CONTRACT N° : G4RD-2000-00228

PROJECT N° : GRD1-1999-10516

ACRONYM : MA-AFAS

TITLE : THE MORE AUTONOMOUS - AIRCRAFT IN THE FUTURE AIR TRAFFIC MANAGEMENT SYSTEM

D18 – Airborne System Requirements Specification

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NLR (Netherlands)	

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Skysoft (Portugal)	SOFREAVIA (France)
Stasys Limited (UK)	Thales ATM (France)

Report Number :	**560/79410**
Project Reference number :	**MA-AFAS – WP1.3-BAESYSTEMS**
Date of issue of this report :	**22 November 2001**
Issue No:	**1.2**
PROJECT START DATE :	**1/3/2000 DURATION : 36 months**

Project funded by the European Community under the 'Competitive and Sustainable Growth' Programme (1998-2002)

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Airborne System Requirements Specification

Data Deliverable D18

Document No. 560/79410
Issue 1.2

Contains 64 pages total

Comprising:

7 pages front matter

57 pages text and figures

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LIST OF EFFECTIVE PAGES AND CHANGE HISTORY

Insert latest changed pages. Destroy superseded pages

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 64
CONSISTING OF THE FOLLOWING

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1 SCOPE

1.1 Identification

This document has been produced by the Avionics Systems Group of BAE SYSTEMS as deliverable item D18 “System Requirements Specification for the Airborne Equipment“ for the MA-AFAS programme.

This deliverable defines the functionality required of the airborne equipment that is to be used in demonstrating the MA-AFAS concept.

Functionality defined within this document will be included in the MA-AFAS simulations and flight trials programme.

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 (MA-AFAS D9). Secondly, the Operational Concepts have been translated into system requirements specifications for the overall system (MA-AFAS D13), the ground functionality (MA-AFAS D11) and the airborne functionality (MA-AFAS D18 - this document), and the Operational Services necessary for the integration of Ground and Air facilities defined (MA-AFAS D14). From these documents, the necessary hardware and software components will be developed and implemented. Finally, the Operational Concepts will be validated using the hardware and software in carefully planned simulator and in-flight trials. The results of the trials will then be available to form the basis of a Minimum Operational Performance Standard to be developed by a body such as EUROCAE.

This programme is focused on the ATM solution required for aircraft retrofit with the system design being based on a core ARINC 702A Advanced Flight Management Computer System (FMS), an ARINC 725 Electronic Flight Instrument System (EFIS) and an ARINC 758 Communications Management Unit (CMU).
The capabilities that will be added to the core FMS and validated within this programme include the following:

- Evaluation of airborne 4D trajectory generation and guidance, including negotiation of the flight path with the Air Traffic Control (ATC) via data link.
- The use of a Global Navigation Satellite System (GNSS) with ground and space based augmentation for enhancing approach procedures under 4D flight path control.
- The use of received Automatic Dependent Surveillance – Broadcast (ADS-B) data transmissions (using VDL Mode 4) which will
  - Provide an Enhanced Situation Awareness via a Cockpit Display of Traffic Information (CDTI)
  - Be a facilitator for Autonomous Operations by means of an Airborne Separation Assurance (ASA) System.
- Integration of an on-board map database and data linked Taxi instructions and clearances.
- Support for the Airline Operational Centres in respect of aircraft maintenance, and the control and management of their aircraft fleet.
- Evaluation of the flight deck Human Machine Interface (HMI) improvements to support the increased capabilities of the FMS with particular emphasis on the 4D trajectory generation and monitoring in a more autonomous environment.

- Integration of the full Aeronautical Telecommunications Network (ATN) stack (using VDL mode 2 and VDL mode 4 sub networks) in the airborne environment to support Airlines Operation Centre (AOC) and ATC communications using ODIAC defined standards.

Requirements within this document are presented in a manner consistent with a single box solution that can be used as a trials fit for the MA-AFAS validation exercise. However, it is recognised that a production solution will need to comply with ARINC standards and will therefore probably comprise two main units; a FMU based upon ARINC 702A, and a CMU based on ARINC 758. In either case, the functional specification will be identical whereas the physical specification may be different. Throughout this document, the physical specifications are those for a production type system. Where the system needs to be adapted to cater for specific needs of the trials aircraft/rigs, particularly in the external interfaces, the differences will be identified in lower level documentation.

It is acknowledged that a production FMS will be capable of functioning in aircraft with a dual or triple redundancy fit for the flight management functions. The trials equipment, however, will not address this other than ensuring that any design produced will not preclude an eventual upgrade to the implementation of a multiple redundant system.

In addition to the FMU and CMU components, the MA-AFAS system will require a Cursor Control Device (CCD), a display surface and, possibly, extra radio equipment to be supplied. For the trials fit, these components may well be 'ad hoc' items as available at the time. However, in a production system it is anticipated that these items will conform to ARINC specifications and will be available in the aircraft.

Throughout this document, references to the 'Airborne Equipment' refer to this entire MA-AFAS avionics system.

1.3 Document overview

The structure of this document follows the guidelines for a system specification as detailed in the MIL-STD-498 software documentation standard.

Section 1 gives an overview of the airborne equipment of MA-AFAS and identifies where it fits within the overall system, as well as defining any MA-AFAS specific terminology.

Section 2 references all applicable documents, including international and European standards with which the airborne equipment must comply.

Section 3 lists the system requirements for the airborne equipment and specifies the methodology that will be used to validate each requirement.

This document is organised into functional categories unlike MA-AFAS D13 which followed the themes identified to be a part of the MA-AFAS programme. It should be noted that this structure is intended to facilitate the definition of an integrated system and in no way imposes constraints upon the work breakdown of the project. The terminology of the different themes has been used where appropriate in this document to facilitate the transition between themes and functionality.

The functional categories are thus:

a) Flight Management - this covers those items that are defined in ARINC 702A

b) Airborne Separation Assurance, covering Autonomous Operations (Conflict Detection and Resolution), Partial Delegation (Spacing and Passing/Crossing manoeuvres) and No Delegation operations.

c) 4D En-Route, covering Trajectory Generation and Negotiation and Aircraft Guidance.

d) Precision Approach and Departure

e) Taxi Management

f) Data Management, covering the database and Data Logging requirements.

g) Human Machine Interface (HMI). This section includes all HMI related requirements for all of the specified functionality.

h) Communications, covering all aspects of data and voice communications required by the MA-AFAS system.

Section 4 defines the methodology that will be applied to validate the airborne equipment, including detailing the testing philosophy required before the equipment can be integrated into simulation test beds and trials aircraft.
Certification issues are also dealt with in this section.

Section 5 deals with the traceability of the requirements presented within this document to those requirements in the MA-AFAS System Requirements Specification, D13..

Section 6 provides a list of abbreviations and a glossary of terms used within this document.

