from the specified location as a fraction of the maximum blending distance.

[Analysis / TBD] [D19-434]

The weighting applied to the temperature estimate shall be set to the complement of this weight.

[Analysis / TBD] [D19-435]

The wind direction parameter has a discontinuity at the 0/360 degree boundary which makes the application of interpolation algorithms very difficult. This problem can be eliminated by processing the wind speed and direction as North and East components. The processing for each of the components then follows the same methodology that is applicable for temperature. Once all of the interpolation processing is complete, the North and East components can be used to compute the interpolated air speed and direction.

The System shall apply linear interpolation in 3 dimensions to the North and East components of the wind in order to estimate the wind speed and direction at any arbitrary point within the boundaries of a data file.

[Analysis / TBD] [D19-441]

The estimated wind speed and direction shall be blended with aircraft measurements using the method described for air temperature.

[Analysis / TBD] [D19-442]

3.5.8 Airport Map Database

The ARINC 702A-1 standard does not provide any indication of how many airport maps should be provided only some suggestions for the map content.

3.5.8.1 Content

The precise definition and content of the airport map database will be defined by ETG in consultation with BAES.

The System shall include a standalone database of airport maps.

[Inspection / TBD] [D19-402]

The definition of an individual airport map shall be in accordance with the requirements of ED-99.

[Analysis / TBD] [D19-403]

3.5.8.2 Access

The database shall support a single access request type that generates a copy of the airport information for a single specified airport.

[Measurement / TBD] [D19-407]

3.6 Adaptation Requirements

For flight and development trials, the MA-AFAS equipment will need to support a variety of interfaces. At the current time, it is proposed that some standalone software or hardware interface handlers are generated so that the core part of the system is unaware of the actual data source.

The System design includes an Ethernet interface to enable simulated data to be input from a variety of test equipment. The Ethernet interface also allows data to be input for systems that do not currently exist within the trials aircraft, e.g. the ACMS.

3.7 Safety Requirements

TBD

3.8 Security and Privacy Requirements

TBD

3.9 CSCI Environment Requirements

Based on experience gained in previous programs, e.g. AFMS/AATMS, and its position within the marketplace, VxWorks has been selected as the operating system for the MA-AFAS FMS.

3.10 Computer Resources

3.10.1 Computer Hardware

The architecture design that is described in Section Four of this document assumes that the Avionics box comprising a set of processing cards located on a VME backplane. The design assumes separate processors for the CMU and FMS components of the System along with relevant hardware interface modules, e.g. ARINC 429, Ethernet, RS232 and SVGA. The following diagram shows the proposed physical implementation of the System model.

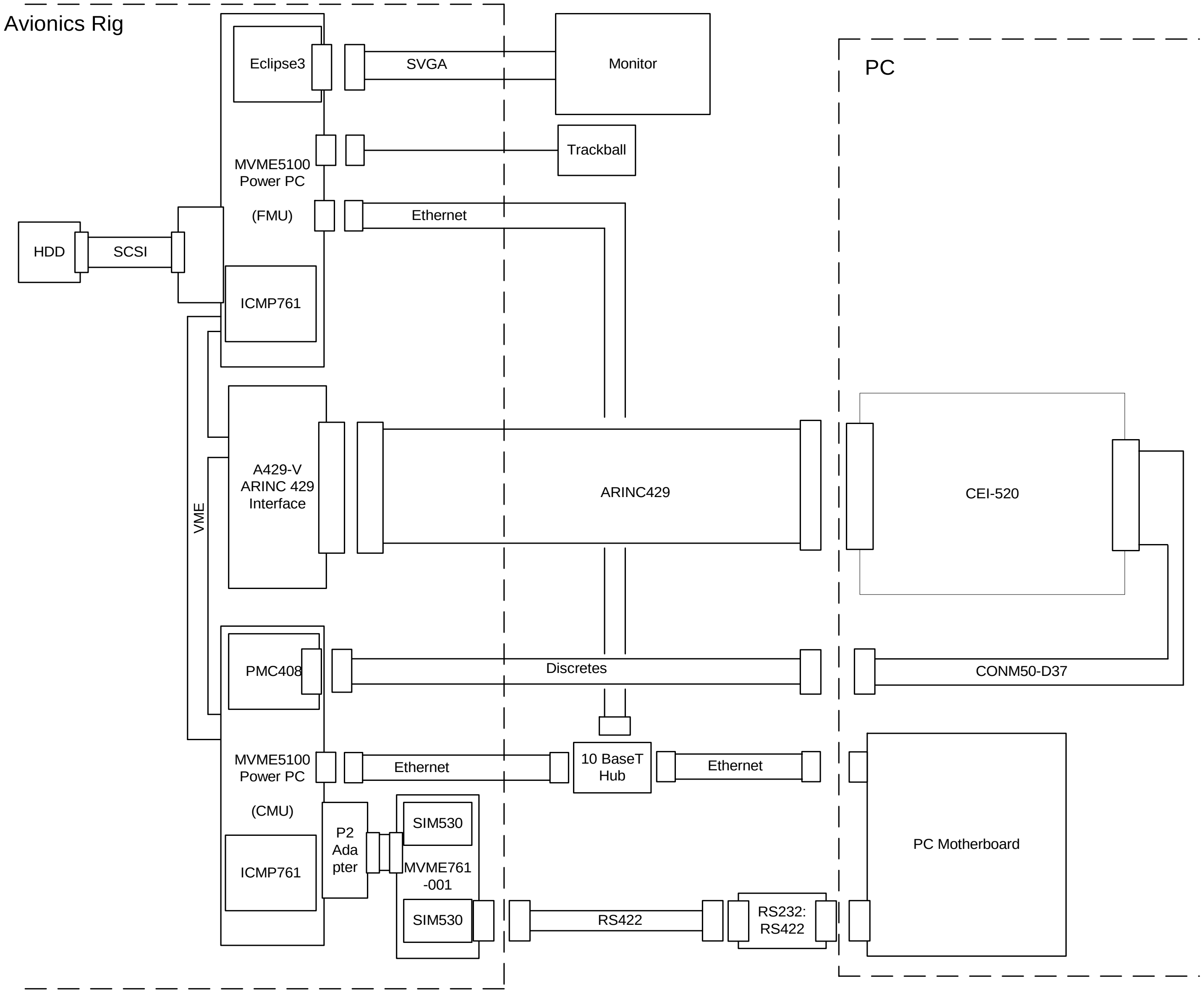
Avionics Rig
Eclipse3
SVGA
Monitor
PC
Trackball
MVME5100
Power PC
(FMU)
Ethernet
HDD
SCSI
ICMP761
A429-V
ARINC 429
Interface
VME
ARINC429
CEI-520
PMC408
Discretes
CONM50-D37
MVME5100
Power PC
(CMU)
Ethernet
10 BaseT
Hub
Ethernet
P2
Ada
pter
SIM530
MVME761
-001
ICMP761
SIM530
RS422
RS232:
RS422
PC Motherboard

Figure 2 MA-AFAS Hardware Architecture

The System design shall include a Hard Disk Drive for holding information that must be maintained in non-volatile memory.

[Inspection / TBD] [D19-412]

The interface between the HDD and the system shall be a SCSI.

[Inspection / TBD] [D19-1838]

The exact computer resources required for the MA-AFAS equipment are not known due to the immaturity of several of the MA-AFAS functions. In order to make assessment of the computing resources required, some rough order of magnitude estimates were made, with fall back additional resources identified.

The estimates carried out were based upon information obtained from the AFMS/AATMS programme computer resources.

Within the AFMS/AATMS programme, the system ran on 3 PowerPC 604 cards, where each card had 32 Mbyte of onboard RAM. The functions implemented on these cards were 4D Trajectory Generation (covering Missed Approach), Negotiation, Guidance, Database and HMI (including Taxi Map display, synchronisation of Navigation Display and MCDU).

In the AFMS/AATMS environment there was a significant amount of interprocessor communication. It was estimated that this would reduce the efficient running of the processes. From the AFMS/AATMS trials, it was estimated that the 3 cards were running at no more than average 80% capacity (although peaks could be up to 100% for short periods of time (less than 1 minute)).

It was assumed that the AFMS/AATMS functionality was about half of the functionality that will be required for MA-AFAS, which has the additional Communication Management and Separation Assurance functions. A search of current processor cards identified that the PowerPC 750 was the most suitable processor card for MA-AFAS. It is from the same family as the previous PowerPC cards, enabling the previous knowledge and experience to built aupon, and has higher processing power. The specification identifies that the PowerPC 750 is approximately 4 times faster than the 604.

As the hardware environment is not required to be representative of the production hardware, there are no constraints on the number of processor cards used within the trials system. However, it is the project aim to emulate the expected hardware environment where possible. Initial estimates suggest that a single processor will not be able to run the complete MA-AFAS system (even assuming an improvement in processing performance within the next 3 years as production cards will need to have a card loading of less than 50%), therefore the production equipment is expected to contain 2 processor cards.

As the expected functionality is double that for AFMS/AATMS but the cards are approximately 4 times faster, it is assumed that 2 PowerPC 750 cards will be able to provide the processing performance required for MA-AFAS. The split of functionality across the cards is expected to be CMU for one card and FMS for the other. The interprocess communication for this split is anticipated to be less than the data flow used within the AFMS / AATMS.

If, for some reason, the processing power is insufficient, it is foreseen that additional PowerPC cards could be used, although this will be at a cost of increased interprocessor communication and reduced number of avionic rigs available for integration.

For the assessment of on card memory requirements, the size of the database was used as the main guide. The information management system's largest stores of information are assumed to be ARINC 424 data for a reasonable area (in this case assumed to be the whole of Europe), weather information, aircraft information (including route data) and communication and data logs. It was assessed that the combined storage for this data would be in the order of no more than 45Mbyte. As a result, the cards were selected to have at least this available plus 20% for variables and program code. Therefore, PowerPC cards with 64Mbytes of RAM have been selected.

If this is found to be insufficient, memory expansion modules can be purchased to increase onboard memory or the hard disk can be used to store some of the data that does not need such frequent access.

The architecture models within the system design described in Section 4 indicates that the complete avionics rack will require a total of 24 ARINC 429 channels. The A429-V ARINC 429 Interface card provides 16 ARINC 429 channels configurable for either input or output. The final trials equipment will therefore include two of these cards. During the development phase, only one card will be necessary because the majority of the interfaces will be emulated over an Ethernet link.

Each of the PowerPC cards includes an ICMP761 daughter card to provide additional I/O capabilities such as the SCSI interface to the HDD and the RS232 interface to the trackball.

The Eclipse3 daughter card on the FMS processor provides the SVGA drivers for the graphical display unit that will contain the navigation displays.

It is not possible to fit three daughter cards to the FMS processor and so the interface module for the aircraft discrete signals, the PMC408, is fitted to the CMU processor. In this case, the physical location of the card is not important because they are all linked via the VME.

Each ARINC429 card shall be hardware configured for 32 bit address mode.

[Inspection / TBD] [D19-1868]

The base address for the default ARINC 429 card shall be 0x4800 0000.

[Inspection / TBD] [D19-1867]

The base address for the second ARINC 429 card shall be 0x4808 0000.

[Inspection / TBD] [D19-1869]

3.10.2 Computer Software Requirements

In order to support the progressive development of the software to meet the certification requirements of DO-178B, each primitive function shall include sufficient error checking to prevent the generation of a system level error.

[Inspection / TBD] [D19-128]

Each function shall return a error flag that indicates whether or not a function completed successfully.

[Measurement / TBD] [D19-372]

3.10.3 Computer Software Configuration Items

The architecture diagrams within the system design can be used to identify the main software configuration items. The configuration items have been selected using a functional split and this has been reflected in the structure of section 3.2 of this document.The main configuration items are expected to be:

a) System Initialisation

b) MCDU Interface

c) EFIS Interface

d) Manoeuvre Generation

e) Conflict Processing

f) Trajectory Generation

g) Aircraft Guidance

h) CM/CPLDC Processing

i) ADS-C Functions

j) ADS-B Functions and surveillance database

k) AOC Management Functions

l) FIS Management Functions

4 ARCHITECTURAL DESIGN

This section will be generated from a snapshot of the MA-AFAS aircraft equipment model that is maintained by BAE SYSTEMS using the AxiomSys structured analysis tool. The procedures used by BAE SYSTEMS are based on the Hatley/Pirbhai Structured Analysis methodology. An overview of the methodology and symbology is included within Section 6 of this document.

4.1 System Components

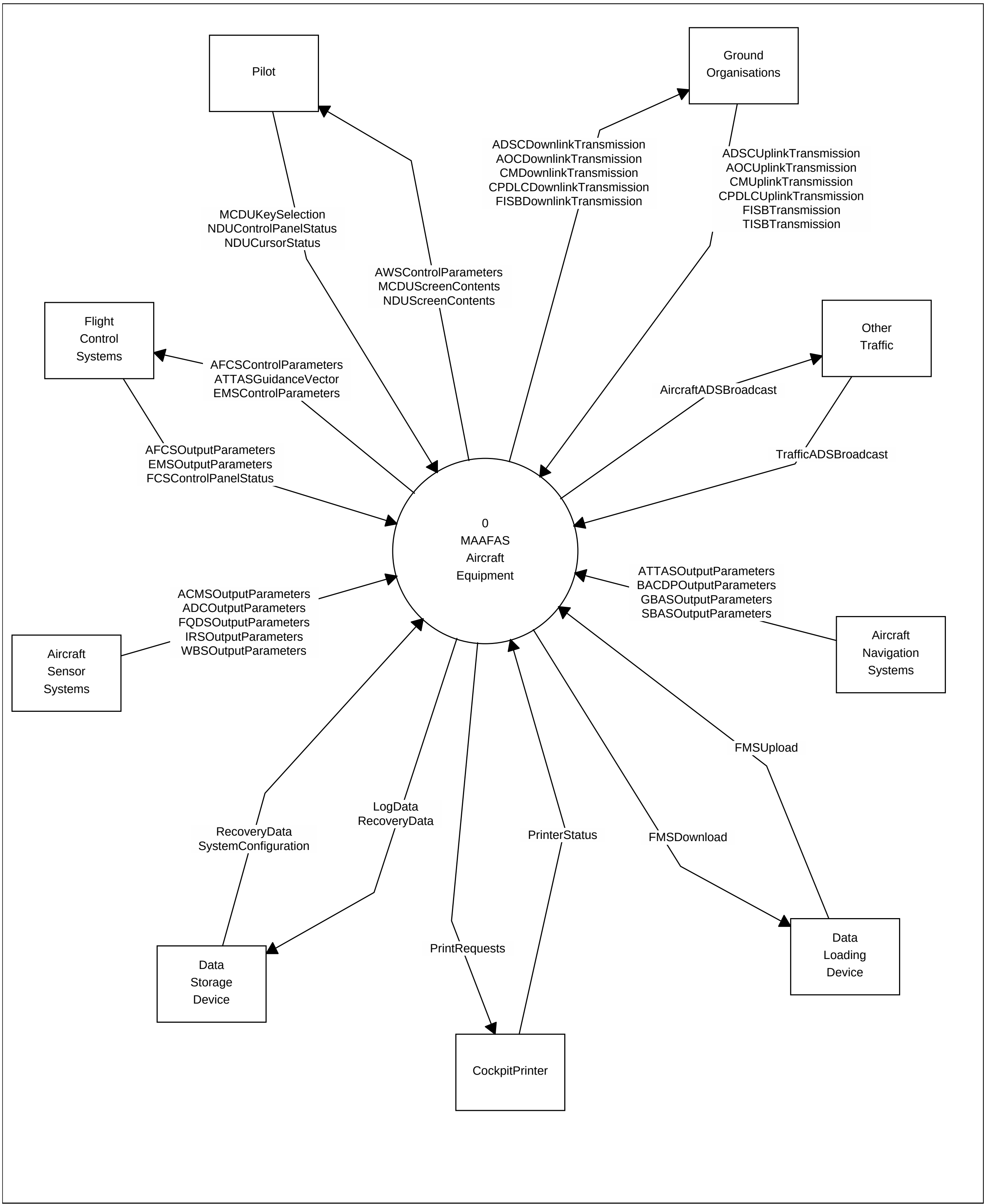

Figure 3 Context Diagram

The context diagram shows the basic inputs and outputs to the MA-AFAS air equipment.The inputs and outputs have been grouped according to the types of information that is input to the system. No regard has been taken with respect to the physical links between the terminators and the system on this diagram. This has been left to the "MAAFAS_Architecture" diagram.

This dataflow model captures the essential capabilities required of a Flight Management System as detailed in the MA-AFAS Aircraft Equipment Specification (MA-AFAS D18) and ARINC 702-A. The core capabilities as identified in ARINC 702-A includes display management for the MCDU and Navigation Display, communications management for auto-tuning of voice and navigation aids, information management including the meteorological, surface map, surveillance and navigation databases. The MA-AFAS specific functions are trajectory generation and guidance, taxi management displays and airborne separation assurance functions. For MA-AFAS, the ASA functionality includes both autonomous operations and delegated operations.

For the MA-AFAS programme, the use of datalink within ATM is considered to be of primary importance. In order to support the close interactions required between the communications system and the flight management system, the aircraft equipment is assumed to comprise both a flight management component and a communications management component.

The communications management unit implements the stacks that are associated with each of the communications channels. Since the emphasis in this model is the FMU, the implementation of the stacks is hidden from the FMU within the CMU by a set of application interfaces.

4.1.1 DataLoadingDevice

This terminator represents a data loading device that can be used for both uploading information into the FMS and downloading from the FMS.

For MA-AFAS, this is unlikely to be an ARINC standard data loader. Any data loading or unloading will be to a laptop computer.

4.1.2 AircraftSensorSystems

This terminator represents the various aircraft sensor systems.

(a) Air Data Computer (ADC).

(b) Weight and Balance System (WBS).

(c) Attitude and Heading Reference System (AHRS).

(d) Inertial Reference System (IRS)

(e) Fuel Quantity Data System (FQDS).

(f) Aircraft Condition Monitoring System (ACMS)

The actual sensors available will depend upon the aircraft fit. During the MAAFAS trials, the BAC 1-11 will only supply information from the ADC and IRS. The WBS, FQDS and ACMS will be emulated.

4.1.3 GroundOrganisations

The ground based organisations terminator represents the Air Traffic Control (ATC), the Airline Operations Centre (AOC) and Air Information Services (AIS). The AIS is responsible for the Flight Information Service (FIS) and the Traffic Information Service (TIS-B).

4.1.4 AircraftNavigationSystems

This terminator represents the ground based and satellite based navigation systems that can be used by the aircraft. This can include but is not limited to the following;

(a) VHF Omni-directional ranging (VOR).

(b) Distance Measuring Equipment (DME).

(c) Instrument Landing System (ILS).

(d) Microwave Landing System (MLS).

(e) Inertial Navigation System (INS).

(f) Global Navigation Satellite System (GNSS).

For MA-AFAS, only the GNSS is of interest.

4.1.5 FlightControlSystems

The flight control systems terminator represents the Aircraft Flight Control System (AFCS) and an engine management system (EMS) under the control of an autopilot and auto-thrust controller.

4.1.6 OtherTraffic

This terminator represents other aircraft and pertinent ground traffic that can either transmit ADS-B messages or receive ADS-B messages.

4.1.7 Pilot

This terminator represents any user of the flight management system. This will normally be the pilot or first officer but can include maintenance personnel.

4.1.8 DataStorageDevice

This terminator represents a data storage device. For MA-AFAS, this is likely to be a hard disk drive within the system. This is used to hold information that must be retained in non-volatile memory. This includes the system configuration information, database information and logged data files.

4.1.9 CockpitPrinter

This terminator represents the cockpit printer.

4.2 MAAFASAircraftEquipment

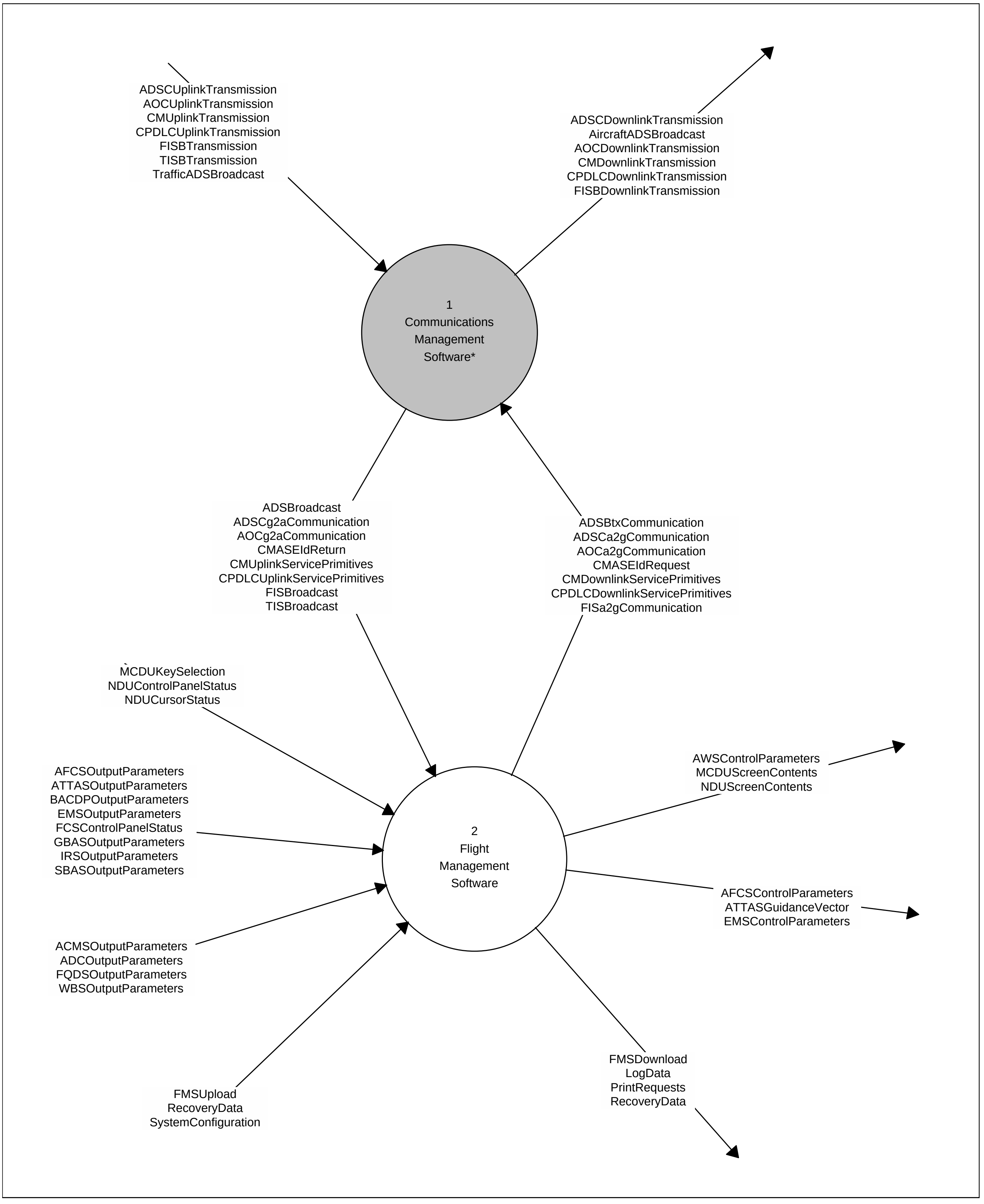

Figure 4 MAAFASAircraftEquipment DFD

The aircraft equipment includes two primary groups of software, the flight management software and the communications management software. These correspond to the software that will exist on the FMU and CMU respectively.

The CMU provides the means for decoding VHF transmissions from the ground and for encoding messages for broadcast from the aircraft. This includes ATN communications, non-ATN communications and broadcast messages.

The FMU is responsible for flight management activities. This includes the provision of a pilot interface to enable route planning to be performed, visibility of messages from the ground and visibility of flight progress. When the FMU has been selected to control the autopilot, then the FMU will use the inputs from the various aircraft sensor systems in order to generate commands for the auto-pilot.

4.3 CommunicationsManagementSoftware

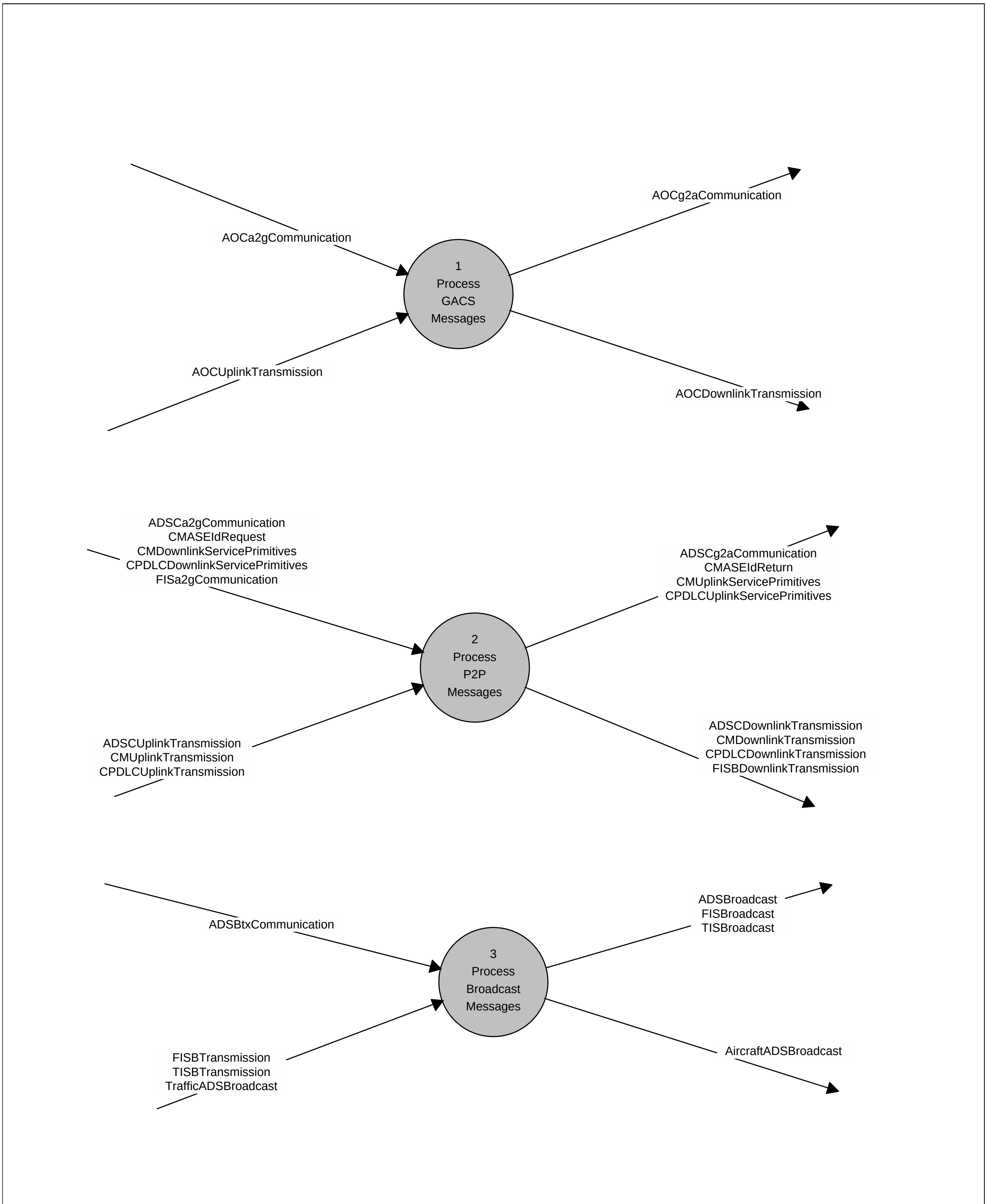

Figure 5 CommunicationsManagementSoftware DFD

The communications management software is responsible for handling the various stacks that are used for encoding and decoding VHF transmissions between the ground and the aircraft. At the highest level, this comprises three processes. The first process is responsible for handling messages that re sent over the GACS network. The second process is responsible for handling messages that are sent over the ATN. The third process is responsible for handling broadcast messages.

4.3.1 ProcessGACSMessages

This process represents the top level of the generic application service interface.

4.3.2 ProcessP2PMessages

This process represents the top level of the remote application service interface.

4.3.3 ProcessBroadcastMessages

This process represents the top level of the broadcast application service interface.

FlightManagementSoftware

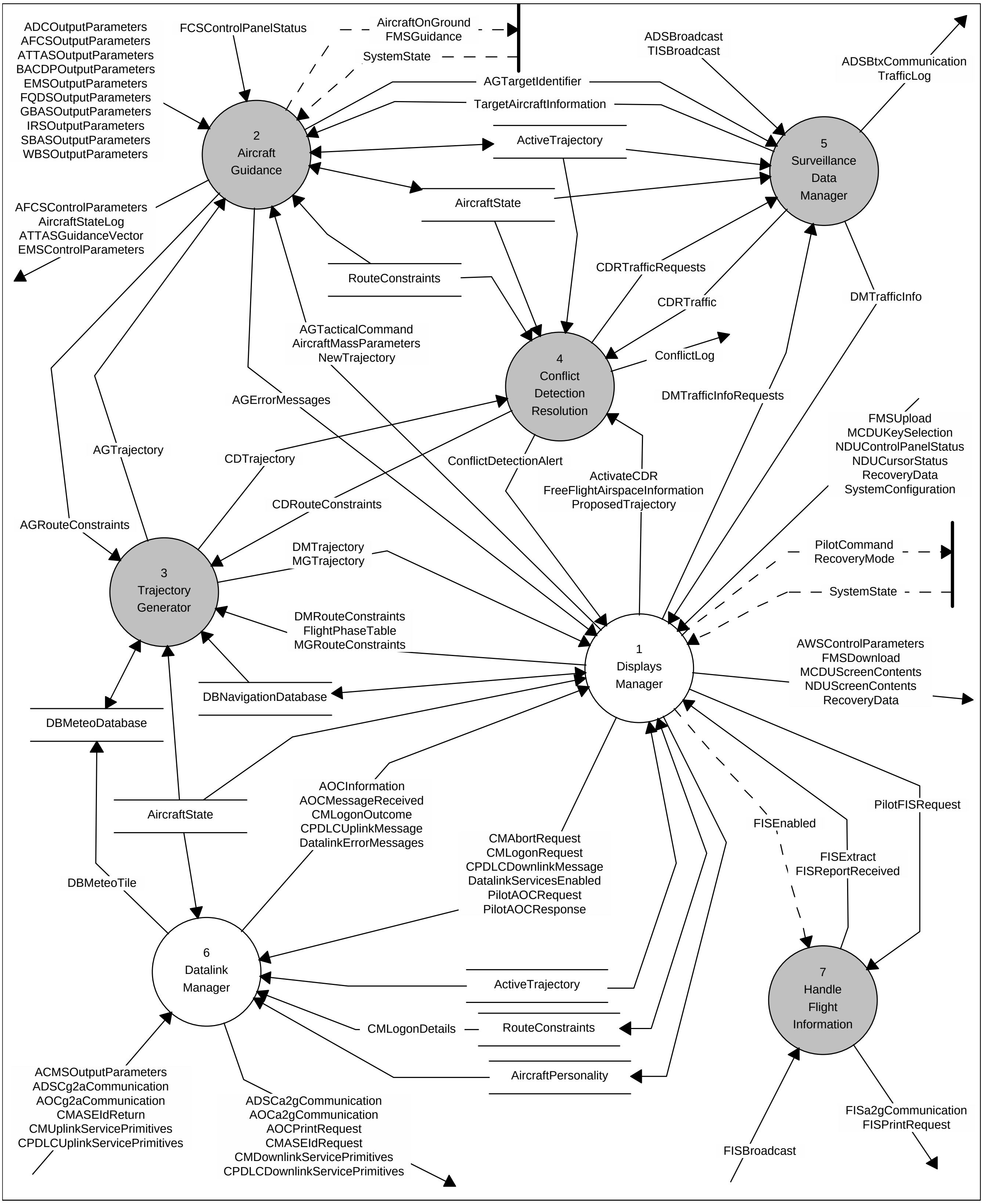

Figure 6 FlightManagementSoftware DFD

The Flight Management System Software includes all aspects of flight management required by the MA-AFAS programme. The processes shown at this level captures some of the main themes of the

MA-AFAS programme, 4D trajectory generation and guidance, conflict detection and resolution, ADS-B and datalink applications. The primary dataflows through the System are described in the following paragraphs.

The received broadcast traffic information, both ADS-B and TIS-B, is used to create a single coherent traffic database that can be accessed by any process that requires traffic information. The input data flows "ADSBroadcast" and "TISBroadcast" are merged to create the database structure "DBSurveillanceData". This information is used in two places. It is used within the "Displays Manager" process in order to support CDTI and it is used within the "ConflictDetectionResolution" process as the source of traffic state and intent data. The "AircraftGuidance" process requires information from just a single specified target aircraft when it is performing a delegated manoeuvre, "TargetAircraftInformation". In addition, the traffic information is written to the HDD at regular intervals via the "TrafficLog" data flow.

In order to support the ADS-B processing onboard other aircraft, the aircraft state and intent must be broadcast to them. The process "ManageSurveillanceData" is also responsible for this. It makes use of the "AircraftState" information and the "ActiveTrajectory" in order to provide the information required by an ADS-B transmission. The result of the processing appears in the "ADSBtxCommunication" dataflow.

The "HandleFlightInformation" process is responsible for extracting FIS reports from the "FISBroadcast" data. These reports are stored within a internal database structure that can be accessed by the pilot via the "PilotFISRequest" dataflow from the "Displays Manager". When requested information is not available in the database, the process is responsible for creating a specific information request flows to the ground, "FISa2gCommunication". When the requested data is received, the "FISReportReceived" dataflow is issued in order to alert the pilot to the receipt of the requested information.

The "DisplaysManager" represents the primary interface between the pilot and the System. It is responsible for processing pilot inputs and updating the displayed data accordingly. For MA-AFAS, one of the prime activities is the generation of a 4D trajectory. This is accomplished by generating a set of "RouteConstraints" to define the flight plan. These constraints are used to create a set of "ProposedConstraints" which includes any AOC constraints or pilot preferences. These are sent to the "TrajectoryGenerator" process. The "TrajectoryGenerator" process uses the "ProposedConstraints" to create a trajectory. The trajectory is returned as the "AlternateTrajectory" so that the active trajectory is unaffected. The new trajectory is then available to the pilot for review. If he is happy with the trajectory, it will be copied to the "ActiveTrajectory" data store.

The "TrajectoryGenerator" process is also responsible for logging each activation of the process. The "TrajectoryLog" dataflow will incorporate the constraints for the trajectory and the computed trajectory.

The "AircraftGuidance" process is responsible for maintaining the aircraft within the limits of the "ActiveTrajectory" while the FMS is engaged as the master for aircraft guidance. The guidance function uses inputs from various aircraft systems to monitor its current status and hence to compute commands to drive the autopilot and engine management systems. The current state of the aircraft is written to a data store "AircraftState" that can be accessed by other processes within the System. When a "TacticalCommand" is received, the guidance function modifies its behaviour to take account of the command information. If the command represents a delegated manoeuvre, then the guidance function will use information about the specified target aircraft in order to maintain a safe distance between the two aircraft.

In order to maintain the aircraft within the limits of the "ActiveTrajectory", the guidance function predicts the aircraft position at a fixed time ahead. If the predicted position lies outside the bounds of the trajectory limits, the guidance function initiates a revision to the active trajectory. A set of "RevisedConstraints" based upon the "RouteConstraints" are passed to the "TrajectoryGenerator" process and a "RevisedTrajectory" is created. If this trajectory keeps the aircraft within the "ActiveTrajectory" limits, then the revised trajectory information is copied to the "ActiveTrajectory" data store without notifying the pilot. If the revised trajectory does not keep the aircraft within the specified limits, then a pilot alert is created.

The "ConflictDetectionResolution" process is active while the aircraft is in or transitioning into FFAS. It uses the "AircraftState" information, the "ActiveTrajectory" and traffic surveillance information in order to determine whether conflicts exist. When a conflict is detected, the process is responsible for generating a trajectory that resolves the conflict. The new trajectory is added to the "ConflictDetectionAlert" along with the alert status and issued to the "DisplaysManager" when it is available to the pilot for review. If the pilot accepts the trajectory information, then it will be copied into the "ActiveTrajectory" data store.

The "DatalinkManager" process is responsible for all aspects of communications using datalink. This includes Context Management (CM), CPDLC and also AOC communications. The CM application is only activated in response to a "CMLogonRequest" from the pilot via the "DisplaysManager". The result of the processing is returned via the "CMLogonOutcome" dataflow.

CPDLC dialogs can be initiated by either the pilot or a controller. When the controller initiates a dialog, the uplinked message is added to the "CPDLCMessages" data store and a message is sent to the pilot to alert him to the arrival of the message. The "DisplaysManager" can read the message from the store and enables the pilot to create an apprpriate response. The response message, "CPDLCUplinkResponse" is sent back to the CPDLC application which will then tidy up the message store. When the pilot initiates a dialog, the downlinked message information is added to the "CPDLCMessages" store until a response is received from the ground.

AOC communications with the pilot are also received over a datalink. Upon receipt of a message, an alert is sent to the pilot so that he knows that new information has been received. The AOC application is responsible for handling the new information and adding it to the appropriate stores. Some information is added directly to stores that can be accessed by the "TrajectoryGeneration" function. All other information is held by the AOC function until requested.

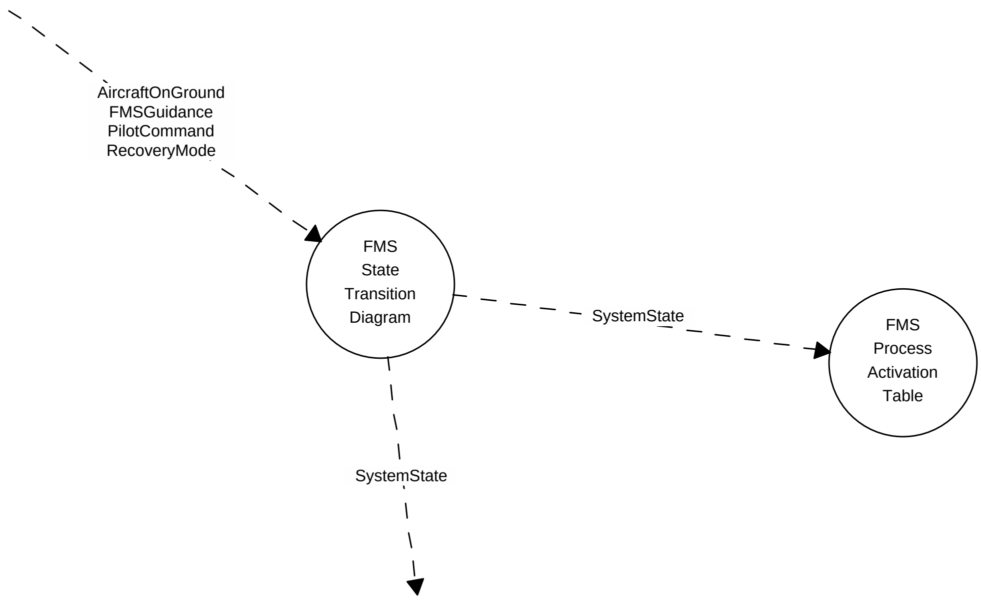

Figure 7 FMS Control Diagram

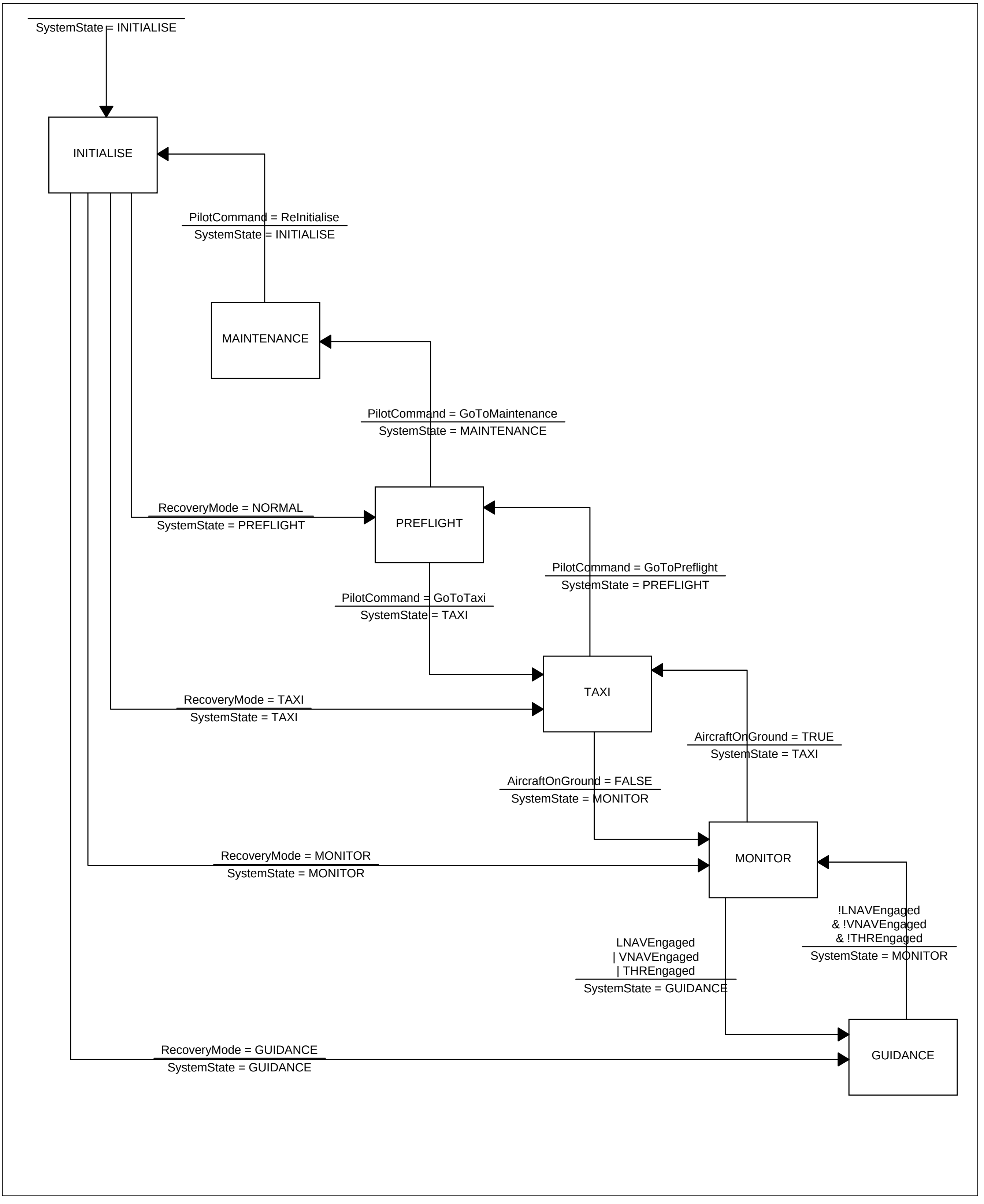

Figure 8 State Transition Diagram

Inputs	***Process Activation***						
SystemState	**DisplaysManager**	**AircraftGuidance**	**TrajectoryGenerator**	**ConflictDetectionResolution**	**SurveillanceDataManager**	**DatalinkManager**	**HandleFlightInformation**
INITIALISE	1	0	0	0	0	0	0
PREFLIGHT	1	1	1	0	1	1	1
MAINTENANCE	1	0	0	0	0	0	0
TAXI	1	1	1	1	1	1	1
MONITOR	1	1	1	1	1	1	1
GUIDANCE	1	1	1	1	1	1	1

Table 1 Process Activation Table

4.3.4 DisplaysManager

This represents a top level control process for modelling the displays management only.

The "ManagePilotInterface" function represents a high level process for handling inputs to the MCDU and the EFIS by the pilot.

The "ManageSystemInitialisation" function is only active when the System is in the "Initialise" state. It is responsible for reading the content of the configuration datafile and for creating the Navigation database.

The System allows the pilot to create manoeuvre commands using either the MCDU or the EFIS or a combination of both. The manoeuvre information is held within a data store that can be accessed by both processes. When the manoeuvre information is loaded, the "ManageManoeuvreGeneration" function is activated in order to generate a new trajectory. This "AlternateTrajectory" can be viewed using either display function before being set as the new "ActiveTrajectory" by the pilot.

The "ManageCPDLCDialogs" process represents the process for handling CPDLC messages.

4.3.5 AircraftGuidance

This task is primarily responsible for generating the commands necessary to control the movements of the aircraft. The autopilot commands will direct the aircraft either along the active trajectory or in accordance with a received tactical command. The operation of the system depends upon the status of the autopilot and whether or not a tactical command is being implemented.

Autopilot Not Engaged

When the FMS has not been selected to drive the autopilot, it can do no more than monitor the progress of the aircraft. The outputs from the aircraft navigation and sensor systems are combined to create an aircraft state vector that can be used by other parts of the system. The state vector is passed to the Information Manager where it is logged. The aircraft position is compared with the position predicted by the active trajectory and a set of deviation data is created for output to the Displays Manager.

Autopilot Engaged and No Tactical Command Issued

This represents the most common operating mode of the Aircraft Guidance functions. In this mode, the progress monitoring functions have a more active role. As before, the outputs from the aircraft navigation and sensor systems are combined to create an aircraft state vector. The aircraft position is compared with the position predicted by the active trajectory and a set of deviation data is created for output to the Displays Manager. Provided that the aircraft remains within the specified trajectory tolerances for the current sector then no further action is necessary. If the aircraft moves outside of the allowed trajectory bounds, a revised set of route constraints are generated and a new trajectory is created to replace the current active trajectory. The position of the aircraft is then compared with the required position on the currently active trajectory in order to generate commands for the autopilot.

Autopilot Engaged and Tactical Command Issued

When a tactical command is selected for implementation by the pilot, the action taken depends upon the type of command issed. If the command requires a simple change to the speed, heading or altitude, then this is implemented by suspending the currently active trajectory and commanding the autopilot to make the required change. If the command requires a manoeuvre to be implemented, a set of constraints are generated appropriate to the manoeuvre and a manoeuvre trajectory is created. This is set as the new active trajectory and the guidance function then drives the aircraft along this trajectory while monitoring the distance from the specified target aircraft. Adjustments to the trajectory are made if the aircraft separations are predicted to become unsafe.

4.3.6 TrajectoryGenerator

This process is responsible for route planning in the air and on the ground. It includes the 4D Enroute processing for the trajectory generation. It is also capable of 2D and 3D route planning.

Some of the constraints do not need to be specified explicitly as they do not change with time and hence are stored with the central data store. Any such data can be retrieved from the store directly.

4.3.7 ConflictDetectionResolution

This process is responsible for the Conflict Detection and Resolution processing.

4.3.8 SurveillanceDataManager

This process is responsible for the management of the traffic surveillance data. When the System is switched on, the surveillance database will be empty. Once the System begins to receive TIS-B and ADS-B transmissions, then this process will begin its processing. There are several activities that must be performed by the process.

When a data message is received, either TIS-B or ADS-B, the processing must first check whether the message is for an existing or an unknown aircraft (or ground based vehicle). If the information is for an unknown aircraft, then a new record must be created in the database. If the information is for a known aircraft, then the new information must be merged with the existing information.

Independently of the normal message processing activities, the processing will need to perform some housekeeping activities in order to remove database objects which are no longer within ADS-B range of the aircraft or for which no further TIS-B information is being received.

This process is also responsible for transmitting the own aircraft state and intent data via ADS-B, and for updating the traffic log which is held on the hard disk.

4.3.9 DatalinkManager

The "DatalinkManager" process is responsible for aspects of datalink communications. This includes Context Management activities, the management of dialogs between the controller and the pilot and also communications between the pilot and AOC.

The CM tasks are driven by requests from the HMI. There are essentially two types of request, a logon request and an abort request. The result of any logon request is passed back to the HMI via the "CMLogonOutcome" dataflow.

The CPDLC application is responsible for the maintenance of message dialogs between the pilot and the controller. It maintains a store of open dialogs that can be accessed by the HMI for display to the pilot. When a message is received from the controller, the message is added to the list of open dialogs and an alert is sent to the HMI to notifiy the pilot to the receipt of a message. When the pilot responds to a message, the process closes the dialog from the aircraft point of view and sends the response to the ground. When the pilot initiates a dialog, the initial message is stored until a response is received from the ground. When the response is received, the pilot is alerted to the response.

The AOC application is responsible for handling information received from the AOC and also for the generation of OOOI messages.

4.3.10 HandleFlightInformation

This process is responsible for handling both broadcast and point to point communications that contain flight information supplied from the AIS.