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.
Since an automated tool is being used for requirements capture, each system requirement that has been identified within this document has been uniquely numbered using the DOORS numbering facility. This identification number is shown on the line immediately following the statement of the requirement.

As well as the requirement text, the DOORS database holds attributes that define the validation method that will be used to show how the developed system is compliant with the stated requirement and a validation phase, that defines when the system will be tested to show compliance. These attributes are also shown on the line immediately following the statement of the requirement.

The contents of the document have been generated with the help and guidance of numerous MA-AFAS partners to whom the author gratefully extends his thanks.

1.4 Special Usage

Where a mandatory requirement is to be specified, the word “shall” shall be used. Where a recommendation (wish) is intended, the words “may” or “should” shall be used. When the system is implemented, recommendations using “may” or “should” will be considered but will not be implemented if they are thought to be unnecessary.
The use of the present tense has been reserved for descriptive or commentary text.

The use of Verification Phase "Post MA-AFAS" for a requirement indicates that it is not intended to satisfy the requirement during the MA-AFAS programme, but the requirement is stated as an indication of future intent.

2 REFERENCED DOCUMENTS

2.1 MA-AFAS Documents

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.

ATM Operational Concept. Version 1, 27 October 2000.

MA-AFAS D9: MA-AFAS Operational Concept, Issue 1, 27-Oct-2000

MA-AFAS D11: MA-AFAS Ground Equipment Specification

MA-AFAS D13: Definition of ATM MA-AFAS Airborne and Ground Functions. GRD1-2000-0228. BAE Systems 560/78706, Issue 1.1.

MA-AFAS D14: Operational Services and Environment Definition for MA-AFAS (OSED), Issue 1.0, May 2001

MA-AFAS D15: Airworthiness and Operational Approval Requirements and Methods for MA-AFAS. WP1.6

MA-AFAS D45; Operational and Airworthiness JAA Approval Plan, WP4, Issue TBD, Date; TBD.

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

ASAS/CDTI: Autonomous Operation. Revision 3d, 13 Sept 2000. WP1.3.

2.2 Standards

2.2.1 ARINC Standards

ARINC 413A; Guidance for Aircraft Power Utilization and Transient Protection; Date 12/76

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 646; Etehernet Local Area Netwirok (ELAN), 8 December 1995.

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 (EFI), 5 Nov 1984.

ARINC 726-1; Flight Warning Computer System, 8 Sept 1980.

ARINC 755-1: Multi-mode Receiver.

ARINC 756-2: GNSS Navigation and Landing Unit.

ARINC 758-1: Communications Management Unit (CMU) Mark 2, 13 Feb 1998.

2.2.2 Documentation Standards

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

2.2.3 Other Standards

ASSAP MOPS: Minimum Operational Performance Standards for Airborne Surveillance and Separation Assurance Processing; Number and Issue TBD, Date TBD.

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

DO178B/ED12B; Software Considerations in Airborne Systems and Equipment Certification; Errata 26-Mar-1999, published by RTCA.

DO-242; Minimum Acceptable System Performance Specification for Automatic Dependant Surveillance - Broadcast (ADS-B MASPS); Issue TBD, Date TBD, published by RTCA.

ED-78A: Guidelines for Approval of the Provision and use of Air Traffic Services supported by Data Communications, issue dated December 2000, published by EUROCAE,.

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

ODIAC AGC-ORD-01: Operational Requirements for Air/Ground Co-operative Air Traffic Services, Issue 1.0, Dated 2 April-01, produced by Operational Development of Integrated surveillance and Air/ground data Communications.

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

2.3 Other Documents

The GEARS Conflict Resolution Algorithm by Richard Irvine, EEC. Issued by American Institute of Aeronautics and Astronautics AIAA-98-4236

Application of Airborne Conflict Management: Detection, Prevention and Resolution. Prepared by: RTCA Special Committee 186, WG1. Dated 19 October 2000.

93/68/EEC; "CE Marking" Directive

73/23/EEC; Low Voltage Electrical Equipment (LVD)

89/337/EEC; Electromagnetic Compatibility (EMC)

EUROCAE WG53 Baseline 1; Baseline 1 subset of the ATN SARPS. Prepared by: EUROCAE WG53

AMCP/7-WP/81; Manual on Detailed Technical Specifications for the VDL Mode 4 Data Link; Appendix B Draft updated 19-Dec-00.

3 REQUIREMENTS

3.1 Required states and modes

The airborne equipment that is produced from this specification will reside in one or more boxes. As such, the states definitions have to cover the partial working of the functions defined. It is expected that in normal usage, when the system is powered the state transitions from Off to Operate without operator intervention. However, if a part of the airborne equipment is not powered, the system will remain in initialise until either the system is fully powered or the operator chooses what state to engage (i.e. Operate or Maintenance).

Because of the intended rapid transition to Operate, it is necessary to allow operator interaction to control Operate to Maintenance transitions, to cover cases where the maintenance crew require to enter the Maintenance state with a fully functional equipment set. Entry to Maintenance will, however, always be covered by password protection.

The Airborne Equipment shall exist in 1 unpowered and 3 powered states as depicted in Figure 1.

[Analysis / DESN] [Air-SS-1127]

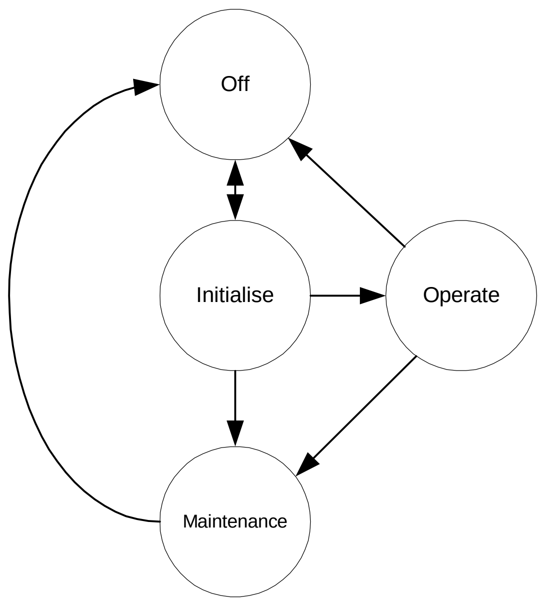


Figure 1 Air Equipment States

The transition from the Off state to Initialise shall occur upon the application of primary power to any component of the system.

[Analysis / DESN] [Air-SS-1128]

The transition from Initialise to Operate shall occur when all components of the system, as identified in the current configuration list, are powered and have passed their power-on tests.

[Analysis / IHT] [Air-SS-1129]

The transition between Initialise and Maintenance shall occur on operator command when all components of the MA-AFAS system are powered and have performed their power-on tests.

[Demonstration / IHT] [Air-SS-1141]

The transition between Operate and Maintenance shall occur on operator command.