4.4 Architecture Context

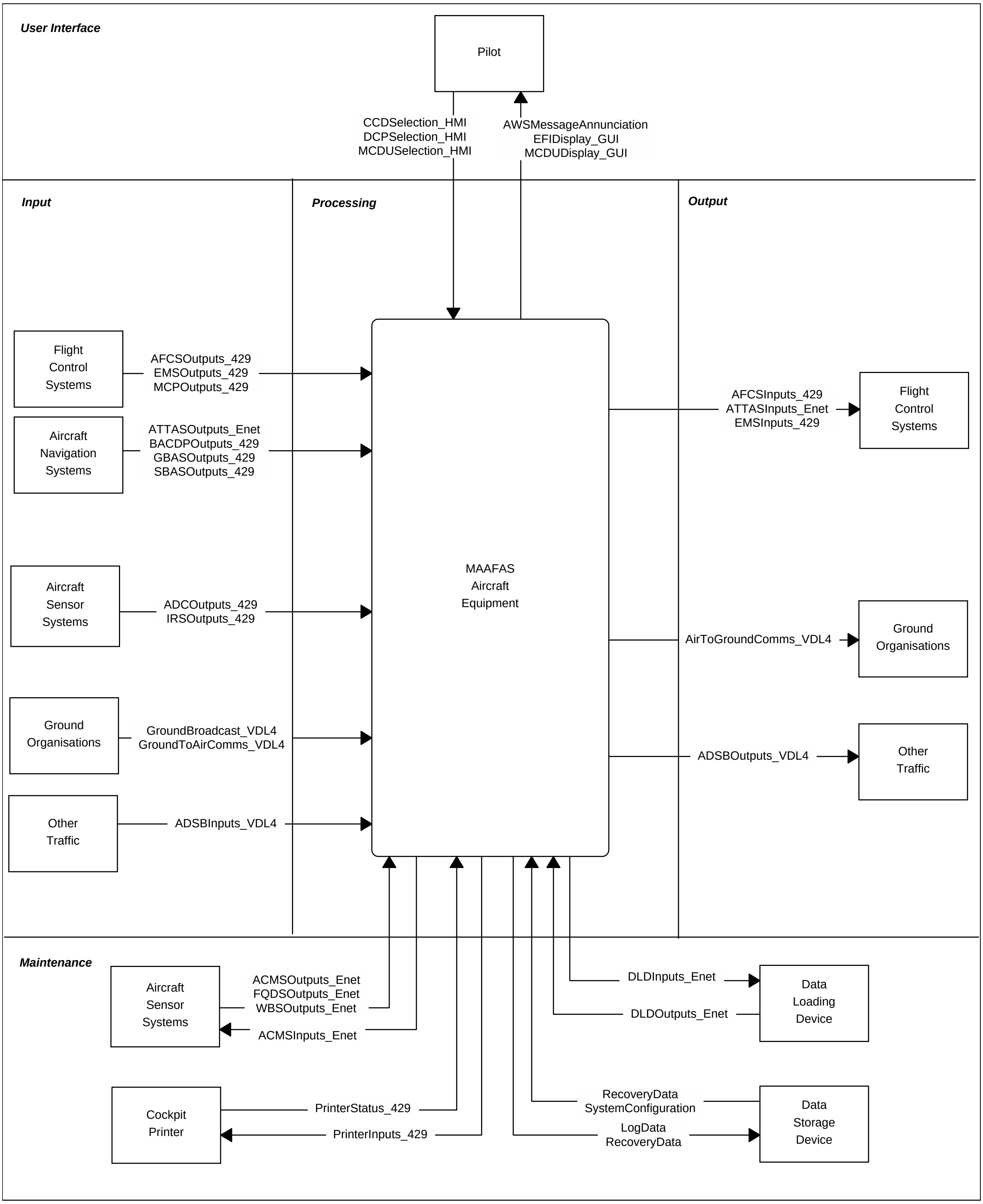

Figure 9 Architecture Context Diagram

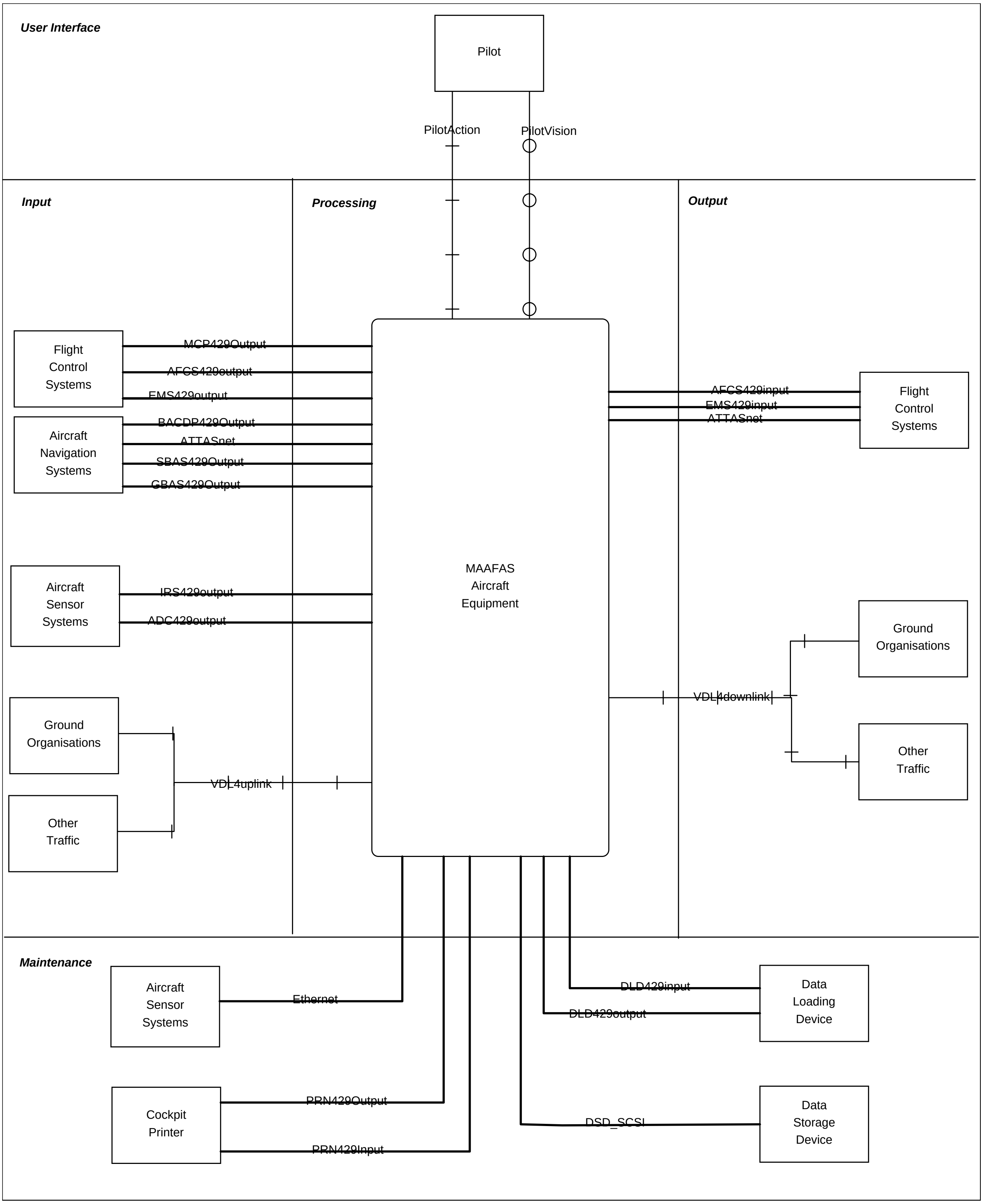

Figure 10 Architecture Interconnection Diagram

This architecture module represents the set of aircraft equipment that make up the MA-AFAS avionics suite.

This comprises a VME rack that contains the main processing components of the system and a set of pilot input and display devices. The MA-AFAS System drives two display surfaces, an Electronic Flight Instrument (EFI) that contains the navigation display formats and the Multi-purpose Control and Display Unit (MCDU). The pilot can control the navigation display using a rollerball cursive device or by selecting buttons on a dedicated Display Control Panel. The pilot controls the MCDU display content using the Line Selection Keys, dedicated menu keys and the alphanumeric keys on the MCDU. The main processing rack supports a variety of input/output protocols for communications with other aircraft equipment. This includes ARINC 429 links, SCSI links and Ethernet.

4.5 Aircraft Equipment

This diagram shows the high level message flows between the various aircraft equipment.

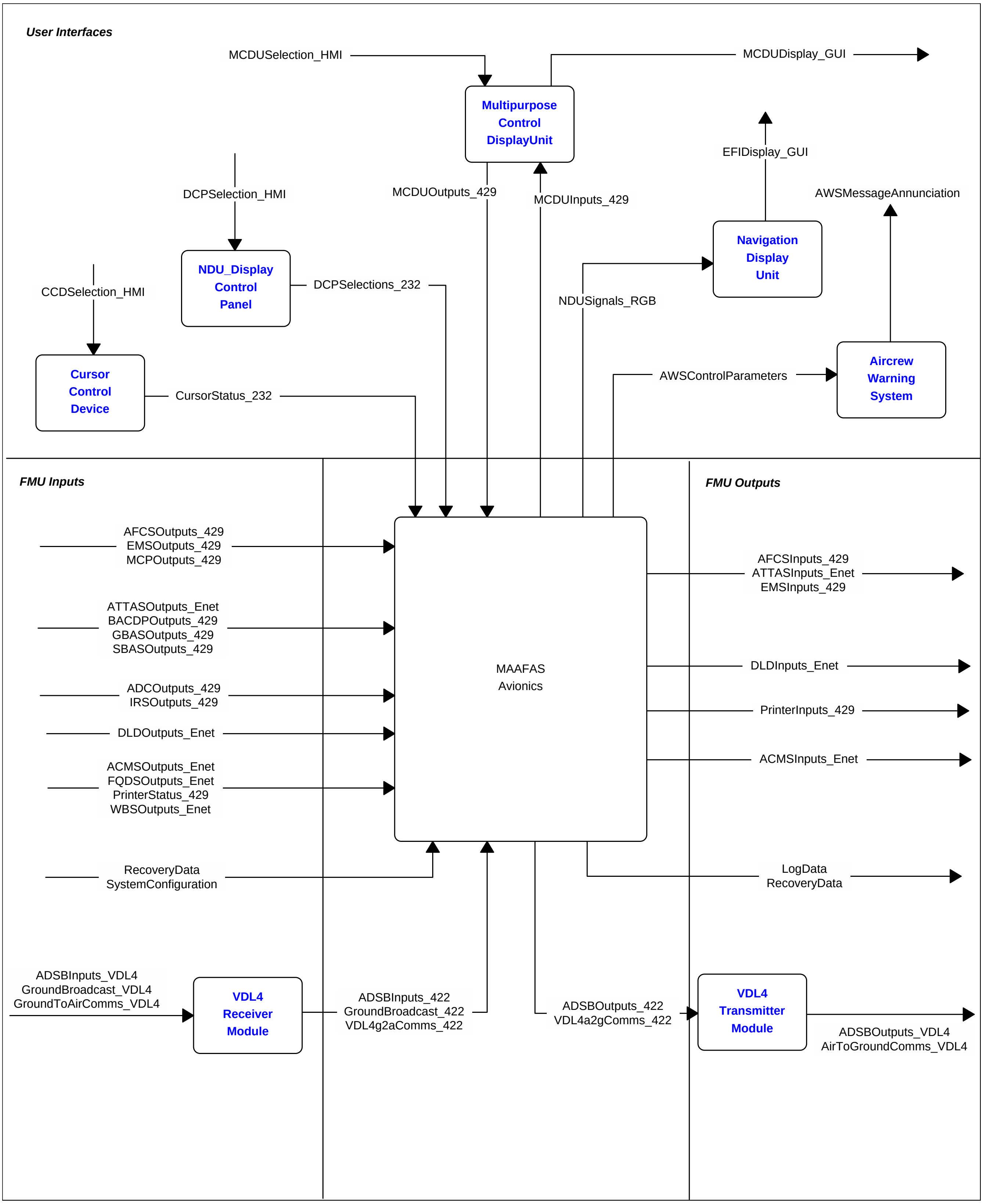

Figure 11 Aircraft Equipment Message Flows

This diagram shows the interfaces between the various items of aircraft equipment.

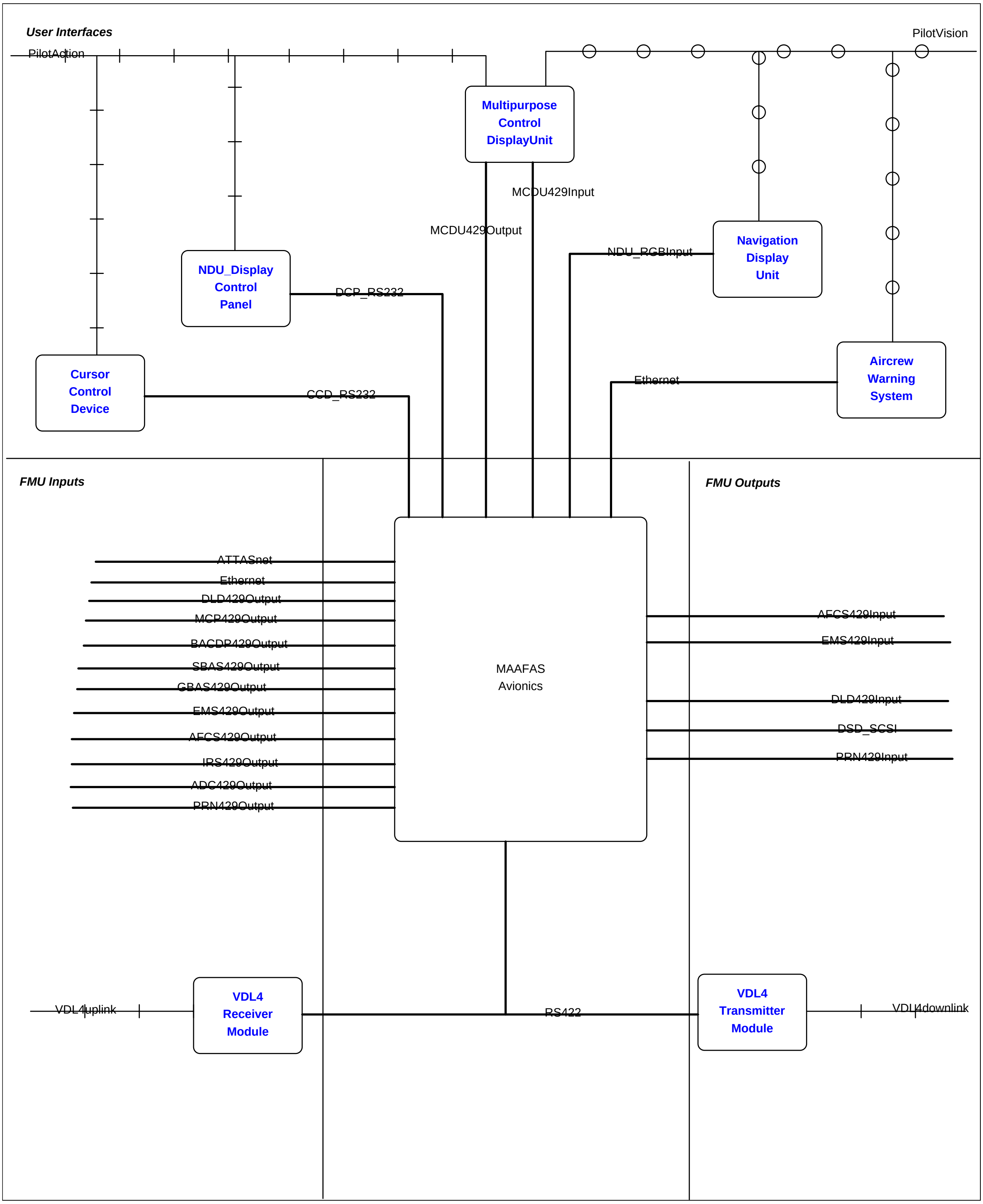

Figure 12 Equipment Interfaces

This architecture module represents the set of aircraft equipment that make up the MA-AFAS avionics suite.

This comprises a VME rack that contains the main processing components of the system and a set of pilot input and display devices. The MA-AFAS System drives two display surfaces, an Electronic Flight Instrument (EFI) that contains the navigation display formats and the Multi-purpose Control and Display Unit (MCDU). The pilot can control the navigation display using a rollerball cursive device or by selecting buttons on a dedicated Display Control Panel. The pilot controls the MCDU display content using the Line Selection Keys, dedicated menu keys and the alphanumeric keys on the MCDU. The main processing rack supports a variety of input/output protocols for communications with other aircraft equipment. This includes ARINC 429 links, SCSI links and Ethernet.

4.5.1 MAAFASAvionics

This part of the architecture model captures the core components of the MA-AFAS avionics rack. This includes both the FMU and CMU processing functions. The avionics rack also includes interface modules to handle ARINC 429 inputs and outputs, RS232 inputs and RS422 inputs. All links between the ARINC 429 input and output modules for the FMU and the CMU are assumed to be over a VME backplane.

4.5.2 CursorControlDevice

This represents the Cursor Control Device and provides a mechanism for the pilot to move a cursor. It is assumed to be a standalone piece of hardware and hence a primitive item with regard to the design of the FMS.

4.5.3 NDU_DisplayControlPanel

This module represents that section of the cockpit control panel that contains the control switches for the navigation display unit.

4.5.4 MultipurposeControlDisplayUnit

This represents the Multi-purpose compute display unit. This provides a key pad and textual display surface.

It is considered to be a standalone piece of hardware for the purposes of the design that is compliant with ARINC Characteristic 739A-

4.5.5 NavigationDisplayUnit

This module represents the Navigation Display Unit. For the purposes of the design, it is assumed to be a primitive component.

4.5.6 AircrewWarningSystem

This module represents the aircrew warning system and is responsible for generating aural alerts.

For the purposes of this design, it is considered to be a primitive item.

For the MA_AFAS trials, the system will be provided by the sound card within the IHTP.

4.5.7 VDL4TransmitterModule

This module represents the VDL mode 4 transmitter and its associated processing. It is assumed that this is implemented on a standalone piece of hardware.

It is considered to be a primitive item with respect the system design of the Flight Management System architecture.

4.5.8 VDL4ReceiverModule

This module represents the VDL mode 4 receiver and its associated processing. It is assumed that this is implemented on a standalone piece of hardware.

It is considered to be a primitive item with respect the system design of the Flight Management System architecture.

4.6 MA-AFAS Avionics

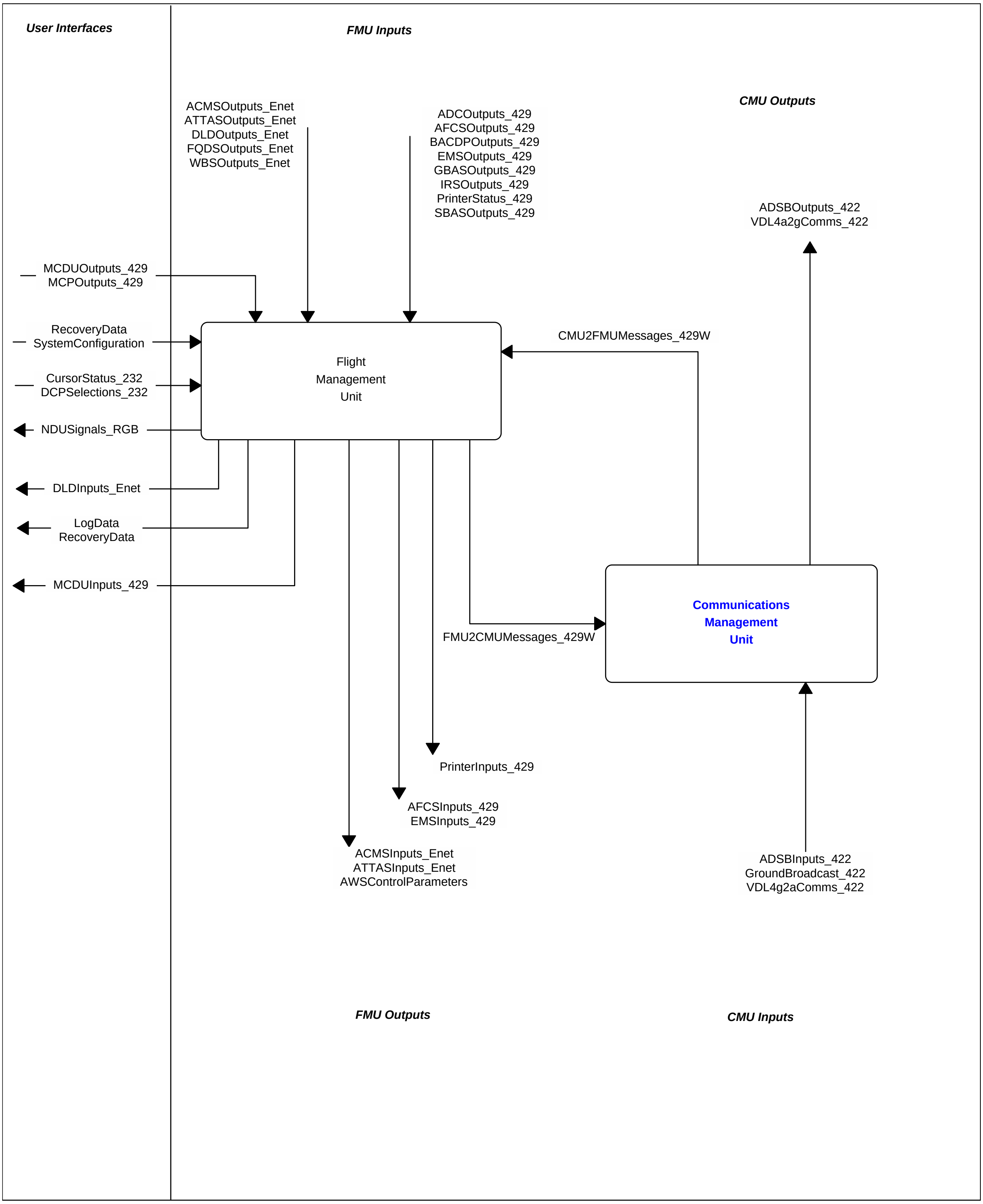

Figure 13 MAAFASAvionics AFD

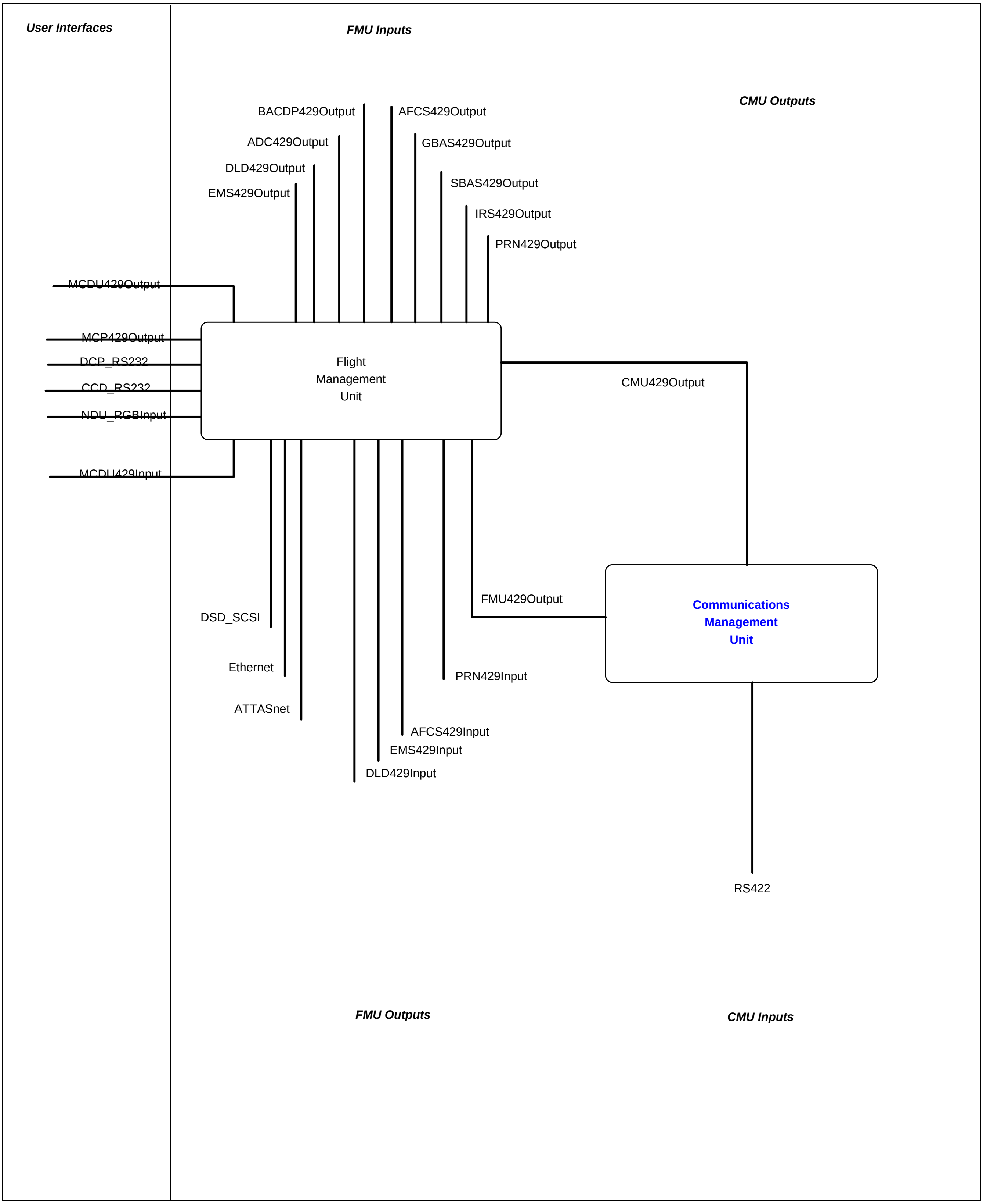

Figure 14 MAAFASAvionics AID

This part of the architecture model captures the core components of the MA-AFAS avionics rack. This includes both the FMU and CMU processing functions. The avionics rack also includes interface modules to handle ARINC 429 inputs and outputs, RS232 inputs and RS422 inputs. All links between the ARINC 429 input and output modules for the FMU and the CMU are assumed to be over a VME backplane.

4.6.1 FlightManagementUnit

This architecture module represents all of the software partitions that make up the functionality required of the Flight Management Unit.

The software partitions have been selected to match the high level functions identified within the main requirements model. Two additional partitions have been created to handle functions that are used by several of these core functions. These are the interfaces partition which will handle all of the external interfaces, e.g. ARINC 429 links, RS232, RS422 and Ethernet and a database partition.

The creation of an external interfaces partition means that the individual applications within the FMU do not need to be aware of the physical data source or sink because they only communicate with the External Interfaces partition. This simplifies the overall configuration control of the system.

The database partition is primarily aimed at containing the Navigation database. This is used by both the Displays manager functions and the Trajectory Generator functions.

The communications manager partition contains the following applications; ADS-C, AOC, CM, CPDLC, FIS and the Broadcast API.

The Display Manager partition includes separate control functions for the MCDU and NDU. These have been combined into a single partition because it simplifies the process of co-ordinating the displays in respect of handling CPDLC messages or creating delegated manoeuvres using both input devices.

The channel diagram aims to show all of the queuing ports and sampling ports that will appear within the final software. The names indicate the way in which the port is being used, e.g. "Any2DM_QP" specifies a queuing port within the Displays Manager that can receive information from a number of different partitions. In some cases, the channel names reflect expected task processes within a partition. The following abbreviations have been used within the diagram.

AG	Aircraft Guidance partition
AOC	AOC task within the COmmunications Manager partition
BAPI	Broadcast API within the Communications Manager partition
CG	Control Guidance within the Aircraft Guidance partition
CM	Context Management within Communications Partition
CP	Conflict Processing partition
CPD	Controller Pilot Datalink Communications within Communications Manager
DM	Displays Manager
FI	Flight Information Services within the Communications Manager
IH	Interface Handler
MCDU	MCDU control task within the Displays Manager partition
MG	Manoeuvre Generation control task within the Displays Manager partition
MP	Monitor Progress task within the Aircraft Guidance partition

ND	Navigation Database partition
NDU	NDU control task within the Displays manager partition
SD	Surveillance Database partition
TG	Trajectory Generation partition

4.6.2 CommunicationsManagementUnit

This module is responsible for the management of the different types of commmunications interfaces. For MA-AFAS, this is specifically VDL mode 4 communications.

This module is being treated as a primitive within this model because it is being developed by one of the partners.

4.7

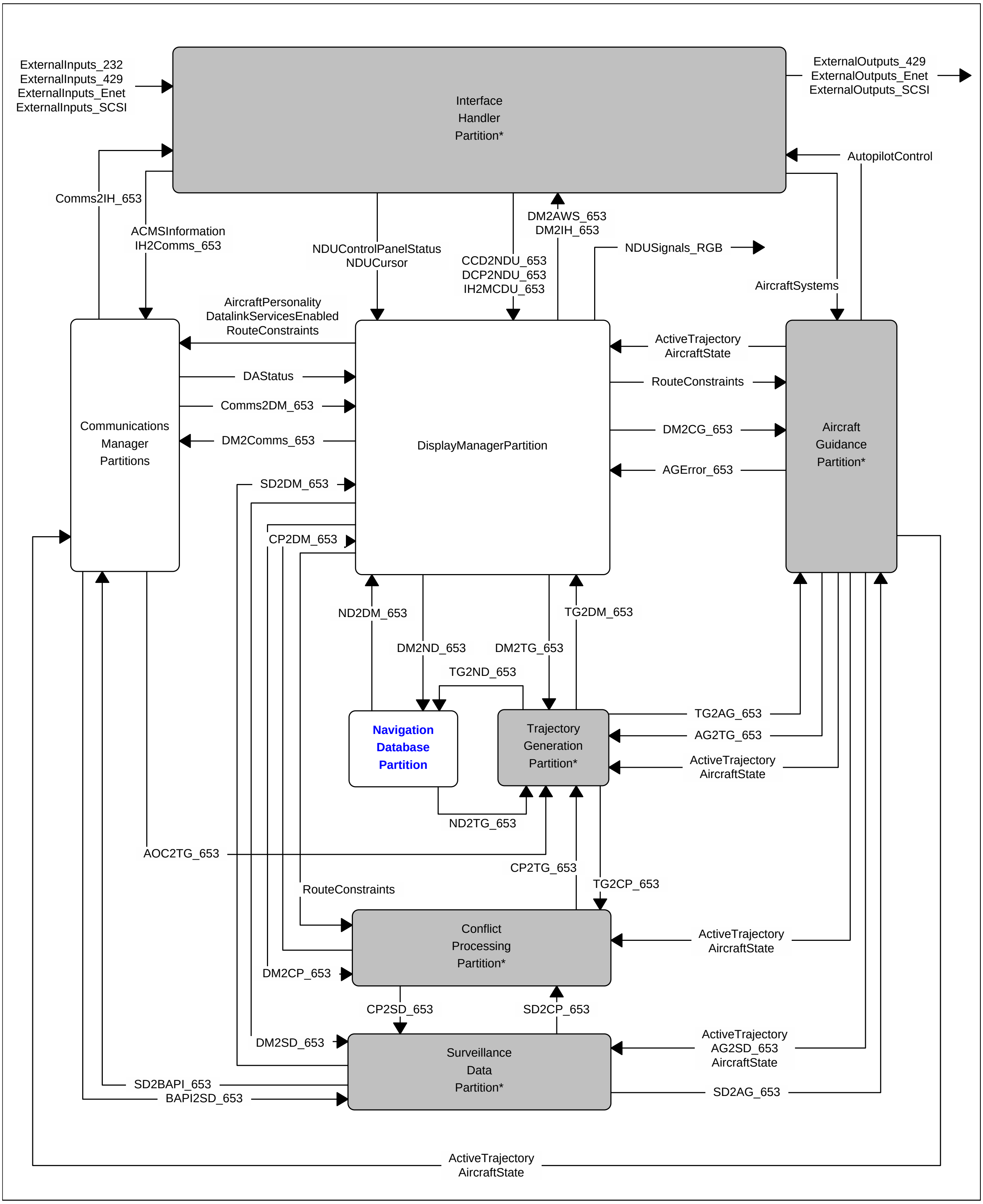

Figure 15 FlightManagementUnit AFD

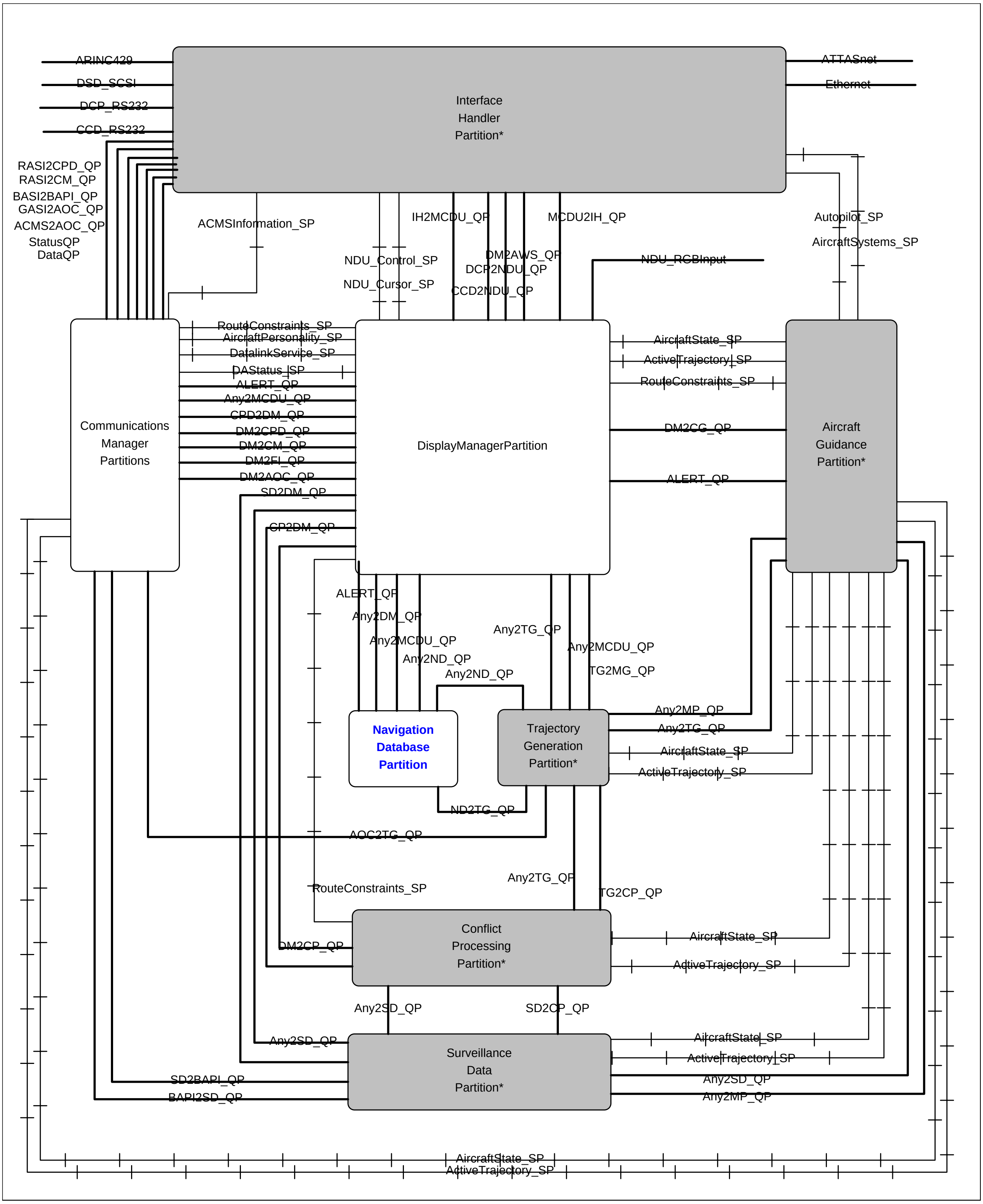

Figure 16 FlightManagementUnit AID

4.7.1 DisplayManagerPartition

This module represents the processing tasks that make up the Displays Manager. The processing has been split between five separate tasks.

The MCDU application represents the overall master for all of the tasks. It is responsible for maintaining the MCDU display surface and for responding to pilot entries. It provides the primary data entry surface for the pilot because it is only place where alphanumerical data can be entered manually.

The NDU application is responsible for controlling the content of the Navigation display unit. It has inputs from the Display control panel and cursor control unit. The display is created using an RGB interface.

The CPDLC Manager is responsible for maintaining any datalink dialogs. Any dialogs that are currently open can be accessed via a blackboard. Control functions are provided by ARINC 653 buffers.

The Manoeuvre Generator application is considered to be stand-alone application that can be activated from the MCDU. It shares its output data with both the MCDU and NDU.

The display data manager is responsible for obtaining the data required for drawing map displays, primarily the traffic data and any navigation data. The process of retrieving the data has been deliberately separated from the display processing applications so that the retrieval rate dose not have been tied to display update rates.

Initialisation

=========

The initialisation occurs in distinct stages. In the first stage, the partition initialisation is perfromed. This requires the queuing ports, sampling ports, buffers and blackboards to be defined using information that is stored in AAA blueprint files. Upon completion of this stage, then the tasks are created. The MCDU task will be created first so that a display surface is made available for presenting any errors that are detected. WHen each task is activated, it will complete its own initialisation processing before becoming available to the other processes.

4.7.2 CommunicationsManagerPartitions

This module is a container for all of the services that require a direct interface with any ground applications. This includes ADS-B, ADS-C, AOC, CM, CPDLC, FIS-B and TIS-B. The broadcast services of ADS-B, FIS-B and TIS-B are handled initially within a Broadcast API which determines the content of the broadcast message and routes the message to the approprate application. The ADS-B and TIS-B data are both passed to the Surveillance Database partition while the FIS-B data is passed to the FIS application. The remaining applications all operate independently within the partition.

Partition Processing

===============

When the system is initialised, the partition processing begins with its own initialisation tasks. There are two stages to the initialisation. IN the first stage, all of the partition level information is defined. This includes the creation of links to all of the Queuing Ports, Sampling ports and blackboards. WHen this is complete, the individual processing applications are started and they will each instigate their own local initialisation processes.

4.7.3 NavigationDatabasePartition

This module represents the control software for the Navigation database.

The module has one input queuing port on which all data requests are received. In practice, requests can only be received from either the displays manager or the Trajectory generator.

The module has access to two output queuing ports for returning the results of data requests.

Process Description

===============

There are three distinct phases to the processing within this partition. The first phase involves the creation of queuing port information using AAA protocols and blueprint files. When this is complete, the database initialisation begins. In this phase, information is read from data files and the individual database structures are created. In the final phase, the database monitors the input port for data requests and then services these requests as they are received.

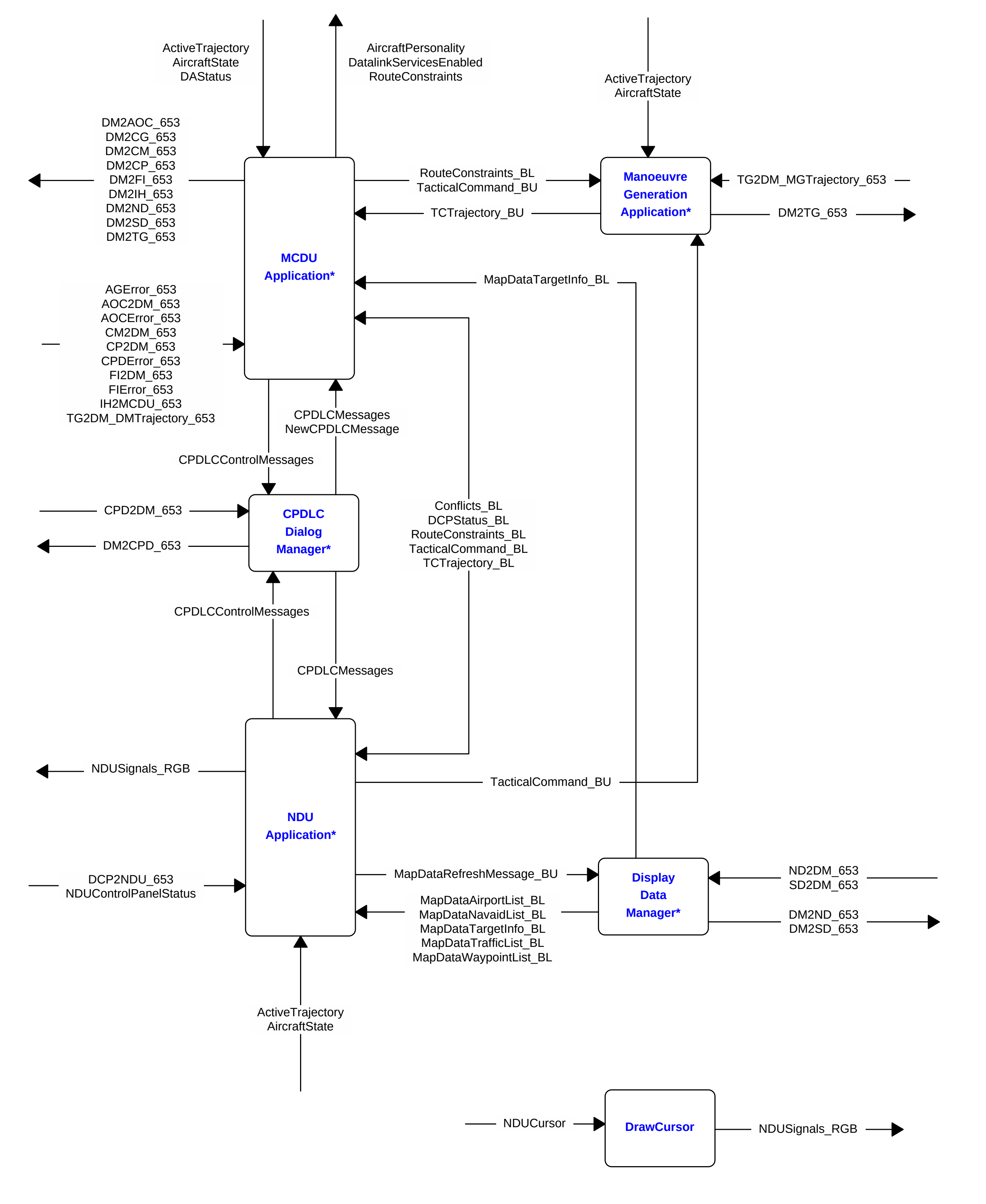

Figure 17 DisplayManagerPartition AFD

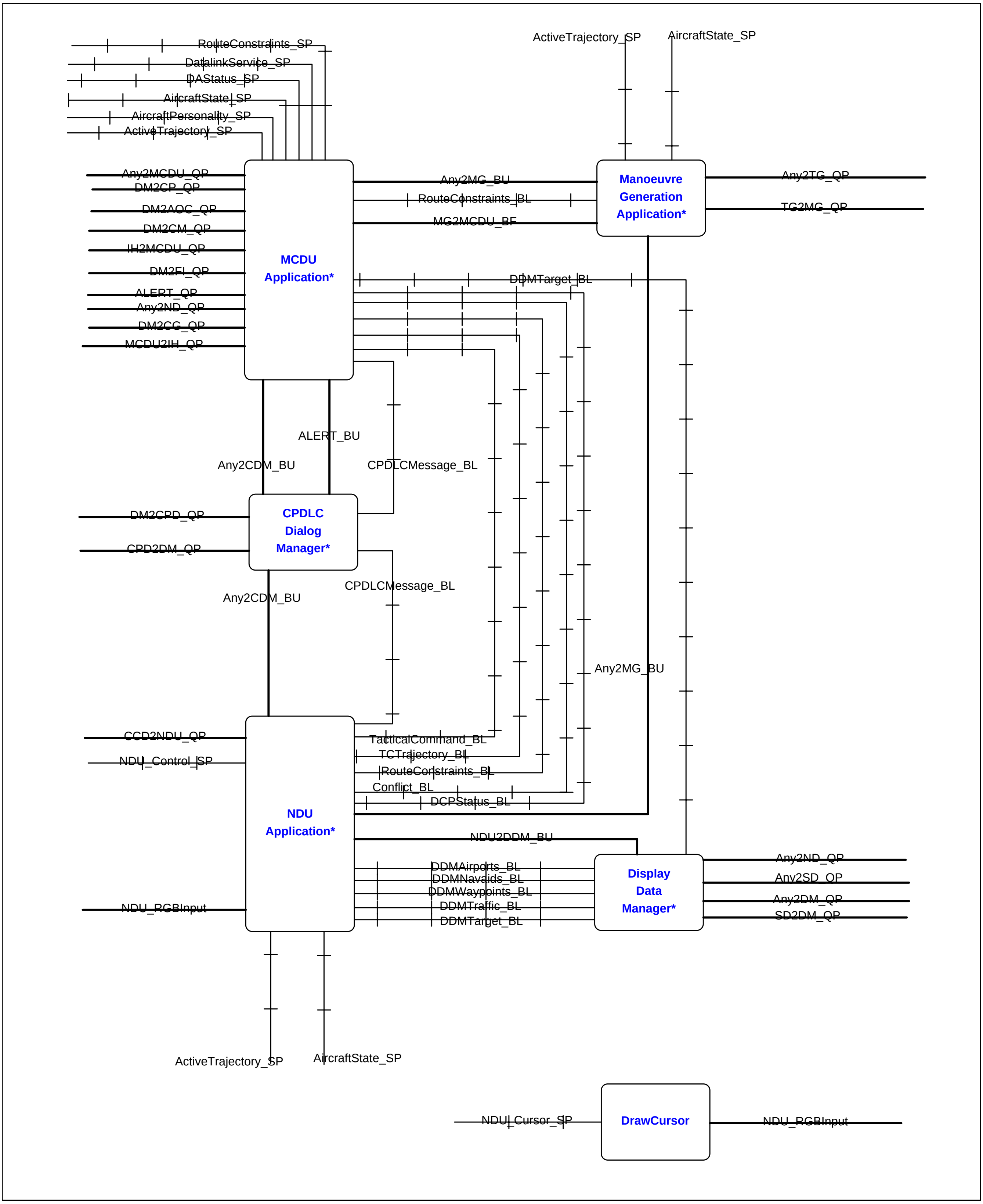

Figure 18 DisplayManagerPartition AID

4.7.3.1 DrawCursor

This task is responsible for drawing the cursor on the display screen. It uses the information that is provided on the cursor position sampling port and then draws the cursor accordingly.

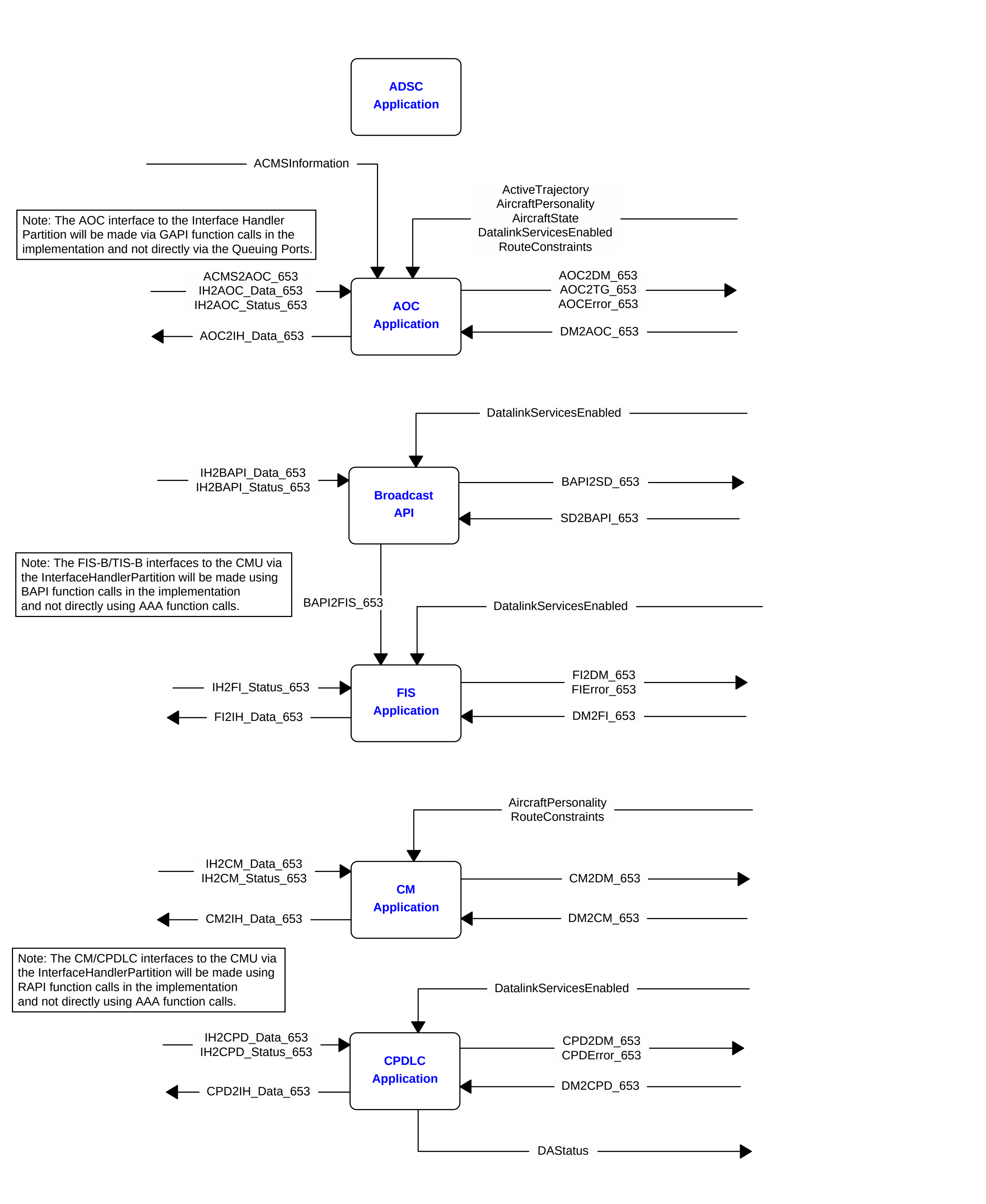

Figure 19 CommunicationsManagerPartitions AFD

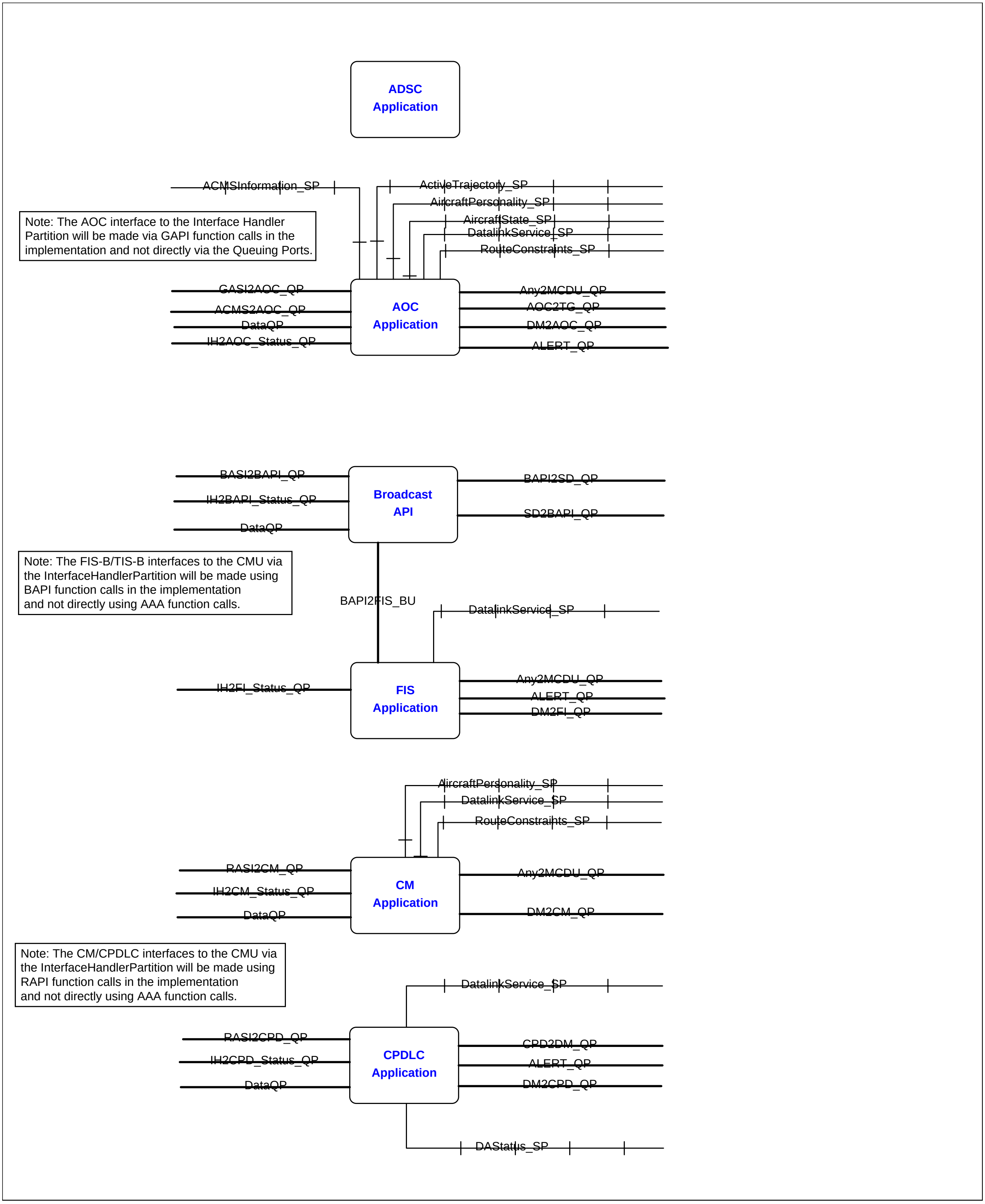

Figure 20 CommunicationsManagerPartitions AID

4.7.3.1.1 ADSCApplication

This module represents the software task that implements the ADS-C processing. This is not required within the MA-AFAS time scales.

4.7.3.1.2 AOCApplication

This module represents AOC Air Application software that is being generated by Skysoft.

The module has visibility of a number of general data stores through Sampling Port interfaces. These can be read as required from the ports.

The module requires 3 queuing ports for sending and receiving data from the CMU. Two of these are input ports and the third is an output port. One of the input ports is used for receiving data messages and the other is for receiving status messages.