[Demonstration / IHT] [Air-SS-1543]

The transition to the maintenance state shall be restricted by means of a password protection system.

[Demonstration / IHT] [Air-SS-1259]

The system shall transition to the Off state upon removal of primary power.

[Demonstration / DESN] [Air-SS-1131]

There are no Modes defined for the Airborne Equipment.

3.2 System capability requirements

3.2.1 Flight Management

3.2.1.1 Basic FMU

The airborne equipment shall be capable of providing basic FMU functionally as defined in the following Table:

[Inspection / IHT] [Air-SS-409]

ARINC 702A Functionality	ARINC 702A Paragraph
System Response to Power Interrupts	3.3
Real Time Clock	4.3.1.7

Table 1 Required FMU Functionality

3.2.1.2 Route Generation

The system will contain a Route Generator that allows the pilot to generate routes using the on-board databases and/or manual inputs.

The Route Generator will generate a route that comprises a series of constraints. These constraints will be based upon current situation and may cover the entire flight; runway to runway, or just a portion.

The system shall include a Route Generator that is capable of generating a route from the on-board databases (SID, STAR, company preferred route, etc.).

[Demonstration / IHT] [Air-SS-2544]

The Route Generator shall be capable of generating a missed approach route based upon the on-board navigation procedures (SID/STAR) database.

[Demonstration / IHT] [Air-SS-233]

The pilot shall have the ability to edit any route generated by the function.

[Demonstration / IHT] [Air-SS-2572]

The pilot shall be able to accept or reject the generated route.

[Demonstration / IHT] [Air-SS-2573]

3.2.1.3 Manoeuvre Generation

The system will include a manoeuvre generator that will be able to generate a standard manoeuvre that may be used in either MAS and FFAS. The manoeuvre generator will be responsible for creating a set of constraints that define a manoeuvre. This manoeuvre could be a spacing manoeuvre, either in-descent spacing or level flight spacing as defined in section 3.1 of MA-AFAS D14, or a passing or crossing manoeuvre. In all cases, the constraints will be passed to the Trajectory Generator for the generation of a trajectory which will be passed to the pilot for inspection and approval prior to implementation. The generator will not generate manoeuvres that cross the airspace boundaries.

Note that manoeuvres commanded by ATC whilst the aircraft is in MAS will not be checked for Airspace Boundary infringement.

3.2.1.3.1 Spacing Manoeuvres

The Manoeuvre generation function shall be capable of generating a capture route set of constraints such that the resultant trajectory will position the aircraft at a specified longitudinal distance or time behind a selected lead aircraft with an optional vertical offset.

[Demonstration / IHT] [Air-SS-230]

The Manoeuvre generation function shall be capable of generating a capture route set of constraints such that the resultant trajectory will position the aircraft at a specified longitudinal distance or time behind a selected lead aircraft with an optional lateral offset.

[Demonstration / Post MA-AFAS][Air-SS-2594]

The Manoeuvre generation function shall be capable of generating a set of constraints such that the resultant trajectory maintains the aircraft at a specified longitudinal distance or time behind a selected lead aircraft with an optional vertical offset.

[Analysis / IHT] [Air-SS-231]

The Manoeuvre generation function shall be capable of generating a set of constraints such that the resultant trajectory maintains the aircraft at a specified longitudinal distance or time behind a selected lead aircraft with an optional lateral offset.

[Analysis / Post MA-AFAS] [Air-SS-2595]

Where CPDLC communications are being used, the target aircraft for Spacing operation shall be selected automatically from the CPDLC message.

[Demonstration / IHT] [Air-SS-259]

The system shall be able to receive the required separation parameters (e.g. distance and tolerance) from the ground using a datalink.

[Demonstration / TT-R] [Air-SS-452]

The system shall be capable of receiving the 'End of Manoeuvre' details from the CPDLC message.

[Demonstration / IHT] [Air-SS-2556]

If the system generates a Partial Delegation Alert (as defined in 3.2.2.4.1) then the spacing manoeuvre shall be automatically terminated

[Demonstration / IHT] [Air-SS-2557]

3.2.1.3.2 Passing Manoeuvres

The Manoeuvre generation function shall be capable of generating a set of constraints such that the resultant trajectory implements a lateral passing manoeuvre that maintains a specified separation distance.

[Analysis / IHT] [Air-SS-234]

The Manoeuvre generation function shall be capable of generating a set of constraints such that the resultant trajectory implements a vertical passing manoeuvre that maintains a specified separation distance.

[Analysis / IHT] [Air-SS-235]

3.2.1.3.3 Crossing Manoeuvres

The Manoeuvre generation function shall be capable of generating a set of constraints such that the resultant trajectory implements a lateral crossing manoeuvre that maintains a specified separation distance.

[Analysis / IHT] [Air-SS-1138]

The Manoeuvre generation function shall be capable of generating a set of constraints such that the resultant trajectory implements a vertical crossing manoeuvre that maintains a specified separation distance.

[Analysis / IHT] [Air-SS-1139]

3.2.2 Airborne Separation Assurance

The functionality that comprises Airborne Separation Assurance performs two primary roles. One is to generate constraints for use by the trajectory generator in order to create a trajectory that will ensure that the ownship Protected Airspace Zone (PAZ) remains inviolate during Autonomous Operations. The second role is the monitoring of the aircraft position in relation to other traffic during Autonomous Operations and manoeuvres during periods of partial delegation of authority.

Associated with Separation Assurance is the increased situation awareness that is provided by passing the separation information, via the HMI, to the pilot.

The concepts used herein are derived from the Application of Airborne Conflict Management document.

3.2.2.1 General

Computations performed to provide the ASA functionality shall conform to the requirements defined in the document Minimum Operational Performance Standards (MOPS) for Airborne Surveillance and Separation Assurance Processing (ASSAP).

[Analysis / DESN] [Air-SS-370]

3.2.2.2 Airborne Separation Monitoring

The Separation Assurance function monitors the aircraft position in relation to designated target aircraft to ensure the maintenance of the assigned separation. The outputs from these monitors will be used to generate alerts to the pilot when the aircraft is operating under full or partial delegation conditions.

When in a manoeuvre, the system shall monitor the separation distance or time between the aircraft and all other traffic participating in the manoeuvre.

[Analysis / IHT] [Air-SS-453]

When the aircraft is the trailing member in a Spacing manoeuvre, the system shall monitor the speed of the leading aircraft.

[Analysis / IHT] [Air-SS-456]

When the aircraft is the trailing member in a Spacing manoeuvre, the system shall monitor the position of the leading aircraft.

[Analysis / IHT] [Air-SS-458]

When the aircraft is the trailing member in a Spacing manoeuvre, the system shall monitor the altitude rate of the leading aircraft.

[Analysis / IHT] [Air-SS-460]

When the aircraft is the trailing member of an in-descent Spacing manoeuvre, as signified by the reception of a Top Of Descent clearance, the monitoring of the lead aircraft's altitude rate shall be suspended.

[Measurement / IHT] [Air-SS-2575]

3.2.2.3 Autonomous Operations

Autonomous operations will only occur in Free Flight Airspace when full responsibility for separation has been delegated to the aircraft. The Airborne Equipment will assist the pilot by performing the following actions:

- detecting conflicts with other traffic (using the surveillance database).
- providing a trajectory that will resolve all known conflicts
- providing warnings in the event of loss of separation.

3.2.2.3.1 Conflict Detection

The requirements below use 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.

3.2.2.3.1.1 General

The system shall be capable of detecting potential conflicts between the aircraft and all traffic that is identified in the surveillance database.

[Measurement / IHT] [Air-SS-103]

The conflict detection function shall be applied to each new object as it appears in the surveillance database.

[Analysis / IHT] [Air-SS-417]

The conflict detection algorithm(s) shall be applied to all traffic objects where the Virtual Conflict Time is less than 20 minutes.

[Analysis / IHT] [Air-SS-1234]

The conflict detection algorithm(s) shall be applied to traffic objects at a period that is at most half the Virtual Conflict Time.

[Analysis / IHT] [Air-SS-221]

For traffic objects where the Virtual Conflict Time is less than 5 minutes, the Conflict Detection algorithm(s) shall be additionally run whenever new surveillance data is received.

[Analysis / IHT] [Air-SS-1169]

In the MA-AFAS programme, it is intended to use data transmitted by traffic (ADS-B) with the current ownship data to predict conflicts that may occur within the ADS-B data horizon.
When the system has generated a proposed trajectory, this will be used to test for potential conflicts before acceptance as the active trajectory.

3.2.2.3.1.2 Active Trajectory Conflicts

The system shall use the active trajectory and data gathered by the Surveillance function to identify conflicts with other airborne objects.

[Analysis / IHT] [Air-SS-1115]

3.2.2.3.1.3 Proposed Trajectory Conflicts

The system shall use the proposed trajectory and data gathered by the Surveillance function to cross check that the proposal will not cause conflicts with other airborne traffic.

[Analysis / IHT] [Air-SS-416]

3.2.2.3.2 Conflict Resolution

To resolve a conflict, the conflict resolution function, in conjunction with the trajectory generator, will generate a proposed trajectory that minimises the likelihood of occurrence for any conflict that has been detected by the system. This is then presented to the pilot who can accept, reject or modify the proposal.
For the MA-AFAS trials, two algorithms will be used: the short term revised Voltage Potential Algorithm from NLR and the longer term GEARS algorithm from EUROCONTROL. It is possible that manoeuvres such as spacing and passing will be included to cover the cases where two aircraft are following similar trajectories with the trailing aircraft moving faster than the lead aircraft.

The MA-AFAS equipment will be able to support both implicit and explicit co-ordination methods for conflict resolution as discussed in MA-AFAS D14.

It is anticipated that the Conflict Resolution function will be run at a fixed rate, possibly governed by the Pilot Decision Time, such that a new resolution path is not computed each time a new conflict is detected.

The Conflict Resolution algorithm(s) shall only be used to support Autonomous Operations in FFAS.

[Analysis / IHT] [Air-SS-224]

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 / IHT] [Air-SS-160]

The system shall allow the generation and execution of Spacing, Crossing and Passing manoeuvres to resolve conflicts whilst the aircraft is operating under Autonomous Operations conditions.

[Analysis / IHT] [Air-SS-1567]

Any proposed trajectory shall resolve all conflicts detected at the time that the revision is generated.

[Analysis / IHT] [Air-SS-161]

The Conflict Resolution process shall utilise the Airspace Boundary definitions database to ensure that the resolution trajectory does not include a boundary crossing.

[Analysis / IHT] [Air-SS-220]

The computed trajectories shall allow for the Pilot Decision Time.

[Analysis / DESN] [Air-SS-162]

The pilot shall be able to modify the proposed trajectory.

[Demonstration / IHT] [Air-SS-262]

The system shall replace the active trajectory with the proposed trajectory upon acceptance of the proposal by the pilot.

[Demonstration / IHT] [Air-SS-263]

Modifications made to the proposed trajectory shall be checked for conflicts prior to acceptance by the system.

[Analysis / IHT] [Air-SS-442]

If a proposed trajectory is not accepted or modification initiated by the pilot within the Pilot Decision Time then the system shall repeat the conflict resolution process.

[Demonstration / IHT] [Air-SS-163]

If a communications channel has been established with the conflicting object, the system shall be capable of using explicit co-ordination in the resolution of the conflict.

[Analysis / Post MA-AFAS] [Air-SS-443]

The system shall be capable of implicit co-ordination for the resolution of a conflict.

[Analysis / IHT] [Air-SS-444]

The system shall be capable of using relative priorities of the conflicting aircraft to allow a priority based conflict resolution.

[Analysis / IHT] [Air-SS-445]

The system shall compute the relative priorities between the ownship and conflicting traffic using Extended visual Flight Rules (EFR).

[Analysis / DESN] [Air-SS-447]

EFR Rules:
1 high priority is given to a descending aircraft
2 medium priority is given to an aircraft flying level
3 low priority is given to a climbing aircraft
4 in the case where the state data of both aircraft are identical, the aircraft closest to the point of loss of separation has higher priority
5 in the event of the systems continued inability to resolve priority, the aircraft with the lowest ICAO address shall manoeuvre.

The aircraft with the lowest priority shall execute the manoeuvre

[Demonstration / IHT] [Air-SS-451]

The resulting scenarios from these rules are depicted in the following table

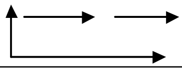
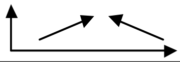
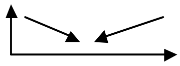
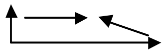
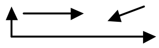
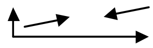
Conflict situation	Description	Manoeuvring Aircraft
Both in level *		The farthest in distance from the point of loss of separation
Both climbing*		The farthest in distance from the point of loss of separation
Both descending*		The farthest in distance from the point of loss of separation
A in level, B climbing		B
A in level, B descending		A
A climbing, B descending		A

Figure 2 EFR Priority Rules

3.2.2.3.3 Autonomous Operations Alert Generation

In line with section 2.3.1 of the Application of Airborne Conflict Resolution document, the system will be capable of generating conflict alerts to the crew. For MA-AFAS there will be 2 levels of alerts:

a) Information Only the situation display will identify potential conflicts

b) Advisory A text message will be displayed on the MCDU alerting the pilot of the impending situation. This may be in conjunction with data presented on the situation display.

The actions associated with these are defined in the HMI section.

If a conflict is detected and has a time to conflict of greater than 2 minutes then an information alert shall be generated.