The module requires 2 queuing ports for sending and receiving data from the Displays Manager.

An additional queuing port is used for sending Meteo data to the meteo database that is maintained within the trajectory generator partition.

4.7.3.1.3 BroadcastAPI

This module represents the Broadcast API software.

The module requires 3 queuing ports for interfacing with the CMU, two input ports and one output ports. One input port is dedicated to the receipt of data messages and the other port is dedicated to the receipt of status messages.

The module requires 2 quueing ports for sending and receiving messages to and from the Surveillance database partition.

The module also requires a separate link with the FIS application. This is likely to be via a blackboard as both applications exist within the one partition.

4.7.3.1.4 CMApplication

This module represents the CM Air Application software that is being generated by Skysoft.

The module has visibility of a number of general data stores through Sampling Port interfaces. These can be read as required from the ports.

The module requires 3 queuing ports for sending and receiving data from the CMU. Two of these are input ports and the third is an output port. One of the input ports is used for receiving data messages and the other is for receiving status messages.

The module requires 2 queuing ports for sending and receiving data from the Displays Manager.

4.7.3.1.5 CPDLCApplication

This module represents CPDLC Air Application software.

The module has visibility of a number of general data stores through Sampling Port interfaces. These can be read as required from the ports.

The module requires 3 queuing ports for sending and receiving data from the CMU. Two of these are input ports and the third is an output port. One of the input ports is used for receiving data messages and the other is for receiving status messages.

The module requires 3 queuing ports for sending and receiving data from the Displays Manager. There are two output ports because Error messages and CPDLC messages are sent to a different ports.

4.7.3.1.6 FISApplication

This module represents the FIS Air appication software.

The module contains one queuing port for sending data to the ATS. A second queuing port has been defined for receiving status information from the FMU/CMU interface application.

The module includes two queuing ports for sending and receiving messages to and from the Displays manager.

4.8 Concept Of Execution

In order to simplify the description of the System execution, a number of "use cases" have been created that aim to capture some of the main operating functions of the System.

4.8.1 Power On

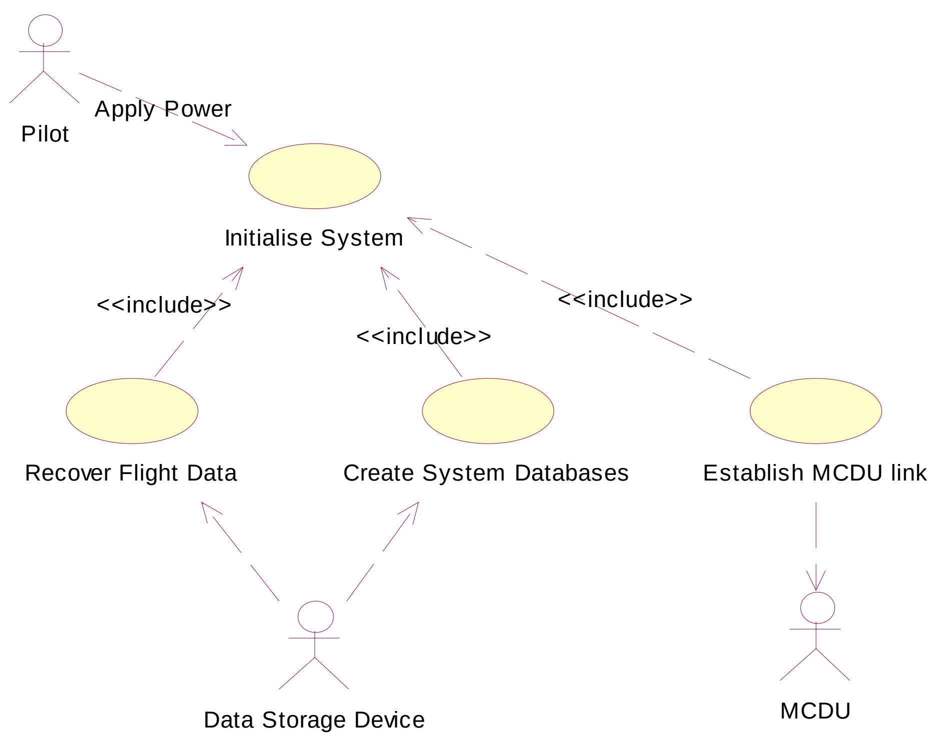

Figure 21 Initialisation Use Case Diagram

After the application of power to the System and before the System becomes available for use by the pilot, the following series of actions are performed.

The first task is the verification of the correct operation of the internal hardware followed by an integrity check of the program software and the internal data. The software and associated data are then downloaded from the hard disk.

Next, the stored flight data is examined in order to decide whether a warm or cold boot must be performed.The type of initialisation process will be dependent upon how much time has elapsed since power was removed from the system. If the elapsed time is less than 10 seconds, then a "warm" boot is implemented and the flight information at the time of the power loss must be re-instated. When the elapsed time is greater than 10s, then the System implements a normal boot process.

This is followed by the creation of the system databases using information that is held on the data storage device. A configuration datafile contains the locations of all of the datafiles that contain information that is required by the system. Each datafile will be read in turn in order to generate a particular database for the System.

The final task is the establishment of a communications link with the MCDU so that the pilot can interact with the System. The control of the MCDU by the System requires that a communications link is set up using ARINC 429 protocols defined in the ARINC 739A specification. This requires label 172 to be transmitted by the System to the MCDU in order to identify the System. Communication is established when an "ENQ" label is returned. Once communication is established, then a "RTS" label should be sent in order to request control of the MCDU. When a "CTS" label has been returned, the initial menu page can be displayed.

4.8.2 Maintain Database

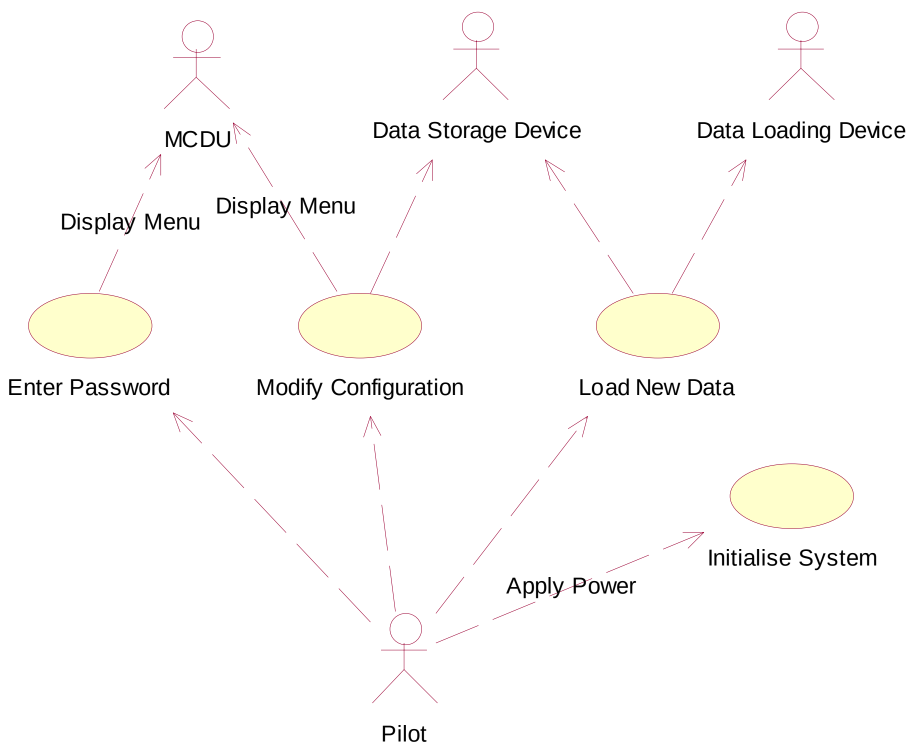

Figure 22 Maintenance Use Case Diagram

The database maintenance functions have been designed so that they are only available after the System initialisation sequence has been completed. In order to prevent any accidental changes to the database during a flight, the set of maintenance functions are password protected so that their use is limited to authorised users only. As a further level of protection, access to the database functions will normally be limited to situations where the aircraft is stationary. For the MA-AFAS trials, this extra check may be disabled.

Once an authorised user has entered the correct password, the System will check for the presence of a data loading device. If a data loader is available, then the user will be able to upload new information onto the System data storage device. In order for this new data to become available to the System, the System must be powered down and re-initialised.

An authorised user will also be able to modify the configuration data for the System. Any modifications will be written to the data storage device so that they are available when the System is next initialised.

4.8.3 Negotiate Trajectory

The trajectory negotiation functions are only available when the System is in the normal operating state.

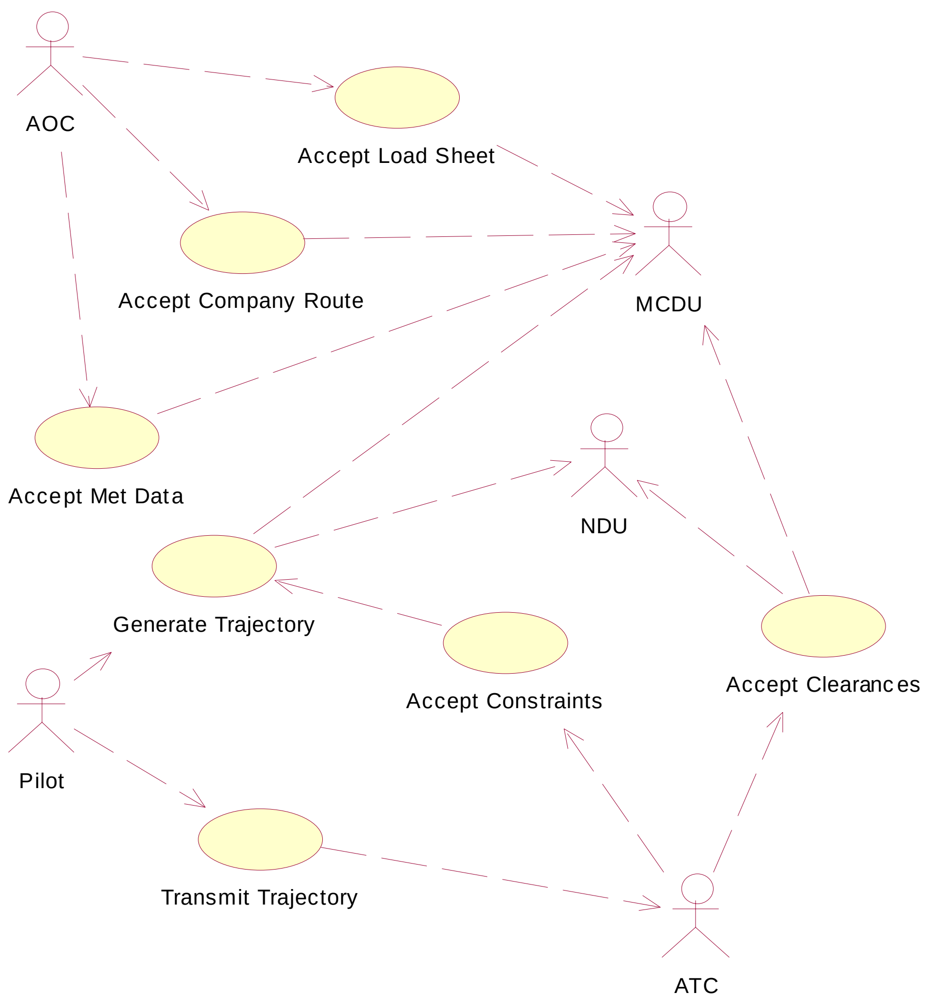

Figure 23 Trajectory Negotiation Use Case Diagram

The trajectory negotiation process involves the AOC, the ATC and the pilot. It can occur at any stage of a flight beginning with pre-flight, and normally repeating with each new sector as it is approached, unless an ATSU has been able to give a multi-sector clearance.

The process typically begins with the pilot generating a trajectory from the company route information that has been specified by the AOC. The basic route data may need modification as a result of other information that is supplied by the AOC such as Meteorological data and load sheet information.

Whenever new AOC information is received by the System, an alert message will be displayed on the MCDU. It is then the pilot's responsibility to review the new information and act accordingly.

When a trajectory is generated, the result will be displayed on both the MCDU and the NDU. The MCDU presents the trajectory information in textual form while the NDU presents the information in graphical form.

When the pilot is happy with the trajectory, he will transmit the trajectory to the ATC in order to obtain the necessary clearances. The ATC will check the trajectory data against the previously filed flight plan and check that no conflicts are generated with other aircraft. If the ATC approve the trajectory, they will transmit clearances for any segments of the trajectory for which they have responsibility. If the ATC require modifications to the trajectory to be made, a request for changes is transmitted to the pilot along with a clearance (which assumes that the crew will be able to accept the changes). When additional constraints are specified by the ATC, then the trajectory will be automatically re-generated upon receipt ofthe information and the revised trajectory information will be displayed.

Upon receipt of clearance data for a trajectory, the pilot sends an acknowledgement message to the ATC.

4.8.4 Handle Controller Pilot Datalink Communications

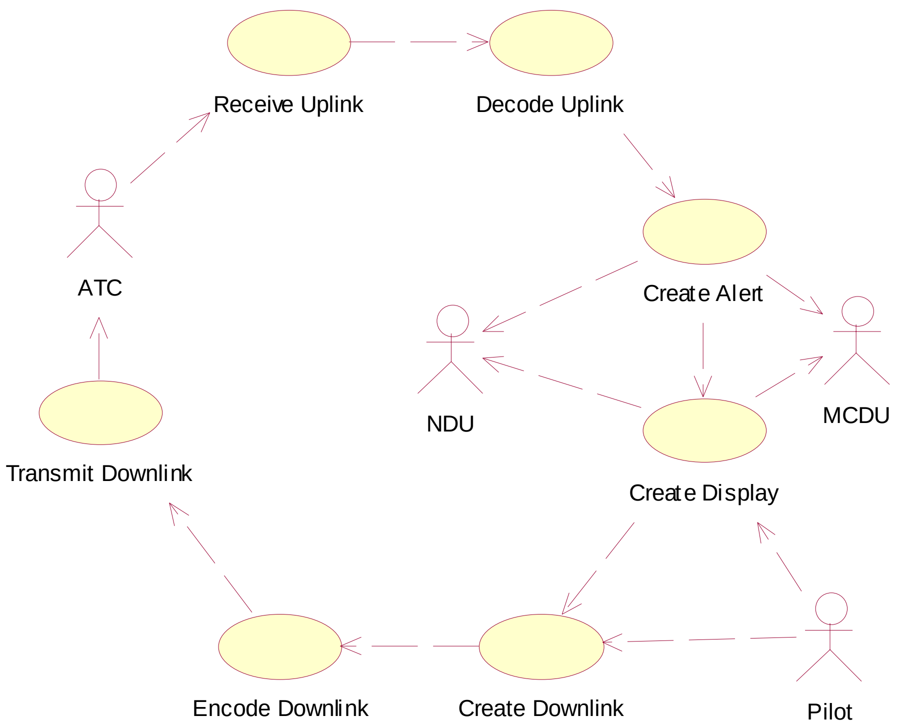

Figure 24 Handle CPDLC Usecase Diagram

CPDLC can be considered to comprise two types of dialogue where each dialogue includes an initial message and a response to that message. A dialogue can be initiated either by the pilot or the controller.

When a dialogue is initiated by the Controller, a message is transmitted to the aircraft over a VHF link using an agreed protocol, e.g. VDL mode 4. Upon receipt of the message, the System extracts the message from within the various stack layers. This task represents one part of the CMU processing activities. After the message has been transferred to the FMU, the extracted message is then decoded into a form that can be used by the HMI processing.

When a message is received by the HMI, an alert message is created on both the MCDU and the NDU so that the pilot is made aware of the new message. When the pilot has time to view the message, the will make the appropriate menu selections to display the message.

If the message requires a response, the System will enable the pilot to create a response message. This message will be encoded and then passed to the CMU for transmission to the Controller.

The process for pilot initiated dialogues is very similar. In this case, the pilot uses the menus on the MCDU to create a message. This is encoded and passed to the CMU for transmission. At some later time, the Controller will transmit a response to this message. This is decoded and an alert indicating the receipt of a message response will be created. The pilot can view this response in his own time.

It is the task of the encoding and decoding processes to co-ordinate messages and responses for both Controller initiated dialogues and Pilot initiated dialogues.

4.8.5 Implement Tactical Command

The implementation of a tactical command represents a modification to the normal aircraft guidance mode and depends upon the type of command that is received.

If the command requires a simple change to the speed, heading or altitude, then this is implemented by suspending the currently active trajectory and commanding the autopilot to make the required change.

If the command requires a manoeuvre to be implemented, a set of constraints are generated appropriate to the manoeuvre and a manoeuvre trajectory is created. This is set as the new active trajectory and the guidance function then drives the aircraft along this trajectory while monitoring the distance from the specified target aircraft. Adjustments to the trajectory are made if the aircraft separations are predicted to become unsafe.

5 REQUIREMENTS TRACEABILITY

This document is maintained using the DOORS requirements management tool. The following paragraphs indicate where each of the requirements identified in D18 is addressed within the system design.

Text for D19	D18 Link Information
5.1 Operating States and Modes	
5.1.1 Power Off State	
When power is applied to the System, it shall enter the Initialise state.	Air-SS-1128 [There are no other states that can be entered when power is applied to the system.] [Partially Compliant] [Direct]
5.1.2 Initialise State	
Once the initialisation processing is complete, the System status and any necessary recovery data, e.g. active trajectory or traffic information, shall be written to an area of store on the Hard Disk Drive at time intervals of not greater than 30 seconds so that in the event of a power failure, the System can resume processing with minimal input from the pilot.	Air-SS-409 [This requirement only captures the need for storing essential data in order to enable system recovery after a power failure.] [Partially Compliant] [Direct]
A production standard version of the System shall continue normal operation if the duration of a power interruption is less than 200ms.	Air-SS-409 [The time limit is taken from ARINC 702A-1, paragraph 2.4.1.] [Partially Compliant] [Derived]
If the time since power was removed is greater than 10 seconds, then a "cold" boot process shall be initiated.	Air-SS-409 [The time limit chosen is the longest allowed in ARINC 702A-1, paragraph 3.3.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
Upon completion of a "cold" boot process where data and code transfers have been completed successfully, the system shall enter the Preflight state.	Air-SS-1129 [The Preflight state in D19 represents one part of the Operate state that is identified in D18.] [Fully Compliant] [Direct] Air-SS-409 [This requirement addresses the requirements of ARINC 702A-1, paragraph 3.3.] [Partially Compliant] [Derived]
For power interruption intervals of less than 10 seconds but greater than 200 milliseconds, the System state prior to the power interruption shall be restored with no input required from the pilot provided that all navigation systems are operable.	Air-SS-409 [The time limits have been extracted from ARINC 702A-1.] [Fully Compliant] [Derived]
5.1.3 Preflight State	
The System shall transition from the Preflight state to the Maintenance state only on pilot command.	Air-SS-1141 [The proposed state transition diagram does not allow this transition because the interpretation of the Initialise and Operate states in D18 do not map directly to the states used in D19.] [Partially Compliant] [Derived] Air-SS-1543 [The transition requires the pilot to select the appropriate menu option on the MCDU.] [Fully Compliant] [Direct]

Text for D19	D18 Link Information
The transition from the Preflight state to the Maintenance state shall require a password to be entered.	Air-SS-1259 [] [Fully Compliant] [Direct]
The transition from the Preflight state to the Taxi state shall occur only upon pilot command subject to the condition that all navigation systems are operable.	Air-SS-1127 [D19 identifies additional states within the Operate state of D18.] [Partially Compliant] [Derived]
5.1.4 Maintenance State	
It shall be possible for the pilot to cause a re-initialisation of the System from the Maintenance state.	Air-SS-1127 [D18 indicates that power must be removed before the System can be re-initialised. This may not always be practical and so the option of selecting a re-initialisation has been provided.] [Partially Compliant] [Direct]
5.1.5 Taxi State	
The System shall generate a single internal signal, "Aircraft On Ground", that indicates whether the aircraft is on the ground or in the air using as a minimum, the "Weight On Wheels" signal and the aircraft air speed.	Air-SS-1127 [These states are not defined explicitly in D18 and so this transition represents an internal transition within the Operate state of D18.] [Partially Compliant] [Derived]
The System shall transition from the Taxi state to the Monitor state when Take-Off occurs, i.e. the “Aircraft On Ground” signal is removed.	Air-SS-1127 [These states are not defined explicitly in D18 and so this transition represents an internal transition within the Operate state of D18.] [Partially Compliant] [Derived]
5.1.6 Monitor State	

Text for D19	D18 Link Information
A transition from the Monitor state to the Guidance state shall occur when the FMS is selected by the pilot to guide the aircraft subject to the condition that all navigation systems are operable.	Air-SS-1127 [This transition occurs as a direct result of a pilot action and is not a specific requirement of D18.] [Partially Compliant] [Derived]
The System shall transition from the Monitor state to the Taxi state when the aircraft lands as indicated by the generation of a “Aircraft On Ground” signal.	Air-SS-1127 [These states are not defined explicitly in D18 and so this transition represents an internal transition within the Operate state of D18.] [Partially Compliant] [Derived]
5.1.7 Guidance State	
A transition from the Guidance state to the Monitor state shall occur when the FMS guidance is disengaged by the pilot.	Air-SS-1127 [These states are not defined explicitly in D18 and so this transition represents an internal transition within the Operate state of D18.] [Partially Compliant] [Derived]
5.2 Capability	
5.2.1 HMI	
5.2.1.1 MCDU	
5.2.1.1.1 Physical Characteristics	
The physical characteristics of the MCDU shall be compliant with paragraph 2 of ARINC 739A-1.	Air-SS-2625 [] [TBD] [TBD]
5.2.1.1.2 Display Requirements	

Text for D19	D18 Link Information
The presentation style and behaviour of all displayed information on the MCDU shall follow the guidelines laid down in Attachment 10 of ARINC 739A, "MCDU Display Considerations".	Air-SS-2627 [The behaviour is tied into the behaviour specified within the NLR HMI document that follows these guidelines.] [Partially Compliant] [Direct]
5.2.1.1.3 Function Keys	
The menu behaviour resulting from a button press on a special function key shall be consistent with the behaviour specified in paragraph 3.3.1 of ARINC 739A-1.	Air-SS-2627 [The derived requirement only addresses the behaviour of the display in response to pressing a function key.] [Partially Compliant] [Direct]
5.2.1.1.4 Line Select Keys	
The behaviour of the System with regard to a Line Key selection shall be consistent with the behaviour specified in paragraph 3.4 of ARINC 739A-1.	Air-SS-2627 [The derived requirement only addresses the behaviour of the display in response to pressing an LSK.] [Partially Compliant] [Direct]
5.2.1.1.5 Scratchpad	
The behaviour of the System with regard to the scratchpad shall be consistent with paragraph 3.4.5 of ARINC 739A-1.	Air-SS-2627 [The derived requirement only addresses the scratchpad behaviour.] [Partially Compliant] [Direct]
5.2.1.1.6 Lamps	
The “MSG” lamp shall be lit whenever an alert message or an advisory message has been received by the MCDU that has not been acknowledged by the pilot.	Air-SS-2629 [No change from D18 requirement.] [Fully Compliant] [Direct]

Text for D19	D18 Link Information
The “ATC” lamp shall be lit whenever a CPDLC message has been received from an ATC that has not been acknowledged by the pilot.	Air-SS-2628 [No change from D18 requirement.] [Fully Compliant] [Direct]
5.2.1.2 Navigation Display Unit	
5.2.1.2.1 Display Control Panel	
While the TAXI display mode is selected, the display range scale shall be interpreted as 1/40 of the annotated range scale.	Air-SS-2632 [D18 does not mention the manual switches that are associated with the control of the display.] [Partially Compliant] [Derived]
A request for a display mode change, e.g. change of map scale or a change to the displayed data, shall occur within 1s of the request being made.	Air-SS-2632 [D18 does not mention the manual switches that are associated with the control of the display.] [Partially Compliant] [Derived]
5.2.1.2.2 Cursor Control Device	
The Cursor Control Device (CCD) will be a trackball. The CCD will be positioned in the cockpit aft of the MCDU and in close reach of the pilot. The CCD will be equipped with two select buttons.	Air-SS-2643 [No design decision necessary.] [Fully Compliant] [Direct]
The behaviour of the cursor and the display in response to a cursor button selection shall be consistent with the behaviour described in the NLR HMI design document.	Air-SS-2642 [] [Partially Compliant] [Derived]
5.2.1.2.3 Menu Bar	