[Demonstration / IHT] [Air-SS-472]

If a penetration of the PAZ has occurred or is predicted within the next 2 minutes then an advisory alert shall be generated.

[Demonstration / IHT] [Air-SS-473]

3.2.2.4 Partial Delegation of Authority Operation

The system will be capable of automatically generating manoeuvres to allow the aircraft to pass, follow and cross the track of other traffic whilst maintaining separation. This process involves both the Manoeuvre Generation function, which creates a series of constraints, and the trajectory generator, which generates the 4D path the aircraft is required to follow.

For the system to provide these capabilities, it is assumed that the required manoeuvre has been communicated from ATC by means of a datalink. For the MA-AFAS trials, however, this information may need to be input by hand using the HMI facilities. The system must therefore be capable of accepting either type of input.

In all manoeuvres, the trajectory generator will provide a trajectory that keeps the aircraft away from other traffic. The minimum separation distance will be specified by ATC or the airline operator may specify a preferred distance.

Document MA-AFAS D14 provides reference material as to the definitions of the various manoeuvres defined herein, in the context of the MA-AFAS trials.

The system shall allow the generation and execution of Spacing, Crossing and Passing manoeuvres whilst the aircraft is operating under Partial Delegation conditions.

[Analysis / IHT] [Air-SS-1568]

3.2.2.4.1 Partial Delegation Alert Generation

When under Partial Delegation of Responsibility conditions, the alerts generated will warn of the non adherence to the ATC requirements by the aircraft.

An advisory alert shall be generated when the separation distance measured varies from the value defined for the manoeuvre by more than the defined tolerance.

[Demonstration / IHT] [Air-SS-454]

If a tolerance value has not been set then a figure of 10% shall be used.

[Analysis / IHT] [Air-SS-455]

An advisory alert shall be generated if the specified aircraft separation will be lost in the next 2 minutes

[Analysis / IHT] [Air-SS-258]

When the aircraft is the trailing member in a Spacing manoeuvre, the system shall generate an advisory alert if the speed of the leading aircraft approaches within 30kts of the minimum/maximum normal operating speed of the trailing aircraft in the current configuration.

[Measurement / IHT] [Air-SS-457]

When the aircraft is the trailing member in a Spacing manoeuvre, the system shall generate an advisory alert if the leading aircraft deviates by more than twice the associated airspace's RNP from the trailing aircraft's planned trajectory at that point.

[Measurement / IHT] [Air-SS-459]

When the aircraft is the trailing member of an in-trail Spacing manoeuvre, the system shall generate an advisory alert if the leading aircraft changes altitude rate by more than 200Ft/min.

[Measurement / IHT] [Air-SS-461]

An advisory alert shall be generated if the surveillance data for the target aircraft has not been updated within 3 times the expected ADS-B or TIS-B update interval for the associated airspace.

[Measurement / IHT] [Air-SS-324]

3.2.2.5 Operations with No Delegation of Authority

When the aircraft is operating under full control of the ATC, the system will have a passive role in which no navigational alerts are issued. The CDTI will be used to indicate the current aircraft position in relation to the latest trajectory.

The system shall be able to receive both Strategic and Tactical commands from ATC via the datalink.

[Analysis / FT-B] [Air-SS-2534]

The system shall be capable of obtaining manoeuvre data from the autopilot.

[Analysis / IHT] [Air-SS-2535]

3.2.2.6 Conflicts with Ground Traffic

An advisory alert shall be generated when the system detects traffic on the runway and the aircraft is within TBD of landing.

[Demonstration / Post MA-AFAS][Air-SS-102]

The system shall be capable of detecting conflicts with ground traffic when the aircraft is on the runway designated for take-off or after landing.

[Demonstration / Post MA-AFAS][Air-SS-105]

After the aircraft has received take-off clearance and has entered the runway designated for take-off, an advisory alert shall be generated if a runway incursion by other traffic is detected ahead of the aircraft.

[Demonstration / Post MA-AFAS][Air-SS-93]

3.2.3 4D Enroute

3.2.3.1 Overview

The functionality of the 4D-Enroute facility splits naturally into three main groups. The first group provides a standalone set of functions for trajectory generation. This group is closely linked with the second group of functions that are responsible for handling negotiations between the pilot and ATC. The final group of functions is responsible for the aircraft guidance while the autopilot is engaged with FMS control selected.

It is envisaged that the trajectory generation functions will be available to both the pilot, with control instigated through the HMI, and also independently to the Airborne Separation Assurance (ASA) functions. At all times, overall control will be retained by the pilot.

Once a trajectory has been selected as the active route, the 4D-Enroute functions need to be capable of simultaneously generating autopilot commands from that trajectory while still providing trajectory generation facilities to either the pilot or other aircraft functions such as the ASA.

NOTE: The HMI and communications aspects of the 4D Enroute capabilities are described within the HMI and communications sections of this document respectively.

All of the 4D Enroute functions shall be available when the aircraft equipment is in the operate state.

[Analysis / IHT] [Air-SS-236]

3.2.3.2 Trajectory Generation

The Trajectory Generator will be used to convert identified constraints into a 4D trajectory which can be used to provide guidance for the aircraft. Because of the variability of the sources of constraints, it is possible that the generator will fail to produce a valid trajectory in which case pilot input will be sought.

3.2.3.2.1 General

The lateral route shall be defined in terms of straight legs, consisting of great circle arcs, joined by turns of constant radius.

[Analysis / DESN] [Air-SS-63]

The trajectory generation shall take account of wind speed and direction at all trajectory points along the route.

[Analysis / DESN] [Air-SS-237]

The Trajectory Generator shall use the Meteorological Database to determine air pressures and temperatures along the proposed trajectory.

[Analysis / DESN] [Air-SS-1571]

If it is not possible to generate a trajectory that meets all of the constraints, then an information message shall be generated that indicates which constraints have not been met and, if possible, the reason(s) why the constraint has not been met.

[Analysis / IHT] [Air-SS-59]

The system shall be capable of suggesting actions that will resolve the inability to generate a trajectory.

[Demonstration / IHT] [Air-SS-1152]

The trajectory generation function shall take into account all constraint points between the current position and the destination, and that have been accepted by the pilot.

[Analysis / DESN] [Air-SS-227]

When the aircraft is on the ground, this function shall use the mid point of the runway and the estimated time of departure to define the start of the trajectory.

[Analysis / IHT] [Air-SS-60]

When the aircraft is airborne, the Trajectory Generator shall use the current position of the aircraft as the initial constraint point.

[Analysis / IHT] [Air-SS-61]

The Manoeuvre Generator shall generate and use a constraint point that defines the start of the manoeuvre (i.e. the branch point from the active trajectory).

[Analysis / IHT] [Air-SS-1511]

The Manoeuvre Generator shall allow for the Pilot Decision Time when generating the start point for a manoeuvre.

[TBD / TBD] [Air-SS-2597]

3.2.3.2.2 Constraints

There are a wide variety of constraint types that can be defined to limit the range of possible trajectories from the departure point to the destination point. The simplest constraints are route Waypoints. These comprise a latitude and longitude position with a flag to indicate whether the position must be flown over or just flown past. For 4D routing, each waypoint may also include an altitude and/or time constraint. Other constraint types include weather, airport, e.g. SIDs, STARs, Tactical, e.g. Climb FL 1234, set aircraft speed, or Conflict Resolution constraints.

Throughout the flight, constraints may be altered by the actions of the pilot, AOC, ATC, Weather or the Manoeuvring and Conflict Resolution functions. Each time the constraints change, the pilot will be given the opportunity to initiate the generation of a new trajectory

Each time a trajectory is generated, the pilot will be given the opportunity to review the result. In the event that the pilot notes a conflict between constraints, he will be able to resolve the conflict by editing the constraints and renegotiating with ATC.

The trajectory generation function shall take into account any defined operating procedures such as SIDs and STARs

[Analysis / IHT] [Air-SS-64]

'The trajectory generation function shall attempt to use the aircraft's optimum speed, altitude and thrust settings which will have been defined for the particular flight, modifying these in line with the selected cost index to meet any constraints.

[Analysis / IHT] [Air-SS-65]

The system shall be capable of utilising constraints received from AOC.

[Analysis / IHT] [Air-SS-291]

The system shall be able to generate constraint points that facilitate the avoidance of weather features reported via the SIGMET function.

[Demonstration / Post MA-AFAS][Air-SS-1572]

3.2.3.2.3 Flight Phase Table

The Phase Table in the on-board database represents the full capability for breaking a flight down into phases, each representing a different, optimised procedure for flying the aircraft. A flight plan is entered into the FMS, is modified by constraints, and is then applied to the detailed phase table. At this time, some of the phases in the detailed phase table may not be applicable to the current flight and so they are effectively ignored. The Phase Table itself is predominantly of fixed parameters, representing the efficient and limit settings for controlling the aircraft, but some parameters may be changed on a flight-by-flight basis by the pilot. The precise number of phases may change from aircraft type to aircraft type and from operator to operator, so it is not appropriate to define here the full list of phases to be included, only that a variable number of phases must be allowed for.

The trajectory generation function shall take account of the flight phase table.

[Analysis / IHT] [Air-SS-181]

The system shall provide a static database containing a default phase table for the aircraft.

[Analysis / DESN] [Air-SS-182]

The system shall allow the static phase table database to be updated by the data loader.

[Demonstration / IHT] [Air-SS-2600]

The system shall allow modification of data by the pilot after it has been extracted from the phase table database, before it is used for trajectory generation.

[Demonstration / IHT] [Air-SS-2601]

3.2.3.3 Trajectory Negotiation

The trajectory negotiation process is intended to enable an agreement between the pilot and ATC to be reached about the intended progress of a flight in order to obtain clearances. It is an aim of the negotiation process that this should be achieved in a minimum number of exchanges.
The process is initiated with the generation of a proposed trajectory by the pilot using the route information created by the Route Generator.
Note that it is possible for the system to use an initial constraints list received from AOC or ATC that replaces any, or all, of the preferred route data.

The negotiation process comprises 4 steps:

a) A route is generated either from the on-board databases or a previous route and any extra constraints added.

b) The system generates a trajectory from the route

c) When the pilot is satisfied with the proposal, the flight plan (a sub-set of the trajectory) is transmitted to ATC for review and to check for conflicts.

d) Either

i) ATC approves the plan and transmits clearances (either full or partial)

Or

ii) ATC require changes and transmits extra constraints. This initiates a repeat of the negotiation process.

On receipt of the clearances, the pilot transmits an acknowledgement to the ATC and the pilot is expected to follow the agreed trajectory.

3.2.3.3.1 Trajectory Proposal

The proposed trajectory data transmitted to ATC shall include sufficient detail so that a linear interpolation function can estimate the aircraft arrival time at any position on the route with a maximum error of 2 seconds.

[Analysis / DESN] [Air-SS-272]

The proposed trajectory data transmitted to ATC shall include sufficient detail so that a linear interpolation function can estimate the aircraft altitude at any position on the route with a maximum error of 50 feet during a climb or descent phase and a maximum error of 10 feet during a level flight phase.

[Analysis / DESN] [Air-SS-273]

3.2.3.3.2 Trajectory Amendment

Trajectory amendments can be received from the ground as part of the negotiation process (as described above) or as part of a Collaborative Decision Making (CDM) process. In the latter case, the received data may eventually form the basis of a new trajectory negotiation process.The amendments may consist of a simple adjustment to a single waypoint, e.g. an altitude change, or a more complex revision of part of the trajectory whereby a number of waypoints are moved. In either case, the pilot will be alerted to the arrival of any trajectory modification message.

An advisory alert shall be generated upon receipt of any amendments from the ATC via datalink.

[Demonstration / FT-B] [Air-SS-275]

An advisory alert shall be generated upon receipt of any amendments from the AOC via datalink.

[Demonstration / FT-B] [Air-SS-277]

The system shall be able to use amendments received from ATC or AOC in the generation of a proposed trajectory.

[Demonstration / FT-B] [Air-SS-1242]

3.2.3.3.3 Trajectory Clearances

An advisory alert shall be generated upon receipt of any trajectory clearances from ATC via datalink.

[Demonstration / FT-B] [Air-SS-276]

3.2.3.3.4 Trajectory Acceptance

When a clearance has been received via datalink, a pilot acknowledgement message shall be sent to the ATC via datalink when the pilot accepts the clearance.

[Analysis / FT-B] [Air-SS-278]

The agreed trajectory shall replace the active trajectory upon acceptance of a clearance by the pilot.

[Analysis / IHT] [Air-SS-279]

3.2.3.4 Aircraft Guidance

The aircraft guidance functions shall operate independently of the trajectory generation and negotiation functions.

[Analysis / IHT] [Air-SS-187]

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

[Analysis / IHT] [Air-SS-188]

The guidance function shall be capable of maintaining the aircraft within the tolerance limits of the active trajectory.

[Analysis / FT-B] [Air-SS-189]

When the navigation data quality indicators change, the system shall provide a smooth transition of the tolerance limits.

[Analysis / IHT] [Air-SS-2549]

The Required Navigational Performance (RNP) of the airspace the aircraft will be travelling through shall be used as the lateral tolerance to each point in the Trajectory.

[Analysis / IHT] [Air-SS-1171]

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

[Analysis / IHT] [Air-SS-1172]

The navigational error due to GNSS shall be compared with the default GNSS navigational error component of the ANP and the tolerances adjusted to take into account any differences.