Text for D19	D18 Link Information
The menu controller shall create a menu structure at initialisation using information stored in a file on the System hard disk drive.	Air-SS-2625 [The menu structure should be loadbale at run-time.] [Partially Compliant] [Derived]
5.2.1.3 Alert Handling	
5.2.1.3.1 Alert Management	
All situation awareness alerts generated by the System whilst the aircraft is in under direct ATC control shall be treated as Information alerts.	Air-SS-2653 [The derived requirement provides control that it is not specified in D18.] [Partially Compliant] [Derived]
The System shall issue alerts associated with the Conflict Detection function at a maximum rate of 1 per 30 seconds.	Air-SS-2653 [The derived requirement provides control that it is not specified in D18.] [Partially Compliant] [Derived]
The crew shall be able to cancel/acknowledge alerts via an entry into the MCDU or a menu selection on the navigation display unit.	Air-SS-2653 [The derived requirement provides control that it is not specified in D18.] [Partially Compliant] [Derived]
It shall be possible to inhibit the display of information messages generated by the FMU at any flight phase.	Air-SS-2653 [The derived requirement provides control that it is not specified in D18.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
It shall be possible to inhibit the display of advisory alert messages generated by the FMU at any flight phase.	Air-SS-2653 [The derived requirement provides control that it is not specified in D18.] [Partially Compliant] [Derived]
5.2.1.3.2 MCDU	
When there is more than one message awaiting display to the pilot, the messages shall be presented in priority order.	Air-SS-2653 [D18 does not address the possibility of multiple alerts.] [Partially Compliant] [Derived]
An information message shall be displayed in white text within the scratchpad area.	Air-SS-2653 [D18 does not consider the different alert levels.] [Partially Compliant] [Derived]
An advisory alert message shall be displayed in amber text within the scratchpad area.	Air-SS-2653 [D18 does not consider the different alert levels.] [Partially Compliant] [Derived]
An abnormal alert message shall be displayed in amber text within the scratchpad area.	Air-SS-2653 [D18 does not consider the different alert levels.] [Partially Compliant] [Derived]
5.2.1.3.3 Navigation Display Unit	
All advisory and abnormal alerts shall be displayed in the message bar in amber text.	Air-SS-2654 [Alerts are indicated by displaying a text message at the bottom of the display. Graphical symbology will be used only where appropriate, e.g. in the generation of conflict alerts.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
All warnings shall be displayed in the message bar in red text.	Air-SS-2654 [Alerts are indicated by displaying a text message at the bottom of the display. Graphical symbology will be used only where appropriate, e.g. in the generation of conflict alerts.] [Partially Compliant] [Direct]
5.2.2 Aircraft Guidance	
The operation of the aircraft guidance functions shall take precedence over all other functions.	Air-SS-187 [D18 Requirement.] [Fully Compliant] [Direct]
5.2.2.1 Monitoring	
A trajectory progress monitoring process shall be automatically initiated upon activation of a trajectory by the pilot.	Air-SS-280 [D18 Requirement.] [Fully Compliant] [Direct]
The monitoring functions shall be performed at a rate of approximately 2Hz.	Air-SS-280 [This is derived from the AATMS/AFMS/EFMS programmes.] [Partially Compliant] [Derived]
Each time dependant monitor function shall compute its own activation rate.	Air-SS-280 [This is derived from the AATMS/AFMS/EFMS programmes.] [Partially Compliant] [Derived]
5.2.2.1.1.1 Trajectory Tolerances	

Text for D19	D18 Link Information
The Required Navigational Performance (RNP) of the airspace the aircraft will be travelling through shall be used to define the lateral tolerance for each point in the active trajectory within that airspace.	Air-SS-1171 [D18 Requirement.] [Fully Compliant] [Direct]
These tolerances shall be reduced by the error represented by the current Actual Navigation Performance (ANP) of the aircraft navigation systems.	Air-SS-1172 [D18 Requirement.] [Fully Compliant] [Direct]
The Required Vertical Navigation Performance (RVNP) of the airspace the aircraft will be travelling through shall be used to define the altitude tolerance for each point in the active trajectory within that airspace.	Air-SS-1265 [D18 Requirement.] [Fully Compliant] [Direct]
The Required Time Navigation Performance (RTNP) of the airspace the aircraft will be travelling through shall be used to define the time tolerance for each point in the active trajectory within that airspace.	Air-SS-1266 [D18 Requirement.] [Fully Compliant] [Direct]
The hyperpipe shall be defined by applying the tolerances of each point in the active trajectory to its corresponding point in the active trajectory thereby creating a set of maximum and minimum limits for each point in the active trajectory.	Air-SS-189 [This is needed to perform the monitoring part of the D18 requirement.] [Partially Compliant] [Derived]
The hyperpipe for a trajectory shall be generated when the trajectory is activated.	Air-SS-189 [This is to stop any of the negoiated clearances from being altered.] [Non Compliant] [Derived]

Text for D19	D18 Link Information
The tolerance limits for a position between two trajectory points shall be calculated by linear interpolation.	Air-SS-2549 [D18 Requirement.] [Fully Compliant] [Direct]
5.2.2.1.1.2 Trajectory Position Prediction	
The monitoring function shall predict the aircraft position at 10 second intervals for the next 600 seconds ahead of the current aircraft position.	Air-SS-1573 [This is needed to perform the monitoring part of the D18 requirement.] [Partially Compliant] [Derived] Air-SS-333 [This is needed to perform the monitoring part of the D18 requirement.] [Partially Compliant] [Derived] Air-SS-189 [This is needed to perform the monitoring part of the D18 requirement.] [Partially Compliant] [Derived]
5.2.2.1.1.3 Trajectory Guidance Closed Loop Monitoring	
A System Informational Alert shall be generated if the System predicts that the aircraft will breach the hyperpipe within the next 600 seconds.	Air-SS-1573 [The HMI will be informed of the problem and it will generate the information alert prioritised by what other messages it receives.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
If the System detects that the aircraft will breach the hyperpipe within the next 600 seconds, then a new trajectory shall be generated to correct the deviation.	Air-SS-189 [This is needed to perform the guiding part of the D18 requirement.] [Partially Compliant] [Derived]
The 4D positions in the regenerated trajectory shall be compared with the bounds of the cleared trajectory as defined by the hyperpipe.	Air-SS-189 [This is to check that the regenerated trajectory meets the original clearance negotiated.] [Partially Compliant] [Derived]
A System Advisory Alert shall be generated if the System detects that the regenerated trajectory will breach the hyperpipe.	Air-SS-98 [The original clearance is no longer valid and needs to be re-negotiated. The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Derived]
If the regenerated trajectory does not breach the hyperpipe, then the regenerated trajectory shall be set as the active trajectory.	Air-SS-189 [This is needed to perform the guiding part of the D18 requirement.] [Partially Compliant] [Derived]
5.2.2.1.1.4 Trajectory Monitoring	
The monitoring function shall compare the current aircraft position to the hyperpipe.	Air-SS-1512 [D18 Requirement.] [Fully Compliant] [Direct]

Text for D19	D18 Link Information
A System Advisory Alert shall be generated if the aircraft manoeuvres outside the hyperpipe.	Air-SS-98 [The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Direct]
A System Advisory Alert shall be generated if the 4D predicted aircraft position at (300) seconds ahead of the current aircraft position is beyond the end of the hyperpipe.	Air-SS-333 [The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Direct]
5.2.2.1.1.5 Spacing Monitoring	
When performing a spacing manoeuvre, a Spacing Alert shall be generated if the longitudinal separation between the own aircraft and target aircraft is outside the defined tolerance.	Air-SS-453 [D18 Requirement modified by :- in the current design of the system all other traffic equates to one target aircraft.] [Fully Compliant] [Direct] Air-SS-454 [TBD] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
When performing a spacing manoeuvre, a Spacing Alert shall be generated if the horizontal separation between the own aircraft and target aircraft is less than the specified separation.	Air-SS-453 [D18 Requirement modified by :- in the current design of the system all other traffic equates to one target aircraft.] [Fully Compliant] [Direct] Air-SS-454 [TBD] [Partially Compliant] [Derived]
When performing a spacing manoeuvre with a lateral offset specified, a Spacing Alert shall be generated if the lateral offset is outside its tolerance.	Air-SS-454 [TBD] [Partially Compliant] [Derived] Air-SS-231 [Deviations from lateral offset should be treated the same as deviations from separation.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
When performing a spacing manoeuvre with a vertical offset specified, a Spacing Alert shall be generated if the vertical offset is outside its tolerance.	Air-SS-454 [TBD] [Partially Compliant] [Derived] Air-SS-231 [Deviations from vertical offset should be treated the same as deviations from separation.] [Partially Compliant] [Derived]
When performing a spacing manoeuvre, the separation deviation shall be calculated by taking the difference between the required separation and the actual separation.	Air-SS-258 [The separation deviation needs to be calculated in order to determine whether or not a separation loss will occur.] [Partially Compliant] [Derived]
When performing a spacing manoeuvre, the separation trend shall be calculated from the separation deviation by taking the difference between this separation deviation and the previous and differentiating over the time period between the calculating of the separation deviation.	Air-SS-258 [The separation trend needs to be calculated in order to determine whether or not a separation loss will occur.] [Partially Compliant] [Derived]
When performing a spacing manoeuvre, the separation deviation and trend shall be used to estimate the separation for a time (120) seconds in the future.	Air-SS-258 [The predicted separation needs to be calculated in order to determine whether or not a separation loss will occur.] [Partially Compliant] [Derived]
When performing a spacing manoeuvre, a Spacing Alert shall be generated if the separation distance is predicted to be lost within the next (120) seconds.	Air-SS-258 [TBD] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
When performing a spacing manoeuvre, the calibrated airspeed of the target aircraft shall be monitored.	Air-SS-456 [D18 Requirement.] [Fully Compliant] [Direct]
If the calibrated airspeed of the target aircraft is not available, then the groundspeed of the target aircraft shall be converted to calibrated airspeed.	Air-SS-456 [The target aircraft calibrated airspeed is not always available from the ADS-B/TIS-B messages.] [Non Compliant] [Derived]
When performing a spacing manoeuvre, a Spacing Alert shall be generated if the calibrated airspeed of the target aircraft approaches within 30kts of the minimum normal operating calibrated airspeed of the own aircraft in the current flight configuration.	Air-SS-457 [This performs the minimum speed part of the D18 requirement.] [Partially Compliant] [Derived]
When performing a spacing manoeuvre, a Spacing Alert shall be generated if the calibrated airspeed of the target aircraft approaches within 30kts of the maximum normal operating calibrated airspeed of the own aircraft in the current flight configuration.	Air-SS-457 [This performs the maximum speed part of the D18 requirement.] [Partially Compliant] [Derived]
When performing a spacing manoeuvre the position of the target aircraft shall be monitored. (To do :- Need to replace with calculation of cross track error.)	Air-SS-458 [D18 Requirement.] [Fully Compliant] [Direct]
When performing a spacing manoeuvre a Spacing Alert shall be generated if the cross track error of the target aircraft is greater than twice the associated airspace's RNP for the corresponding point on the aircraft's trajectory.	Air-SS-459 [TBD] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
When performing a spacing manoeuvre the altitude rate of the target aircraft shall be monitored.	Air-SS-460 [D18 Requirement.] [Fully Compliant] [Direct]
When performing a spacing manoeuvre if the altitude rate of the target aircraft is not available the altitude shall be monitored and the altitude rate calculated.	Air-SS-460 [The target aircraft altitude rate/vertical velocity is not always available from the ADS-B/TIS-B messages] [Non Compliant] [Derived]
When performing a level flight spacing manoeuvre a Spacing Alert shall be generated if the altitude rate of the target aircraft changes by ±200ft/min.	Air-SS-461 [This performs the level flight spacing part of the D18 requirement.] [Partially Compliant] [Derived]
When performing an in descent spacing manoeuvre a Spacing Alert shall not be generated if the altitude rate of the target aircraft changes by ±200ft/min.	Air-SS-461 [This performs the in descent spacing part of the D18 requirement.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
When a Spacing Alert is generated a System Advisory Alert shall be generated.	Air-SS-461 [The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Direct] Air-SS-459 [The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Direct] Air-SS-457 [The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Direct] Air-SS-258 [The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Direct] Air-SS-454 [The HMI will be informed of the problem and it will generate the advisory alert prioritised by what other messages it receives.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
5.2.2.2 Guiding	
The aircraft guidance functions shall use the active trajectory as the basis for generating the aircraft guidance commands.	Air-SS-188 [D18 Requirement.] [Fully Compliant] [Direct]
5.2.2.2.1.1 Trajectory Guiding	
The guiding function shall correct the aircraft guidance commands generated for the differences between the actual environmental conditions, contained within the Aircraft State, and the predicted environmental conditions, contained within the active trajectory.	Air-SS-189 [This performs the guiding part of the D18 requirement.] [Partially Compliant] [Direct]
5.2.2.2.1.2 Spacing Guiding	
When the aircraft has manoeuvred to be behind the target aircraft, the target aircraft shall be monitored and the speed of the aircraft adjusted to maintain specified longitudinal separation (specified as a relative distance or a relative time) within the specified tolerance.	Air-SS-231 [This performs the longitudinal separation part of the D18 requirement but without the need to generate constraints and associated trajectory.] [Partially Compliant] [Direct]
If the optional lateral offsets have been specified then when the aircraft has manoeuvred to be behind the target aircraft, the target aircraft shall be monitored and the aircraft guidance commands adjusted to maintain specified lateral offset within a TBD tolerance (e.g. ±100m).	Air-SS-231 [This performs the lateral offset part of the D18 requirement but independently from the longitudinal separation and without the need to generate constraints and associated trajectory.] [Partially Compliant] [Direct]
If the optional vertical offsets have been specified then when the aircraft has manoeuvred to be behind the target aircraft, the target aircraft shall be monitored and the aircraft guidance commands adjusted to maintain specified vertical offset within a TBD tolerance (e.g. ±200m).	Air-SS-231 [This performs the vertical offset part of the D18 requirement but independently from the longitudinal separation and without the need to generate constraints and associated trajectory.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
Only the parameters associated with maintain longitudinal separation and the optional lateral and vertical offsets shall be adjusted.	Air-SS-231 [This is derived from D14 Section 3.1.1.5] [Partially Compliant] [Derived]
All other parameters shall be maintained as previously indicated by the trajectory being performed.	Air-SS-231 [This is derived from D14 Section 3.1.1.5] [Partially Compliant] [Derived]
During In Descent Spacing it is possible for ATC to command Heading Changes via Tactical Commands these shall be followed whilst maintaining longitudinal separation and optional lateral and/or vertical offsets.	Air-SS-231 [This is derived from D14 Section 3.1.1.5.1] [Partially Compliant] [Derived]
When a Spacing Alert occurs then the maintaining of the longitudinal separation shall be stopped.	Air-SS-2557 [D18 requirement clarified by :- the maintenance of the longitudinal separation is the spacing manoeuvre.] [Fully Compliant] [Direct]
When a Spacing Alert occurs then the aircraft shall be guided to the previously generated trajectory until otherwise commanded by the Pilot/ATC.	Air-SS-2557 [This is to allow time for the Pilot/ATC to react to the automatic termination of the spacing manoeuvre.] [Non Compliant] [Derived]
5.2.2.2.1.3 Tactical Command Guiding	
When a tactical command is received the aircraft shall override the indicated parameter(s) and any associated parameter(s) whilst maintaining all other parameters as previously indicated by the trajectory being performed.	Air-SS-2534 [D18 Requirement.] [Fully Compliant] [Direct]
5.2.3 Airborne Separation Assurance	

Text for D19	D18 Link Information
5.2.3.1 Overview	
The second task is the Conflict Detection process. This is a generic process that can be applied to any nominated trajectory. Whenever a new trajectory has been generated, it can be compared with the known traffic movements in order to identify potential conflicts. During the initial flight planning stages, it will not normally be necessary for the aircraft to do this because the conflict detection and resolution will be the responsibility of the ATC. When the aircraft is airborne and approaching an area of FFAS, the pilot will select autonomous operations and the Conflict Detection and Resolution algorithms will be run on a periodic basis.	Air-SS-224 [While the System is capable of resolving conflicts in airspaces other than FFAS, the resolution process is the responsibility of the ATC.] [Fully Compliant] [Direct]
5.2.3.2 Conflict Detection and Resolution	
5.2.3.2.1.1 Conflict Detection	
Although D18 specifies that the Conflict Detection process should be activated whenever a new object has been added to the surveillance database or when surveillance data is received for a traffic object with a Virtual Conflict Time (VCT) of less than 5 minutes, this is not considered to be practical. An alternative approach that activates the processing at regular intervals is preferred. This is described in detail within a separate document - Conflict Detection and Resolution Technical Note.	Air-SS-1169 [As the Conflict Detector process will be activated at very regular intervals it is not necessary to be invoked when surveillance data is received for a traffic object which has a VCT of less than 5 minutes.] [Non Compliant] [Derived] Air-SS-417 [As the Conflict Detector process will be activated at very regular intervals it is not necessary to be invoked when a new object is added to the database.] [Non Compliant] [Derived]

Text for D19	D18 Link Information
When Autonomous Operations have been selected by the pilot, the System shall activate the Conflict Detection function at 30 second time intervals.	Air-SS-1115 [This covers the initiation of the D18 requirement.] [Partially Compliant] [Derived] Air-SS-1234 [All traffic objects shall be regularly checked for conflicts.] [Partially Compliant] [Derived] Air-SS-221 [All traffic objects shall be regularly checked for conflicts.] [Partially Compliant] [Derived]
The Conflict Detection function shall take account of positional errors, both across and along track of both aircraft.	Air-SS-1115 [Active trajectory conflicts.] [Partially Compliant] [Derived] Air-SS-416 [Proposed trajectory conflicts.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
If a conflict is found within the look-ahead time the conflict shall be registered in the conflict database.	Air-SS-1115 [Active trajectory conflicts.] [Partially Compliant] [Direct] Air-SS-416 [Proposed trajectory conflicts.] [Partially Compliant] [Direct]
The Conflict Detection function shall use the predicted time of the conflict to enable the conflict information to be stored in chronological order.	Air-SS-1115 [Active trajectory conflicts.] [Partially Compliant] [Derived] Air-SS-416 [Proposed trajectory conflicts.] [Partially Compliant] [Derived]
If a conflict is found with a conflict time of less than 2 minutes then an advisory conflict alert shall be generated.	Air-SS-473 [No change from D18 requirement.] [Fully Compliant] [Direct]
If a conflict is found with a conflict time of greater than 2 minutes then an information conflict alert shall be generated.	Air-SS-472 [No change from D18 requirement.] [Fully Compliant] [Direct]
5.2.3.2.1.2 Conflict Resolution	

Text for D19	D18 Link Information
The Conflict Resolution function, in conjunction with the trajectory generator, shall be capable of generating a proposed trajectory that prevents occurrence of detected conflicts.	Air-SS-160 [No change from D18 requirement.] [Fully Compliant] [Direct]
The Conflict Resolution function shall ensure that any resolution trajectory presented to the pilot does not cross the FFAS boundary.	Air-SS-220 [Requirement is implemented by Conflict Detection process.] [Partially Compliant] [Derived]
If it is not possible to find a resolution trajectory without crossing the FFAS boundary, then an advisory alert shall be generated.	Air-SS-220 [Requirement is implemented by Conflict Detection process.] [Partially Compliant] [Derived]
The Conflict Resolution function shall utilise the Conflict Detection function to verify that a proposed resolution trajectory does not conflict with any other conflicts currently known.	Air-SS-161 [Ensures that a resolution trajectory is conflict free for all currently known conflicts.] [Fully Compliant] [Direct] Air-SS-160 [Ensures that a resolution trajectory is conflict free.] [Partially Compliant] [Direct]
The Conflict Resolution function shall utilise the Conflict Detection function to verify that a proposed resolution trajectory does not involve a FFAS boundary crossing.	Air-SS-220 [Ensures that a resolution trajectory will not infringe FFAS.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The computation of a resolution trajectory shall include an allowance for a Pilot Decision Time.	Air-SS-162 [No change from D18 requirement.] [Fully Compliant] [Direct]
If a resolution trajectory has been generated but the pilot has either rejected the resolution trajectory or there is no response within the Pilot Decision Time, then the Conflict Resolution process shall be repeated.	Air-SS-163 [No change from D18 requirement.] [Partially Compliant] [Direct]
If a resolution trajectory has been generated and the Pilot has requested a modification, then the Conflict Resolution process shall be repeated with the additional Pilot requested constraint.	Air-SS-163 [No change from D18 requirement.] [Partially Compliant] [Direct] Air-SS-262 [No change from D18 requirement.] [Fully Compliant] [Direct] Air-SS-442 [No change from D18 requirement.] [Fully Compliant] [Direct]
The Cooperative conflict resolution method shall generate an avoidance manoeuvre.	Air-SS-444 [Cooperative method of conflict resolution.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The avoidance manoeuvre shall be converted to a Trajectory Change Point..	Air-SS-444 [Cooperative method of conflict resolution.] [Partially Compliant] [Derived]
The Trajectory Change Point shall be passed to the Trajectory Generator for implementation.	Air-SS-444 [Cooperative method of conflict resolution.] [Partially Compliant] [Derived]
The Priority Rules Based conflict resolution method shall use the relative priorities between the ownship and conflicting traffic, as determined by the Extended visual Flight Rules (EFR), as detailed in Table 2 of D18.	Air-SS-447 [No change from D18 requirement.] [Fully Compliant] [Direct] Air-SS-445 [No change from D18 requirement.] [Fully Compliant] [Direct]
If all traffic objects are of a lower priority then the preferred trajectory shall be sent to the Trajectory Generator.	Air-SS-451 [No change from D18 requirement.] [Partially Compliant] [Derived]
If a higher priority traffic object exists, the lower priority aircraft shall generate a list of avoiding manoeuvres.	Air-SS-451 [No change from D18 requirement] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The list of avoiding manoeuvres shall be searched for the optimum solution which will be presented to the Pilot for acceptance.	Air-SS-262 [No change from D18 requirement.] [Partially Compliant] [Direct]
5.2.4 Data Management	
The system design includes a data storage device that will be used to hold data files that have been loaded through the Data Loader. During the Initialisation phase, the system shall read the contents of these files and create the database in virtual memory.	Air-SS-555 [The use of a HDD will meet the requirement for a non-volatile store.] [Fully Compliant] [Direct]
An error message shall be generated if, during the generation of the database, either a file is not found or a file read error occurs.	Air-SS-1145 [] [Fully Compliant] [Direct]
5.2.5 Context Management	
The System shall be capable of creating a CMLogonRequest message as defined in the ATN SARPS.	Air-SS-446 [] [TBD] [TBD]
The System shall be capable of decoding a CMLogonResponse message as defined in the ATN SARPS.	Air-SS-462 [] [TBD] [TBD]
The System shall be capable of storing logon information for at least 4 ground systems.	Air-SS-1195 [] [TBD] [TBD]
5.2.5.1.1 Flight Information Services	

Text for D19	D18 Link Information
The System shall be capable of receiving and processing Flight Information Service (FIS) uplink messages that are compliant with the NUP FIS-B Service Description Options 1, 2, and 3.	Air-SS-2523 [Option 4 has been explicitly removed within the D18 requirement.] [Fully Compliant] [Direct]
The System shall be capable of creating and transmitting Flight Information Service (FIS) downlink messages that are compliant with the NUP FIS-B Service Description Options 3.	Air-SS-1001 [] [TBD] [TBD]
5.3 External Interface Requirements	
5.3.1 Cockpit Systems	
5.3.1.1 Data Loading Device	
It shall be possible to load company route data files from an external storage device onto the data storage device via the Data Loader.	Air-SS-2462 [The data loading capability will only be enabled when the System is in the Maintenance state.] [Fully Compliant] [Direct]
5.3.1.2 Data Storage Device	
The System design requires an internal storage device to provide an area of non-volatile memory. This storage area is required to hold initialisation files for the System. For the MA-AFAS trials, this will be a Hard Disk Drive (HDD).	Air-SS-555 [The System design requires an internal storage device to provide an area of non-volatile memory. This storage area is required to hold initialisation files for the System.] [Fully Compliant] [Direct]
5.3.1.3 Printer	

Text for D19	D18 Link Information
For the MA-AFAS trials, the System shall include an ARINC 429 interface with the cockpit printer.	Air-SS-1180 [The AOC functions include a capability to print any of the information that has been transmitted to the aircraft by the AOC.] [Partially Compliant] [Derived] Air-SS-2539 [] [TBD] [TBD] Air-SS-2540 [] [TBD] [TBD] Air-SS-2538 [The AOC functions include a capability to print any of the information that has been transmitted to the aircraft by the AOC.] [Partially Compliant] [Derived]
5.3.2 Pilot Interfaces	
5.3.2.1 MCDU	

Text for D19	D18 Link Information
The System shall include an ARINC 429 Interface driver for controlling the MCDU that is compliant with section 3.7 of ARINC 739A.	Air-SS-382 [The necessary control for multiply redundant systems will not be implemented under the MA-AFAS program.] [Non Compliant] [Direct] Air-SS-381 [The necessary control for multiply redundant systems will not be implemented under the MA-AFAS program.] [Non Compliant] [Direct] Air-SS-369 [The System will incorporate an ARINC 739A compliant MCDU. The interface between this and the System therefore, will be compliant with ARINC 429.] [Fully Compliant] [Direct]
5.3.2.2 EFI Display Control Panel	
The System shall include a ARINC 429 input channel for receiving the outputs from the Display Control Panel.	Air-SS-391 [The control of navigation display unit comes from a separate control panel. The outputs from this panel must be handled in order to ensure that the correct data is displayed.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The System shall be capable of decoding ARINC 420 labels 271, 272 and 273 from the DCP.	Air-SS-391 [The control of navigation display unit comes from a separate control panel. The outputs from this panel must be handled in order to ensure that the correct data is displayed.] [Partially Compliant] [Derived]
5.3.2.3 EFI	
For the MA-AFAS trials, the EFIS display unit on the BAC 1-11 does not have an ARINC 429 interface. The display unit requires RGB inputs.	Air-SS-391 [The BAC 1-11 navigation display unit for the MA-AFAS trials does not have an ARINC 429 input.] [Non Compliant] [Direct]
The System shall include a graphical display driver for the BAC 1-11 display unit.	Air-SS-391 [The display unit inputs are RGB and not ARINC 429.] [Partially Compliant] [Derived]
5.3.2.4 Cursor	
The System shall include a single RS232 interface for handling cursor inputs.	Air-SS-2578 [] [Fully Compliant] [Direct] Air-SS-383 [The MA-AFAS trials equipment only includes a single pilot workstation.] [Non Compliant] [Direct]
5.3.2.5 Head Up Display	

Text for D19	D18 Link Information
The MA-AFAS trials equipment will not be capable of driving a Head Up Display.	Air-SS-392 [The MA-AFAS equipment does not include a HUD.] [Non Compliant] [Direct]
5.3.2.6 Primary Flight Display	
An ARINC 702A standard FMS is not required to provide any inputs directly to a Primary Flight Display Unit. Therefore, the MA-AFAS FMS trials equipment will not be capable of sending data to the Primary Flight Display Unit.	Air-SS-390 [An ARINC 702A standard FMS is not required to provide any inputs directly to a Primary Flight Display Unit. Therefore, the MA-AFAS FMS trials equipment will not be capable of sending data to the Primary Flight Display Unit.] [Non Compliant] [Direct]
5.3.2.7 Aircrew Warning System	
An ARINC 702A standard FMS is only required to provide a single discrete output to the Aircrew Warning System. There is no requirement for an ARINC 429 link. Therefore, the MA-AFAS FMS will only include a mechanism for generating a discrete signal to trigger the generation of an aural alert.	Air-SS-393 [An ARINC 702A standard FMS is only required to provide a single discrete output to the Aircrew Warning System. There is no requirement for an ARINC 429 link. Therefore, the MA-AFAS FMS will only include a mechanism for generating a discrete signal to trigger the generation of an aural alert.] [Non Compliant] [Direct]
5.3.3 Aircraft Systems	
5.3.3.1 Air Data Computer	
The System shall include an ARINC 429 interface for receiving information from the Digital Air Data Computer that is fitted to the BAC 1-11.	Air-SS-406 [The System requires an ARINC 429 input channel in order to receive the ADC data.] [Fully Compliant] [Direct]