[Analysis / IHT] [Air-SS-2468]

The Required Vertical Navigation Performance (RVNP) of the airspace the aircraft will be travelling through shall be used as the altitude tolerance of each point in the trajectory

[Analysis / IHT] [Air-SS-1265]

The Required Time Navigation Performance (RTNP) of the airspace the aircraft will be travelling through shall be used as the time tolerance of each point in the trajectory

[Analysis / IHT] [Air-SS-1266]

When the AFCS status indicates that the pilot has selected GBAS, the airborne equipment shall inhibit the generation of guidance commands.

[Analysis / IHT] [Air-SS-2550]

Whilst flying in response to tactical commands issued by ATC, the system shall compute the cost, in terms of fuel and time, of returning to the previously computed trajectory.

[Analysis / IHT] [Air-SS-2660]

On reception of a 'Resume Own Navigation' command from ATC, the system shall use the strategy (ie most economic or shortest time) selected by the pilot to generate a new trajectory.

[Analysis / IHT] [Air-SS-2661]

3.2.3.4.1 Progress Monitor

The system will include a progress monitor to check that the aircraft is following the computed trajectory. This monitor will be initialised when a clearance is received and will continuously operate. If a tactical command is received and actioned, the progress monitor will still operate and at the end of the manoeuvre indicate to the pilot the route required to resume the original trajectory. If resumption is not possible, then an alert will be raised to inform the pilot that a new trajectory needs to be negotiated with ATC.

A trajectory progress monitoring process shall be automatically activated upon acceptance of a clearance by the pilot.

[Analysis / DESN] [Air-SS-280]

The monitoring function shall compare the aircraft position to the active trajectory.

[Analysis / DESN] [Air-SS-1512]

An advisory alert shall be generated if the aircraft manoeuvres outside the tolerance limits of the active trajectory, unless this manoeuvring is caused by acceptance of a tactical command from ATC.

[Analysis / IHT] [Air-SS-98]

An information alert shall be raised if the system detects that the aircraft will breach the tolerance limits of the active trajectory within the next 10 minutes, unless this breaching is caused by acceptance of a tactical command from ATC.

[Analysis / IHT] [Air-SS-1573]

An advisory alert message shall be generated if the aircraft approaches within 5 minutes of a segment of the active trajectory for which no clearance exists.

[Analysis / IHT] [Air-SS-333]

The system shall generate an advisory alert message when it detects that the aircraft is within 10 minutes of a constraint point that cannot be met, unless the missing of the constraint is caused by acceptance of a tactical command from ATC

[Analysis / IHT] [Air-SS-2658]

Whilst flying in response to tactical commands issued by ATC, the system shall compute the cost, in terms of fuel and time, of returning to the previously computed trajectory.

[Analysis / IHT] [Air-SS-2656]

On reception of a 'Resume Own Navigation' command from ATC, the system shall provide the pilot with the strategy (ie most economic or shortest time) selected by the pilot to generate a new trajectory

[Demonstration / IHT] [Air-SS-2657]

An advisory alert message shall be generated when an ATC command is received to return to the original trajectory, if the aircraft is flying under a tactical command with a trajectory still active and can no longer meet one or more constraints in the active trajectory.

[Analysis / IHT] [Air-SS-2659]

3.2.4 Precision Guidance

Precision Guidance is the term used for the guidance of the aircraft using navigation data that is augmented by data from a space or ground based augmentation system. For MA-AFAS, it is assumed that the augmentation data is mixed with the navigation data by an external system (probably the GNSS) even though part of the MA-AFAS airborne equipment is used to decode the augmentation data transmissions. In this way, the airborne equipment will not know what system is currently being used other than by inference of the data quality information. For trials, it is anticipated that only SBAS and GBAS will be used.

The GBAS will be used to perform landings, but this is outside the scope of the MA-AFAS equipment and thus the only requirements are that when the MA-AFAS detects that the GBAS has control of the AFCS then all MA-AFAS generated navigation alerts and guidance commands will be inhibited.

The MA-AFAS must, however, be capable of identifying when the aircraft has landed to allow the Taxi Management function to activate.

3.2.5 Taxi Management

3.2.5.1 Introduction

Taxi Management provides an improved situation awareness for the pilot whilst the aircraft is moving on the ground. The function comprises two facets:

a) The generation of plan-view display of an airport map and the overlay of traffic information upon the map.

b) The provision of pilot guidance indicators.

The system will receive a taxi route from GMC via the datalink. This data will identify the route, defined using taxiway, runway, hold and block identifiers, and any clearances currently issued.

Note that the map generation definition is included in the HMI section of this document and the reception/transmission of Taxi related data is defined in the Communications section.

The Taxi Management function will also allow a preview of the destination airport data whilst the aircraft is airborne.

3.2.5.2 Ground Movement Control

The Ground Movement function shall operate whilst the aircraft is on the ground.
[Analysis / IHT] [Air-SS-301]

The Ground Movement function shall continuously monitor the aircraft's position in relation to the runway map.
[Analysis / DESN] [Air-SS-82]

The guidance information shall include turn directions and severity.
[Analysis / Post MA-AFAS] [Air-SS-358]

The guidance information shall include the distance from the next turn.
[Analysis / Post MA-AFAS] [Air-SS-359]

The guidance information shall include the distance to the next hold box.
[Analysis / Post MA-AFAS] [Air-SS-360]

The guidance information shall provide Stop/Go status for the hold box.
[Analysis / IHT] [Air-SS-361]

The guidance information shall indicate the need for any speed change.
[Analysis / Post MA-AFAS] [Air-SS-362]

3.2.5.3 Alert Generation

An advisory alert shall be generated when the aircraft approaches a runway crossing for which clearance is required and has not been granted.

[Demonstration / IHT] [Air-SS-90]

An advisory alert shall be generated whenever the own aircraft is about to enter or cross a runway unless clearance for the action has been received via the datalink.

[Demonstration / TT-D] [Air-SS-91]

Positional alerts shall be suppressed when the available positional information has insufficient accuracy and integrity for ground manoeuvring

[Analysis / IHT] [Air-SS-317]

If the aircraft passes a waypoint that has the hold-short-of attribute set without gaining clearance, an advisory alert shall be generated.

[Analysis / IHT] [Air-SS-364]

3.2.6 Data Management

3.2.6.1 Database

The database is the central repository for the data needed for the system to function correctly. As such, the database performs different functions in each state of the equipment: When off, the database must retain the data, when in initialise state, the data integrity will be verified, in maintenance the contents of the database may be modified and/or deleted, and in operate state the database must prepare the data for use by the other system functions.

3.2.6.1.1 General

Data defined in this section shall be stored in non-volatile memory.

[Analysis / IHT] [Air-SS-553]

The non-volatile memory shall be capable of retaining data without power for a minimum of 6 months.

[Inspection / DESN] [Air-SS-555]

The database shall store only data, not any system executable code.