Text for D19	D18 Link Information
The System shall be capable of decoding ARINC 429 labels 203, 205, 206, 210 and 213 from the ADC.	Air-SS-406 [The MA-AFAS equipment does not need to be capable of processing all output labels generated by the ADC.] [Partially Compliant] [Direct]
5.3.3.2 Attitude and Heading Reference System	
The System shall include an ARINC 429 interface for receiving information from the Attitude and Heading Reference System that is fitted to the BAC 1-11.	Air-SS-379 [The System requires an ARINC 429 input channel upon which to receive the AHRS information.] [Fully Compliant] [Direct]
The System shall be capable of decoding ARINC 429 labels 320, 324, 325, 335, 336, 337, 364, 365, 373 and 374 from the AHRS.	Air-SS-379 [The MA-AFAS equipment does not need to be capable of decoding all output labels sent by the AHRS.] [Partially Compliant] [Direct]
5.3.3.3 Inertial Reference System	
The System shall include an ARINC 429 interface for receiving information from the Inertial Reference System that is fitted to the BAC 1-11.	Air-SS-378 [The System requires an ARINC 429 input channel in order to receive the IRS output information.] [Fully Compliant] [Direct]
The System shall be capable of decoding ARINC 429 labels 310 to 317 inclusive, 320 to 327 inclusive, 330 to 337 inclusive and 364 to 367 inclusive from the IRS.	Air-SS-378 [Only those labels that are used by the FMS are identified here. Any other labels output by the IRS will not be recognised.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
5.3.3.4 Global Navigation Satellite System	
The System shall include an ARINC 429 interface for receiving information from the Global Navigation Satellite System that is fitted to the BAC 1-11.	Air-SS-377 [The System requires an ARINC 429 input channel in order to receive the GNSS output information.] [Fully Compliant] [Direct]
The System shall be capable of decoding ARINC 429 labels 076, 101, 102, 103, 110, 111, 112, 120, 121, 130, 133, 136, 140, 141, 150, 165, 166, 174, 247, 273 and 355 from the GNSS.	Air-SS-377 [Only those labels that are used by the FMS are identified here. Any other labels output by the IRS will not be recognised.] [Partially Compliant] [Derived]
5.3.3.5 Flight Control System	
The System shall include an ARINC 429 interface for receiving information from the Flight Control System that is fitted to the BAC 1-11.	Air-SS-2551 [The System requires an ARINC 429 input channel to receive the AFCS outputs.] [Fully Compliant] [Direct]
The System shall include an ARINC 429 interface for sending information to the Flight Control System that is fitted to the BAC 1-11.	Air-SS-388 [The System requires an ARINC 429 output channel to transmit the AFCS inputs.] [Fully Compliant] [Direct]
The System shall be capable of encoding and sending ARINC 429 labels 121, 361, 362, 363, 364, 365, 366, 367, 370, 372 and 373 to the AFCS.	Air-SS-388 [Only those labels that are recognised by the BAC 1-11 have been identified here.] [Partially Compliant] [Derived]
5.3.3.6 Engine Management System	

Text for D19	D18 Link Information
The System shall include an ARINC 429 interface for receiving information from the Engine Management System that is fitted to the BAC 1-11.	Air-SS-2470 [The System requires an ARINC 429 input channel in order to receive the EMS outputs.] [Fully Compliant] [Direct]
The System shall be capable of decoding ARINC 429 labels 245 and 246 from the EMS.	Air-SS-2470 [The System will only recognise a limited set of all of the possible output labels.] [Partially Compliant] [Direct]
The System shall include an ARINC 429 interface for sending information to the Engine Management System (Auto-Throttle) that is fitted to the BAC 1-11.	Air-SS-388 [The Engine Management requests are sent to the AFCS within the BAC 1-11 architecture.] [Partially Compliant] [Derived]
The System shall be capable of encoding and transmitting ARINC 429 labels 363 and 366 to the EMS.	Air-SS-388 [The Engine Management requests are sent to the AFCS within the BAC 1-11 architecture.] [Partially Compliant] [Derived]
5.3.3.7 Weight And Balance System	
The BAC 1-11 that will be used in the MA-AFAS trials does not include a WBS that generates outputs which are accessible to the FMS. The aircraft mass can only be input by the pilot using the MCDU.	Air-SS-380 [The MA-AFAS equipment will not support this input for the trials because it is not available on the BAC 1-11.] [Non Compliant] [Direct]
5.3.3.8 Other Navigation Equipment	

Text for D19	D18 Link Information
An ARINC 702A standard FMS should be capable of receiving data from all of the navigation equipment that is fitted to the aircraft, e.g. ILS, DME, etc.. For the MA-AFAS trials, the processing of this data is not critical. The primary emphasis is on the GNSS output. Therefore, for the MA-AFAS trials equipment, the interfaces and associated processing for ILS and DME will not be supported.	Air-SS-375 [An ARINC 702A standard FMU should be capable of receiving data from all of the navigation equipment that is fitted to the aircraft, e.g. ILS, DME, etc.. For the MA-AFAS trials, the processing of this data is not critical. The primary emphasis is on the GNSS output. Therefore, for the MA-AFAS trials equipment, the interfaces and associated processing for ILS and DME will not be supported.] [Non Compliant] [Direct] Air-SS-376 [] [TBD] [TBD]
5.3.3.9 Weather Radar System	
For the MA-AFAS trials, there are no plans to display weather information on the navigation display unit. Therefore, the System design does not include an input channel for weather information.	Air-SS-389 [For the MA-AFAS trials, there are no plans to display weather information on the navigation display unit. Therefore, the System design does not include an input channel for weather information.] [Non Compliant] [Direct]
5.3.4 CMU	
The System shall include an ARINC 429 interface for receiving information from the Communications Management Unit that forms part of the MA-AFAS Avionics equipment.	Air-SS-367 [The System requires a separate ARINC 429 channel for input and outputs. Only the input channel requirement is addressed here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall include an ARINC 429 interface for transmitting information to the Communications Management Unit that forms part of the MA-AFAS Avionics equipment.	Air-SS-367 [The System requires a separate ARINC 429 channel for input and outputs. Only the output channel requirement is addressed here.] [Partially Compliant] [Direct]
5.4 Internal Interface Requirements	
The internal interface between the CMU and FMS components shall be via ARINC 429 links even though they share a common VME backplane.	Air-SS-367 [Separate input and output ARINC 429 channels are included within the design for communications between the CMU and FMU.] [Fully Compliant] [Direct]
5.5 Internal Data Requirements	
5.5.1 Aircraft State Information	
5.5.1.1 Content	
The aircraft state information shall include the barometric altitude of the aircraft.	Air-SS-2496 [Only the baraometric altitude is considered here.] [Partially Compliant] [Direct]
The aircraft state information shall include the estimated altitude of the aircraft derived from radar altimetry if this is available.	Air-SS-2496 [Only the radar derived altitude is considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The aircraft state information shall include the estimated altitude rate of the aircraft.	Air-SS-2496 [Although it is not mentioned explicitly in D18, the altitude rate will be required for performance calculations.] [Partially Compliant] [Derived]
The aircraft state information shall include the estimated Latitude and Longitude co-ordinates of the aircraft.	Air-SS-2493 [This requirement only addresses the storage of the estimated position and not the methods of computing the position.] [Partially Compliant] [Direct]
The aircraft state information shall include the estimated error in the position co-ordinates of the aircraft.	Air-SS-2495 [Only the storage of the information is considered here.] [Partially Compliant] [Direct]
The aircraft state information shall incude the estimated speed of the aircraft including; ground speed, indicated air speed, calibrated air speed and Mach.	Air-SS-2498 [Only the storage of the speed information is considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The aircraft state information shall include the aircraft heading and attitude data.	Air-SS-2497 [Only the storage of information is considered here.] [Partially Compliant] [Direct] Air-SS-2501 [Only the storage of information is considered here.] [Partially Compliant] [Direct]
The aircraft state information shall include the measured outside air pressure, air temperature, wind speed and wind direction.	Air-SS-2502 [Only the storage of information is considered here.] [Partially Compliant] [Direct]
5.5.1.2 Access	
The System shall support an access function that provides the current position estimate of the aircraft and the estimated error in that position estimate.	Air-SS-2495 [The requirement includes the provision of the estimation errors to the requesting function.] [Partially Compliant] [Direct] Air-SS-2493 [This access function provides visibility of the aircraft position to any function that requests it.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The System shall support an access function that provides the current altitude of the aircraft.	Air-SS-566 [This function only considers access to one part of the aircraft state data.] [Partially Compliant] [Derived]
The System shall support an access function that provides the current speed of the aircraft. This includes the Ground Speed, Indicated Air Speed, Calibrated Air Speed and Mach Number.	Air-SS-566 [This function only considers access to one part of the aircraft state data.] [Partially Compliant] [Derived]
The System shall support an access function that provides a copy of all of the aircraft state data that is held in the store.	Air-SS-566 [Only aircraft state information is considered here.] [Partially Compliant] [Derived]
5.5.2 Surveillance Database	
5.5.2.1 Content	
The System shall maintain a database of other traffic.	Air-SS-177 [The database will be used for CDTI as well as ASA applications..] [Fully Compliant] [Direct]
The surveillance database shall be capable of handling 2044 independent traffic objects.	Air-SS-2525 [The figure is derived as the sum of 1022 TIS-B objects and 1022 ADS-B objects.] [Fully Compliant] [Direct]

Text for D19	**D18 Link Information**
The surveillance database shall contain state information for each traffic object.	Air-SS-180 [Only the state information is addressed here.] [Partially Compliant] [Direct] Air-SS-2487 [Smoothed state data is generated as a result of the fusion process.] [Partially Compliant] [Derived]
The state information for a traffic object shall include position in Latitude and Longitude co-ordinates.	Air-SS-180 [This requirement only identifies one part of the traffic state data.] [Partially Compliant] [Derived]
The state information for a traffic object shall include its altitude.	Air-SS-180 [This requirement only identifies one part of the traffic state data] [Partially Compliant] [Derived]
The state information for a traffic object shall include its speed.	Air-SS-180 [This requirement only identifies one part of the traffic state data] [Partially Compliant] [Derived]
The state information for a traffic object shall include its heading.	Air-SS-180 [This requirement only identifies one part of the traffic state data] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
It shall be possible to store intent data for each traffic object.	Air-SS-180 [This requirement only defines the capability for storing intent data.] [Partially Compliant] [Direct] Air-SS-2489 [No change from D18.] [Fully Compliant] [Direct]
The intent data shall include four positions, specified as latitude, longitude and altitude, and the associated estimated time of arrival at that position.	Air-SS-180 [The content of the intent data is specified with the VDL mode 4 SARPS.] [Partially Compliant] [Derived]
The surveillance database shall contain the time at which the information associated with each traffic object was last updated.	Air-SS-321 [] [Fully Compliant] [Direct]
5.5.2.2 Data Fusion	
The surveillance database shall include a fusion function to provide a best estimate of the current state of each object using information extracted from both TIS-B and ADS-B transmissions.	Air-SS-477 [No change to D18 requirement.] [Fully Compliant] [Direct] Air-SS-2488 [Smoothed data will be generated as part of the fusion processing.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The System shall compute and store a Virtual Conflict Time for each traffic object in the surveillance database.	Air-SS-2554 [The definition of the VCT is provisional and subject to change.] [Partially Compliant] [Direct]
When an object passes beyond the RF horizon, its information shall be removed from the surveillance database.	Air-SS-1146 [No change from D18 requirement.] [Fully Compliant] [Direct]
After receipt of new information for a traffic object, the closure vector and closure rate shall be computed.	Air-SS-418 [No change to the D18 requirement.] [Fully Compliant] [Direct]
When the aircraft is in FFAS, an advisory alert shall be generated if the TIS/ADS data for a traffic object that is also in FFAS and has a virtual collision time of less than 8 minutes has not been updated in the last 3 minutes.	Air-SS-323 [No change from D18 requirement.] [Fully Compliant] [Direct]
5.5.2.3 Access	
The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie within a specified range of the current aircraft position.	Air-SS-478 [This requirement is for data access only.] [Partially Compliant] [Direct] Air-SS-566 [Only access to parts of the surveillance database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie within a specified range of a selected position, e.g. an airport.	Air-SS-478 [This requirement is for data access only.] [Partially Compliant] [Direct] Air-SS-102 [This access function provides the means to find out where the ground traffic is located.] [Partially Compliant] [Derived] Air-SS-105 [This access function provides a filter for extracting ground based traffic.] [Partially Compliant] [Derived] Air-SS-566 [Only access to parts of the surveillance database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie within a specified altitude range of the current aircraft position.	Air-SS-478 [This requirement is for data access only.] [Partially Compliant] [Direct] Air-SS-566 [Only access to parts of the surveillance database are considered here.] [Partially Compliant] [Direct]
The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie below a specified altitude.	Air-SS-478 [This requirement is for data access only.] [Partially Compliant] [Direct] Air-SS-566 [Only access to parts of the surveillance database are considered here.] [Partially Compliant] [Direct]
The System shall support a data access request that creates a list of all of traffic objects with their associated state data that lie above a specified altitude.	Air-SS-478 [This requirement is for data access only.] [Partially Compliant] [Direct] Air-SS-566 [Only access to parts of the surveillance database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall support a data access request that creates a list of all of traffic objects with their associated state data that have a virtual collision time that lies between specified limits.	Air-SS-478 [This requirement is for data access only.] [Partially Compliant] [Direct] Air-SS-1169 [The access function has been generalised.] [Partially Compliant] [Direct] Air-SS-1234 [The access function has been generalised.] [Partially Compliant] [Direct] Air-SS-566 [Only access to parts of the surveillance database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall support a data access request that creates a copy of all of the information stored for a specified traffic object.	Air-SS-478 [This requirement is for data access only.] [Partially Compliant] [Direct] Air-SS-453 [This access function will provide more information that just the position of the target.] [Fully Compliant] [Direct] Air-SS-456 [This access function will provide more information that just the speed of the target.] [Fully Compliant] [Direct] Air-SS-460 [This access function will provide more information that just the altitude of the target.] [Fully Compliant] [Direct] Air-SS-458 [This access function will provide more information that just the track of the target.] [Fully Compliant] [Direct] Air-SS-447 [This access function provides all of the information required to allow the relative priorites to be assessed using EFR.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
5.5.3 Navigation Database	
5.5.3.1 Content	
The navigation database shall be based upon the data record types that are described in ARINC 424-15.	Air-SS-212 [Only partial compliance will be achieved during the MA-AFAS programme because Helicopter specific record types will not be included within the database.] [Partially Compliant] [Direct]
5.5.3.2 Access	
5.5.3.2.1 AS Records	
The System shall provide an access function that returns Minimum Off Route Altitude for any specified latitude and longitude co-ordinates.	Air-SS-200 [This requirement only addresses read access of D records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to AS records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.2 D Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of a specified VHF NavAid station.	Air-SS-200 [This requirement only addresses read access of D records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to D records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all reference information held within the database for a specified VHF NavAid station.	Air-SS-200 [This requirement only addresses read access to the D records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to D records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a list of all of the VNF NavAids that are within a selected distance of a specified latitude and longitude position.	Air-SS-200 [This requirement only provides a search method for identifying those objects within the database that lie within a specified distance of a given position.] [Partially Compliant] [Derived] Air-SS-566 [Only access to D records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.3 DB Records	
The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of a specified NDB.	Air-SS-200 [This requirement only addresses read access of DB records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to DB records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all reference information held within the database for a specified NDB.	Air-SS-200 [This requirement only addresses read access to the DB records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to DB records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a list of all of the NDBs that are within a selected distance of a specified latitude and longitude position.	Air-SS-200 [This requirement only provides a search method for identifying those objects within the database that lie within a specified distance of a given position.] [Partially Compliant] [Derived] Air-SS-566 [Only access to DB records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.4 EA Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates along with the waypoint type for a selected waypoint within the vicinity of a specified airport.	Air-SS-200 [This requirement only addresses read access of PC records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to EA records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all reference information held within the PA record for a specified airport.	Air-SS-200 [This requirement only addresses read access to the PC records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to EA records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.5 EM Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all marker information held within the database for a selected localiser.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to EM records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.6 EP Records	
The System shall provide an access function that creates a copy of all reference information held within the database for a specified holding pattern.	Air-SS-200 [This requirement only addresses read access to the EP records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to EP records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.7 ER Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all reference information held within the database for a specified airway.	Air-SS-200 [This requirement only addresses read access to the ER records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to ER records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.8 ET Records	
The System shall provide an access function that creates a copy of all route information held within the database for a specified preferred route.	Air-SS-200 [This requirement only addresses read access to the PT records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to ET records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.9 EU Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all restriction information held within the database for a specified airway.	Air-SS-200 [This requirement only addresses read access to the EA records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to EU records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.10 EV Records	
The System shall provide an access function that creates a copy of all communications information held within the database for a specified airway.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to EV records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.11 PA Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of the airport reference position.	Air-SS-200 [This requirement only addresses read access of PA records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PA records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all reference information held within the database for a specified airport.	Air-SS-200 [This requirement only addresses read access to the PA records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PA records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.12 PB Records	

Text for D19	D18 Link Information
The System shall provide an access function that generates a list of all of the passenger gates at a specified airport.	Air-SS-200 [This requirement only addresses read access of PB records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PB records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates of a selected gate at a specified airport.	Air-SS-200 [This requirement only addresses read access of PB records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PB records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of any notes that are held in the database for a selected gate at a specified airport.	Air-SS-200 [This requirement only addresses read access of PB records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PB records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.13 PC Records	
The System shall provide an access function that generates a list of all of the waypoints within the vicinity of a specified airport.	Air-SS-200 [This requirement only addresses read access of PC records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PC records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of the latitude and longitude co-ordinates along with the waypoint type for a selected waypoint within the vicinity of a specified airport.	Air-SS-200 [This requirement only addresses read access of PC records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PC records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all reference information held within the database for a specified waypoint.	Air-SS-200 [This requirement only addresses read access to the PC records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PC records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.14 PD Records	

Text for D19	D18 Link Information
The System shall provide an access function that generates a list of all of the SIDs from a specified airport.	Air-SS-200 [This requirement only addresses read access of PD records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PD records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all of the detailed procedural information for a selected SID from a specified airport.	Air-SS-200 [This requirement only addresses read access to the PD records of the navigation database.] [Partially Compliant] [Derived] Air-SS-233 [The D19 requirement meets the need to provide access to the details of a specified SID.] [Partially Compliant] [Derived] Air-SS-64 [The D19 requirement meets the need to provide access to the details of a specified SID.] [Fully Compliant] [Direct] Air-SS-566 [Only access to PD records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.15 PE Records	

Text for D19	D18 Link Information
The System shall provide an access function that generates a list of all of the STARs to a specified airport.	Air-SS-200 [This requirement only addresses read access of PE records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PE records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all of the detailed procedural information for a selected STAR to a specified airport.	Air-SS-200 [This requirement only addresses read access to the PE records of the navigation database.] [Partially Compliant] [Derived] Air-SS-233 [The D19 requirement meets the need to provide access to the details of a specified STAR.] [Partially Compliant] [Derived] Air-SS-64 [The D19 requirement meets the need to provide access to the details of a specified STAR.] [Fully Compliant] [Direct] Air-SS-566 [Only access to PE records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.16 PF Records	

Text for D19	D18 Link Information
The System shall provide an access function that generates a list of all of the Approaches to a specified airport.	Air-SS-200 [This requirement only addresses read access of PE records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PF records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all of the detailed procedural information for a selected Approach to a specified airport.	Air-SS-200 [This requirement only addresses read access to the PE records of the navigation database.] [Partially Compliant] [Derived] Air-SS-64 [The D19 requirement meets the need to provide access to the details of a specified approach.] [Fully Compliant] [Direct] Air-SS-566 [Only access to PF records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.17 PG Records	

Text for D19	D18 Link Information
The System shall provide an access function that generates a list of all of the runways at a specified airport.	Air-SS-200 [This requirement only addresses read access of PG records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PG records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all reference information held within the database for a selected runway at a specified airport.	Air-SS-200 [This requirement only addresses read access to the PG records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PG records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.18 PI Records	

Text for D19	D18 Link Information
The System shall provide an access function that generates a list of all of the localisers at a specified airport.	Air-SS-200 [This requirement only addresses read access of PI records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PI records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all reference information held within the database for a selected localiser at a specified airport.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PI records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.19 PL Records	

Text for D19	D18 Link Information
The System shall provide an access function that generates a list of all of the Microwave Landing Systems at a specified airport.	Air-SS-200 [This requirement only addresses read access of PG records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PL records in the navigation database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a copy of all reference information held within the database for a selected Microwave Landing System at a specified airport.	Air-SS-200 [This requirement only addresses read access to the PG records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PL records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.20 PM Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all marker information held within the database for a selected localiser at a specified airport.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PM records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.21 PN Records	
The System shall provide an access function that generates a list of all of the Navaids at a specified airport.	Air-SS-200 [This requirement only addresses read access of PN records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PN records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all information held within the database for a selected beacon at a specified airport.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PM records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.22 PS Records	
The System shall provide an access function that generates a list of all of the Minimum Sector Altitudes at a specified airport.	Air-SS-200 [This requirement only addresses read access of PS records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PS records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all reference information held within the database for a selected Minimum Sector Altitude at a specified airport.	Air-SS-200 [This requirement only addresses read access to the PS records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PS records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.23 PV Records	
The System shall provide an access function that generates a list of all of the Navaids at a specified airport.	Air-SS-200 [This requirement only addresses read access of PV records.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PV records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all communications information held within the database for a specified airport.	Air-SS-200 [This requirement only addresses read access to the PV records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to PV records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.24 UC Records	
The System shall provide an access function that creates a copy of all boundary information held within the database for a specified controlled airspace.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-220 [The access function provides a complete description of the airspace boundary for use by the conflict detection algorithm.] [Fully Compliant] [Direct] Air-SS-566 [Only access to UC records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.25 UF Records	

Text for D19	D18 Link Information
The System shall provide an access function that creates a copy of all boundary information held within the database for a specified FIR or UIR.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to UF records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.3.2.26 UR Records	
The System shall provide an access function that creates a copy of all boundary information held within the database for a specified airspace.	Air-SS-200 [This requirement only addresses read access to the PI records of the navigation database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to UR records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.4 Company Routes Database	
5.5.4.1 Content	
During the Initialisation phase, the system shall read the contents of these files and create the company route database in virtual memory.	Air-SS-569 [This requirement only addresses the generation of the company route database. Verification will be performed as the database is created.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The System shall be capable of storing at least 400 company routes, each containing 128 way points.	Air-SS-2464 [The modified requirement removes the strict 400 limit. The numbr of routes will be limited by the memory capacity.] [Fully Compliant] [Direct]
The structure used for defining a single segment of a company route shall contain the information described in ARINC 424-15 for company routes.	Air-SS-2463 [Compliance with ARINC 424-15 ensures compliance with D18 because more information than just the way points is specified for each route segment.] [Fully Compliant] [Direct]
The total memory storage allocation for company routes shall not exceed 2MB.	Air-SS-2465 [This definition provides a clearer limit on the memory usage. The figure chosen will be sufficient to cater for 400 routes each containing 100 way points using the ARINC 424-15 company route specification format.] [Fully Compliant] [Direct]
5.5.4.2 Access	
The System shall be capable of generating a list of company routes that originate from a specified airport.	Air-SS-200 [This requirement only addresses one access method for the company routes database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to R records in the navigation database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall be capable of generating a list of route segments that make up a single company route.	Air-SS-200 [This requirement only addresses one access method for the company routes database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to R records in the navigation database are considered here.] [Partially Compliant] [Direct]
5.5.5 Computed Trajectories	
5.5.5.1 Content	
The System shall be capable of storing four trajectories and their associated constraint lists.	Air-SS-2490 [The D18 requirement has been extended to enable multiple trajectories to be stored, e.g. alternate routes.] [Partially Compliant] [Direct]
The trajectory detail shall include the departure airport.	Air-SS-2490 [The departure airport is just one part of the trajectory information set.] [Partially Compliant] [Derived]
The trajectory detail shall include the destination airport.	Air-SS-2490 [The destination airport is just one part of the trajectory information set.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The trajectory detail shall include a list of alternate airports.	Air-SS-2490 [The alternate airports are just one part of the trajectory information set.] [Partially Compliant] [Derived]
5.5.5.2 Access	
The System shall provide an access function that identifies the departure airport for the active trajectory.	Air-SS-566 [Only access to parts of the trajectory database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that identifies the destination airport for the active trajectory.	Air-SS-566 [Only access to parts of the trajectory database are considered here.] [Partially Compliant] [Direct]
The System shall provide an access function that creates a list of alternate airports for the active trajectory.	Air-SS-566 [Only access to parts of the trajectory database are considered here.] [Partially Compliant] [Direct]
5.5.6 Performance Database	
5.5.6.1 Content	
The performance model for the aircraft shall be based upon the generic aircraft model defined by Eurocontrol in the document "User Manual for the Base of Aircraft Data (BADA)".	Air-SS-214 [Although the BADA database contains different parameters to those identified in ARINC 702A-1, it has sufficient information to enable the performance of an aircraft to be modelled.] [Partially Compliant] [Derived]

Text for D19	D18 Link Information
The performance parameters for each aircraft used within the MA-AFAS trials shall be taken from the Eurocontrol BADA database.	Air-SS-214 [Although the BADA database contains different parameters to those identified in ARINC 702A-1, it has sufficient information to enable the performance of an aircraft to be modelled.] [Fully Compliant] [Direct]
5.5.6.2 Access	
The System shall support a data access request that generates a copy of all of the aircraft mass related information.	Air-SS-200 [This requirement only addresses data access to one part of the performance database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to parts of the performance database are considered here.] [Partially Compliant] [Direct]
The System shall support a data access request that generates a copy of all of the aircraft speed related information.	Air-SS-200 [This requirement only addresses data access to one part of the performance database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to parts of the performance database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall support a data access request that generates a copy of all of the aircraft lift related information.	Air-SS-200 [This requirement only addresses data access to one part of the performance database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to parts of the performance database are considered here.] [Partially Compliant] [Direct]
The System shall support a data access request that generates a copy of all of the aircraft engine related information.	Air-SS-200 [This requirement only addresses data access to one part of the performance database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to parts of the performance database are considered here.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
The System shall support a data access request that generates a copy of all of the aircraft fuel usage rate related information.	Air-SS-200 [This requirement only addresses data access to one part of the performance database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to parts of the performance database are considered here.] [Partially Compliant] [Direct]
5.5.7 Meteorological Database	
5.5.7.1 Content	
The meteorological database shall be created while the System is in the initialisation state using data files that are stored on the hard disk drive.	Air-SS-569 [This requirement only addresses the generation of the meteo database. Verification of the data is performed as the database is created.] [Partially Compliant] [Derived]
The meteorological record for each altitude at each grid point shall contain the forecast estimates of the air temperature, wind speed and wind direction.	Air-SS-213 [] [TBD] [TBD]
An estimate of the air pressure at sea level shall be provided for each grid point.	Air-SS-213 [] [TBD] [TBD]

Text for D19	D18 Link Information
Each set of measurements shall include a time window for which the forecast data can be assumed to be reliable.	Air-SS-213 [] [TBD] [TBD]
5.5.7.2 Access	
The System shall apply linear interpolation in 3 dimensions in order to estimate the air temperature at any arbitrary position and altitude that lies within the boundaries of a data file.	Air-SS-566 [Only access to parts of the meteo database are considered here.] [Partially Compliant] [Direct]
The System shall apply linear interpolation in 3 dimensions to the North and East components of the wind in order to estimate the wind speed and direction at any arbitrary point within the boundaries of a data file.	Air-SS-566 [Only access to parts of the meteo database are considered here.] [Partially Compliant] [Direct]
5.5.8 Airport Map Database	
5.5.8.1 Content	
The System shall include a standalone database of airport maps.	Air-SS-215 [ARINC 702A-1 provides no indication of how many airports should be contained within the database.] [Fully Compliant] [Derived]
The definition of an individual airport map shall be in accordance with the requirements of ED-99.	Air-SS-215 [ARINC 702A-1 does not specify how airport information is defined only the types of information that should be displayed. This gap is filled by ED-99.] [Partially Compliant] [Direct]
5.5.8.2 Access	

Text for D19	D18 Link Information
The database shall support a single access request type that generates a copy of the airport information for a single specified airport.	Air-SS-200 [This requirement only addresses access to the airport map database.] [Partially Compliant] [Derived] Air-SS-566 [Only access to the airport map database is considered here.] [Partially Compliant] [Direct]
5.6 Adaptation Requirements	
The System design includes an Ethernet interface to enable simulated data to be input from a variety of test equipment. The Ethernet interface also allows data to be input for systems that do not currently exist within the trials aircraft, e.g. the ACMS.	Air-SS-2602 [The System design includes an Ethernet Interface.] [Fully Compliant] [Direct] Air-SS-2583 [The System design includes an Ethernet Interface.] [Fully Compliant] [Direct]
5.7 Computer Resources	
5.7.1 Computer Hardware	

Text for D19	D18 Link Information
The architecture design that is described in Section Four of this document assumes that the Avionics box comprising a set of processing cards located on a VME backplane. The design assumes separate processors for the CMU and FMS components of the System along with relevant hardware interface modules, e.g. ARINC 429, Ethernet, RS232 and SVGA. The following diagram shows the proposed physical implementation of the System model.	Air-SS-2511 [The System Design includes a VME backplane.] [Fully Compliant] [Direct]
The System design shall include a Hard Disk Drive for holding information that must be maintained in non-volatile memory.	Air-SS-553 [] [Fully Compliant] [Direct]
As the expected functionality is double that for AFMS/AATMS but the cards are approximately 4 times faster, it is assumed that 2 PowerPC 750 cards will be able to provide the processing performance required for MA-AFAS. The split of functionality across the cards is expected to be CMU for one card and FMS for the other. The interprocess communication for this split is anticipated to be less than the data flow used within the AFMS / AATMS.	Air-SS-175 [The selection of the processor should ensure that this requirement is met but it will not be possible to verify this until the software has been implemented on the target processor.] [Partially Compliant] [Derived] Air-SS-174 [The selection of the processor should ensure that this requirement is met but it will not be possible to verify this until the software has been implemented on the target processor.] [Partially Compliant] [Derived] Air-SS-1038 [The actual processor loading is unknown at this time.] [Partially Compliant] [Direct]

Text for D19	D18 Link Information
For the assessment of on card memory requirements, the size of the database was used as the main guide. The information management system's largest stores of information are assumed to be ARINC 424 data for a reasonable area (in this case assumed to be the whole of Europe), weather information, aircraft information (including route data) and communication and data logs. It was assessed that the combined storage for this data would be in the order of no more than 45Mbyte. As a result, the cards were selected to have at least this available plus 20% for variables and program code. Therefore, PowerPC cards with 64Mbytes of RAM have been selected.	Air-SS-1039 [The actual memory usage is not known.] [Partially Compliant] [Direct]
5.7.2 Computer Software Requirements	
In order to support the progressive development of the software to meet the certification requirements of DO-178B, each primitive function shall include sufficient error checking to prevent the generation of a system level error.	Air-SS-1036 [Only part of the requirements of DO-178B are addressed here.] [Partially Compliant] [Derived]
Each function shall return a error flag that indicates whether or not a function completed successfully.	Air-SS-1036 [Only part of the requirements of DO-178B are addressed here.] [Partially Compliant] [Derived]

AxiomSys Model Process Name	D19 Requirement
5.8 CommunicationsManagementSoftware	
ProcessGACSMessages	
ProcessP2PMessages	
ProcessBroadcastMessages	
5.9 FlightManagementSoftware	
Control Specification	D19-514 D19-53 D19-498 D19-490 D19-60 D19-382 D19-492 D19-506

AxiomSys Model Process Name	D19 Requirement
5.9.1 DisplaysManager	
5.9.1.1 HandleMCDUInterface	D19-1641 D19-516 D19-497 D19-505 D19-393 D19-831 D19-832 D19-833 D19-834 D19-835 D19-836 D19-837 D19-838 D19-808 D19-806 D19-807 D19-1642 D19-1554 D19-1643
5.9.1.2 HandleEFISInterface	
InterpretGraphicsRequests	
ManageMenuBar	
ManageMessageStack	
5.9.1.2.1 ManageApplicationDisplays	
ChangeDisplayMode	D19-903 D19-904
CreateTaxiDisplays	D19-1644 D19-904
CreateLateralDisplays	D19-1644

AxiomSys Model Process Name	D19 Requirement
CreateVerticalDisplays	D19-1644
5.9.1.3 ManageErrorAndAlertMessages	
5.9.1.4 ManoeuvreGenerator	
5.9.1.5 ManageSystemIntialisation	
StoreSystemStatus	D19-380
RecoverSystemStatus	D19-57 D19-480 D19-482
5.9.2 AircraftGuidance	D19-880 D19-765 D19-767
MonitorProgress	D19-1535 D19-1052 D19-1014 D19-1013 D19-1012 D19-1011 D19-1010 D19-1009 D19-1008 D19-901 D19-899 D19-894 D19-891 D19-890 D19-880 D19-865 D19-864 D19-862 D19-861

AxiomSys Model Process Name	D19 Requirement
	D19-856 D19-855 D19-852 D19-851 D19-850 D19-848 D19-849 D19-854 D19-857 D19-858 D19-859 D19-860 D19-863 D19-884 D19-886 D19-887 D19-893 D19-895 D19-910 D19-1058 D19-1155 D19-1197
GuideToCommandAndOrSpacing	D19-881 D19-880 D19-744 D19-743 D19-741 D19-737 D19-742 D19-763

AxiomSys Model Process Name	D19 Requirement
	D19-875
GuideToTrajectory	D19-880 D19-881 D19-882
ManoeuvreGenerator	D19-880
5.9.3 TrajectoryGenerator	
HandleConstraints	
GenerateTrajectory	
5.9.4 ConflictDetectionResolution	
ConflictDetector	D19-1180 D19-1179 D19-1064 D19-1024 D19-1031 D19-1032 D19-942 D19-1511 D19-1510
ConflictResolver	D19-1480 D19-957 D19-954 D19-1039 D19-1040 D19-960 D19-1042 D19-1043 D19-962 D19-1045 D19-1002 D19-1005 D19-958

AxiomSys Model Process Name	D19 Requirement
5.9.5 ManageSurveillanceData	
ManageSurveillanceData	D19-622 D19-623 D19-624 D19-625 D19-626 D19-627 D19-629 D19-630 D19-631 D19-632 D19-633 D19-634 D19-635 D19-638 D19-639 D19-640 D19-641 D19-642 D19-643 D19-644 D19-645
5.9.6 DatalinkManager	
HandleContextManagement	D19-1652 D19-1650 D19-1649
HandleControllerPilotDatalink	
HandleAOCInformation	
HandleADSCInformation	

AxiomSys Model Process Name	D19 Requirement
5.9.7 HandleFlightInformation	
HandleFISBInformation	D19-583 D19-473
5.10 External Interface Functions	
MCDUARINC429Driver	D19-673
DCPARINC429Driver	
EFIARINC429Driver	
5.11 Hardware Components	
Power Supply Unit	D19-481
VME Backplane	
Hard Disk Drive	D19-412 D19-461
Multipurpose Control and Display Unit	D19-797

6 NOTES

6.1 Abbreviations

ACL	ATC Clearance and Information Services
ACM	ATC Communications Management Services
ADS-B	Automatic Dependent Surveillance – Broadcast
AFCS	Automatic Flight Control System
AFD	Architecture Flow Diagram
AG	Aircraft Guidance Process
AIC	Airborne, Inhabited, Cargo
AID	Architecture Interconnection Diagram
AOC	Airline Operations Centre
ASA	Airborne Separation Assurance
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATSAW	Air Traffic Situation Awareness
ATSU	Air Traffic Services Unit
C-ATSU	Current Air Traffic Services Unit
CCD	Cursor Control Device
CD	Conflict Detector Process
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CFMU	Central Flow Management Unit
CMU	Communications Management Unit
COSEP	Co-operative Separation
COTRAC	Common Trajectory Co-ordination Service
CPDLC	Controller Pilot Data Link Communications
CR	Conflict Resolver Process
D-ATIS	Data-link Automatic Terminal Information Services
D-ATSU	Downstream Air Traffic Services Unit
DCL	Departure Clearance Service
DFD	Data Flow Diagram
DLL	Data Link Logon
DSC	Downstream Clearance
DYNAV	Dynamic Route Availability Service
EFD	Enhanced Data Flow Diagram
EMS	Engine Management System
EOBT	Estimated Off Block Time

FDPS	Flight Data Processing System
FFAS	Free Flight Air Space
FIS	Flight Information System
FLIPCY	Flight Plan Consistency
FMS	Flight Management System
FMU	Flight Management Unit
GACS	Generic ATN Communications Service
GBAS	Ground Based Augmentation System
GM	Guide to Manoeuvre Process
GNSS	Global Navigation Satellite System
GRAS	Ground Based Regional Augmentation System
GT	Guide to Trajectory Process
HMI	Human Machine Interface
HUD	Head Up Display
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
MAS	Managed Air Space
MCDU	Multi-Function Control and Display Unit
MLS	Microwave Landing System
ND	Navigation Display
ODIAC	Operational Development of an Integrated Surveillance and Air/Ground Communications
PFD	Primary Flight Display
PM	Performance Model
RFL	Required Flight Level
RVR	Runway Visual Range
SID	Standard Instrumented Departure
SBAS	Satellite Based Augmentation System
STAR	Standard Arrival Route
SUA	Special Use Airspace
TBD	To Be Defined
TG	Trajectory Generator Process
TIS-B	Traffic Information Service – Broadcast
TMA	Terminal Manoeuvring Area
UMAS	Unmanaged Air Space
URCO	Urgent Communication
VDL	VHF Data Link
VHF	Very High Frequency
WBS	Weight and Balance System

6.2 Glossary of Terms

Collaborative Decision Making – Although a process, CDM is essentially a concept that anticipates the need for active collaboration of all the actors (pilot, ATC and AOC) involved in order to reduce potential risks as much as possible. The goal of CDM is to improve mutual knowledge of the forecast/current situations along with the preferences and capabilities of each actor, so that the person best able to make a decision is the one who does so.

Constraints – A constraint is a condition that should be met by the trajectory. Typical constraints are a position, position and time, altitude, speed, an arrival or departure procedure.

FIR/UIR – This represents a Flight Information Region or Upper Information Region of airspace with defined dimensions within which a Flight Information Service and Alerting Service are provided.

Free Flight Air Space – FFAS is an area of free routing where the responsibility for separation of aircraft has been fully delegated to the aircraft.

The volumes of airspace that will be allocated to FFAS will be promulgated by the airspace planning and management service on a daily basis to reflect the demand patterns expected across the ECAC airspace. This will take into account the forecast traffic flow densities, the capabilities of flights and the balance of benefit to the users' quest for flexibility and economy. The aim will be to adjust the volumes of FFAS to maximise the benefits for capable aircraft, while providing an incentive for aircraft operators with less capable aircraft to upgrade their avionics fits.

Suitably equipped aircraft will be able to fly user-preferred 3-D or 4-D routings. Responsibility for SA from other aircraft operating in the same airspace will rest with the aircraft in almost all circumstances, although some responsibility can be undertaken by ground-based ATM (emergencies) or delegated to other organisations (principally the military). Access to this airspace by less capable aircraft will be subject to acceptance by the ATM service; access by capable aircraft is implicit.

WIthin FFAS, aircraft will be able to choose their own trajectories subject to notification to ATM. CDM will be a major enabler to safety, flexibility and efficiency.

Aircraft operating within FFAS will be supported by a ground ATM network that will provide information and alert services to guarantee safe operations.

Lateral Passing and Crossing – This application is intended to allow one aircraft to cross or pass another aircraft on a similar track in airspace regions where the standard separation criteria would not normally permit such a manoeuvre. However, the lateral crossing application should also be considered feasible for standard sectors. The general idea is to transfer the responsibility of maintaining separation between two aircraft from the ground to the airborne side in a similar manner to descent spacing and level flight spacing applications.

MA-AFAS Trials Requirements – In the context of this document, this means all requirements necessary to complete the specified validation tests.

Managed Air Space – MAS is defined as an airspace with vertical, lateral and time boundaries that will be needed to support en-route operations within which the control of aircraft is the responsibility of the ground ATM organisation.

Traffic structuring, in the form of 2-D and 3-D route networks, will be used in the busiest areas at peak times to enhance capacity. These can also be used to organise traffic flows and to reduce the incidence of conflicts for Enroute and TMA operations. In other areas and outside peak times in the busiest areas, MAS will support the operation of aircraft using user-preferred trajectories outside the structured routes.

In MAS, the responsibility for separation assurance will rest with the ground ATM organisation. This service will be provided on the basis of ' intervention by exception' as far as possible. In some specific traffic situations the responsibility for separation may be explicitly transferred to aircraft suitably equipped to exercise autonomous separation and subject to the agreement of the pilot.

Phases Of Flight – The phases of flight provides a simplified breakdown of a flight from gate to gate. This includes taxi manoeuvres, take-off, ascent, cruise, descent, final approach and landing.

Pilot – In the context of this document, the term pilot is assumed to include the pilot and first officer.

Protected Airspace Zone – This is a defined area surrounding the ownship that is reserved for ownship usage. Penetrations of the zone are regarded as a conflict and the system will advise a manoeuvre to avoid such an occurrence. A typical zone will extend ±1000ft vertically and 5nm laterally.

Separation Assurance – concerns the means by which individual flights remain separated from others, in accordance with minimum separation standards, and from other hazards (e.g. terrain, obstacles, vehicles etc.).

Spacing (Station Keeping) – This is the action of keeping an agreed distance or time behind a specified aircraft, thereby following its trajectory at a constant offset.

Strategic Request – This is a request that has a definite end condition.

Tactical Request – This is an open ended ATC commands such as heading commands e.g. “Turn on to heading 180” or an altitude commands e.g. “Climb to FL360”.

Trajectory - This is a flyable 4D flight path including a 3D position, time, fuel consumption, expected weather and trajectory change points.

Unmanaged Air Space – UMAS will be the same as today’ s “Outside Controlled Airspace” and subject to similar rules as those applied now (Rules of the Air).

Aircraft operating in UMAS will not interact with ATM unless they wish to notify their presence either by filing a flight plan or by broadcasting their position. ATS and in particular, Flight Information Services, may be provided to aircraft in UMAS on request.

Use Case – A use case provides a method of capturing the interactions between a system and a user of the system. The use case represents the functionality provided by the system, that is, the capabilities provided to the user by the system. More formally, a use case is a sequence of transactions performed by the system in order to achieve a measureable result for a particular user.

6.3 Alert Type Descriptions

Emergency - Operational emergency conditions or aircraft equipment conditions that require immediate corrective actions by the pilot.

Abnormal - Operationally abnormal conditions or aircraft equipment conditions that require immediate pilot awareness and subsequent corrective action.

Advisory - Operationally abnormal conditions or aircraft equipment conditions that may require corrective actions by the pilot.

Information - Operational or aircraft equipment conditions that require pilot awareness but not necessarily as part of an integrated alerting system.

6.4 AxiomSys Structured Analysis Tool

Dataflow Context Diagram: The dataflow context diagram shows the system embedded in its environment of terminators.

Data Flow Diagram: A data flow diagram (DFD) is a network representation of a system's required processing capabilities. The system can be automated, manual or automatic. The DFD portrays the requirements in terms of functional processes, the data that flows between the processes and the data stores that the processes share.

Data Flow: A data flow is a pipeline through which information, material or energy of a known composition flows. These are represented as solid lines on a DFD.

Process: A process indicates the transformation of incoming data flows into the outgoing dataflows. These are represented as bubbles on a DFD. A grey bubble indicates a process that will be decomposed further in the software design and detailed in D24. A white bubble indicates that a bubble decomposes further unless the name is shown in blue in which case the process is considered to be a primitive item for which no further decomposition will be performed.

Process Specification: A process specification is used to detail the way in which input data flows are transformed into the output dataflows.

Terminator: A terminator is something that is external to the system with which the system receives, sends or exchanges information, messages, material or energy. These are represented as rectangles on a DFD. Terminators can only appear on context diagrams.

Control Flow: A control flow represents a special type of data flow that is used to activate or deactivate a process. These are represented as dashed lines on a DFD.

Control Specification: Control specifications capture the control processing requirements of the system. They transform control flows into one or more of the following: process activators or new control signals. These are represented as a solid vertical bar on a DFD.

Architecture Context Diagrams: The architecture context diagrams show the system embedded in its environment of terminators.

Architecture Flow Diagram: An architecture flow diagram (AFD) is a network representation of a subset of the architecture modules and the flows between them.

Architecture Interconnection Diagram: An architecture interconnection diagram (AID) provides a graphical representation of the architecture modules and the physical channels over which information, materials or energy are exchanged.

Architecture Module: An architecture module represents a basic building block for the system. A module can take many forms. Examples are hardware elements such as computers or mechanical devices or software elements that perform specific parts of the requirements. The complete system is represented by a network of modules. These are represented as rectangles with rounded corners on architecture diagrams.

Architecture Flow: An architecture flow represents the information, material or energy that is exchanged between architecture modules or between architecture modules and the environment. These flows can represent single or multiple elements. Where the flow represents information, it can be data, control or both.

Architecture Channel: A channel represents the physical means by which an architecture dataflow is transferred from one module to another. The AxiomSys tool identifies three classes of channel, bus, optical and mechanical. These are represented as solid lines, lines with circles and lines with bars respectively.

Architecture Interconnect: An interconnect is the physical means or channel through which information, material or energy is exchanged between architecture modules. It may comprise any medium, e.g. electrical, mechanical, optical, hydraulic.

The set of data flow diagrams provides a model of the system and its required capabilities without regard to the physical constraints of the input and output dataflows. In order to address these aspects, an architecture template is used in order to developed enhanced dataflow diagrams that take account of physical and logical interfaces between the environment and system components. The architecture template is shown in the figure below.

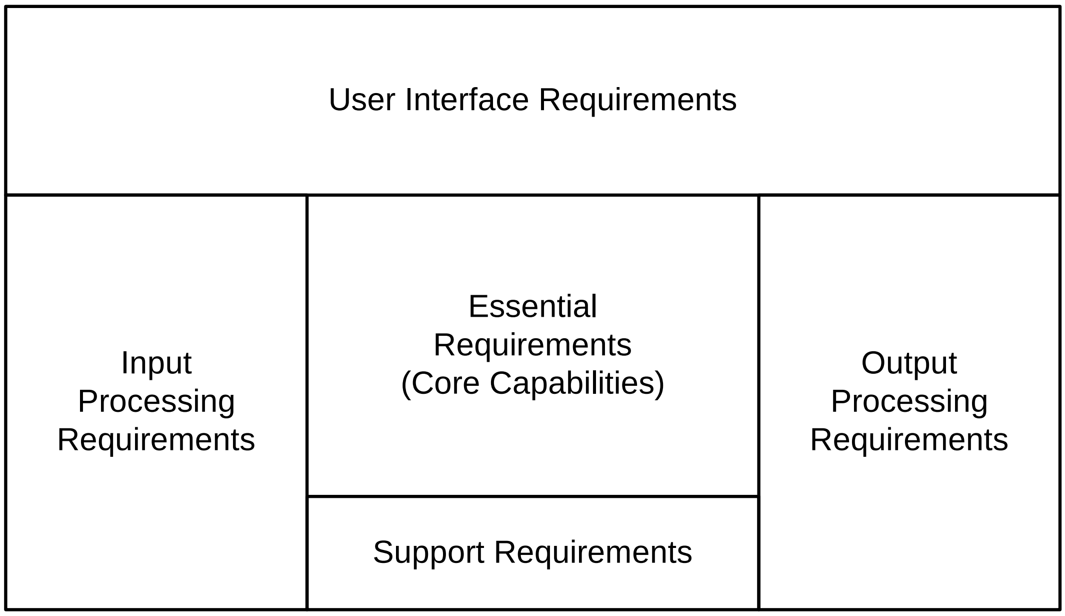

Figure 25 Architecture Template

The benefit of the enhanced dataflow diagrams is that the development of the physical interface components can be separated from the development of the core capabilities of the system. The relationship between the two sets of diagrams is represented by the following diagram.

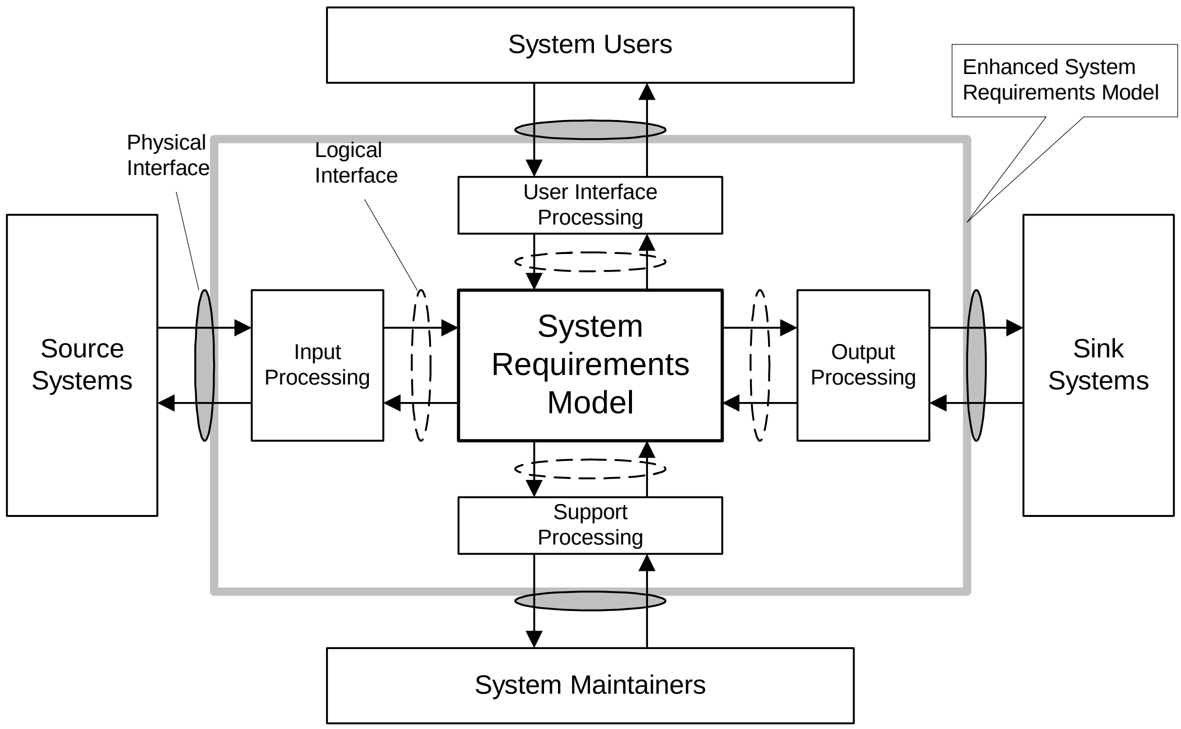

Figure 26 Physical and Logical Interfaces