[Analysis / DESN] [Air-SS-556]

The database structure shall allow an increase in the number of different data types stored.

[Analysis / DESN] [Air-SS-557]

On entry into service a database load for a transcontinental flight shall occupy less than 50% of the available storage capacity.

[Analysis / Post MA-AFAS] [Air-SS-558]

3.2.6.1.2 Initialisation

During the initialisation State, the integrity of the data stored in the database shall be verified.

[Analysis / IHT] [Air-SS-569]

The system shall generate an alert in the event of an integrity failure.

[Demonstration / IHT] [Air-SS-1145]

3.2.6.1.3 Operate

Whilst in operate state, the database shall provide data to requesting functions within the system.

[Analysis / IHT] [Air-SS-566]

The system shall be able to merge meteorological data received via the datalink with the data already stored in the database.

[Analysis / IHT] [Air-SS-1243]

The system shall be capable of merging Flight Phase data received from AOC via a datalink with the data held in the Flight Phase Table.

[Analysis / FT-B] [Air-SS-2386]

The airborne equipment shall be capable of interacting with a data loader conforming to ARINC 615 or ARINC 615A for the upload of database data or the download of logged data.

[Demonstration / IHT] [Air-SS-563]

The system shall be capable of recovery following a power failure to either component during a database load/unload operation

[Demonstration / IHT] [Air-SS-564]

3.2.6.2 Surveillance

The surveillance function will gather data received from the ADS and TIS transmissions and provide basic integrity checking, filtering and fusion functionality. Surveillance will not perform any prediction or extrapolation functions.

The system shall maintain a database of other traffic, compiled using received ADS and TIS data, for use in the Airborne Separation Assurance algorithms.

[Analysis / IHT] [Air-SS-177]

The airborne system shall be capable of handling 2044 simultaneous targets, which is the maximum number of simultaneous surveillance targets supportable in a single NUP service area (NUP TIS-B Service Description).

[Analysis / IHT] [Air-SS-2525]

The Data Management function shall provide control for the storage/retrieval of this data.

[Analysis / DESN] [Air-SS-478]

The surveillance function shall maintain a record of the time of last update for each detected traffic object.

[Analysis / IHT] [Air-SS-321]

The surveillance database shall hold both state and intent data for each traffic object.

[Analysis / DESN] [Air-SS-180]

The surveillance function shall compute a closure vector and rate for each object in the database on reception of new data.

[Analysis / DESN] [Air-SS-418]

The Surveillance function shall include a fusion function to provide a best estimate of the current state of each object.

[Analysis / IHT] [Air-SS-477]

When an object passes beyond the ADS/TIS horizon, information about the object shall be removed from the surveillance database.

[Analysis / DESN] [Air-SS-1146]

When in FFAS, an advisory alert shall be generated if the TIS/ADS data for a traffic object in the database has not been updated within a time estimated by the system to indicate that a potential conflict could be masked.

[Demonstration / IHT] [Air-SS-323]

3.2.6.3 Data Logging

3.2.6.3.1 General

In the event of the allocated memory being filled, the oldest logged data shall be overwritten.

[Analysis / Post MA-AFAS] [Air-SS-571]

Logged data shall be available for download post flight.

[Demonstration / IHT] [Air-SS-1150]

3.2.6.3.2 Data Content

The system shall be capable of logging the following data items:

- Alerts
- Received ADS-B/TIS-B Data
- Aircraft State data
- Surveillance data
- ADC Met data
- Autopilot Settings
- Trajectory Data

[Analysis / IHT] [Air-SS-2382]

All logged data shall be timestamped.

[Analysis / IHT] [Air-SS-2380]

Fault data shall be logged on the first occurrence of the fault.

[Analysis / IHT] [Air-SS-573]

Fault data shall comprise the following information:

a) Fault Id
b) Intermittent/continuous flag

[Analysis / IHT] [Air-SS-574]

During flight any communications received or created by the system shall be logged.

[Analysis / FT-B] [Air-SS-575]

The stored data shall include the time of receipt and the source of the information.

[Demonstration / IHT] [Air-SS-993]

3.2.6.3.3 Update Rates

The aircraft equipment shall record the aircraft state data at 10s intervals.

[Analysis / IHT] [Air-SS-2393]

The aircraft equipment shall record meteorological data from the Air Data Computer at 30s intervals.

[Analysis / IHT] [Air-SS-2394]

The aircraft equipment shall record the contents of the surveillance database at 60s intervals.

[Analysis / IHT] [Air-SS-2395]

During passing, crossing or spacing manoeuvres, the aircraft equipment shall record the position of the target aircraft, as output by the surveillance function, at 10s intervals.

[Analysis / IHT] [Air-SS-2396]

3.2.7 Cockpit HMI

The interface between the Airborne Equipment and the crew will be achieved by the use of display surfaces and data input devices that form part of most modern day cockpits. For the MA-AFAS trials, where some of the standard facilities are not available, extra equipment or functionality will be added to augment the system.

The Airborne Equipment will be designed to allow a single person to access all the facilities identified in this specification. However, due consideration will be given to allow the use of the system by two operators simultaneously. The trials build of the system will, however, only allow a single operator.

In a similar fashion, the system will be designed to allow for dual or even triple redundancy operations where two MA-AFAS FMUs can be used in conjunction with two, or three, Autopilot systems. Again, the MA-AFAS trials system will only provide for simplex operation.

3.2.7.1 Physical Interfaces

Each operator of the system will be provided with the following input devices:

a) Multi-purpose Control and Display Unit (MCDU)

b) Cursor Control Device (CCD)

In addition, there will be a Display Control Panel and an AFCS control panel although these do not form part of the MA-AFAS. Consideration will also be given to the future use of a Head Up Display (HUD) for each operator.

For outputs, the system will provide for the following for each operator:

c) MCDU

d) Navigation Display (ND)

It is not considered likely that the system will interface directly to the Primary Display of the cockpit.

Alerts will be annunciated to the crew either by use of the ND or via the Aircrew Warning System (AWS).

3.2.7.1.1 Multi-purpose Control and Display Unit

The MCDU(s) will provide an operator interface that allows the control of the MA-AFAS functionality and the input of textual/numeric data. The MCDU will form the basis of the interface between the system and the operator.

Briefly, MCDU's comprise a display surface, for textual characters only, an alphanumeric keyboard, a programmable function keypad and several indicator lamps. A complete description of MCDU functionality is given in ARINC 739A

MCDU's will be connected to the Airborne Equipment via two ARINC429 interfaces; one for input and the other for output. The Airborne Equipment will provide control for the MCDU and will receive operator commands from the MCDU.

The only MCDU lamps utilised by the MA-AFAS will be the ATC and MSG lamps which will signify a message received from ATC and an alert message, respectively.

The HMI shall be capable of controlling an MCDU that conforms to ARINC739A.
[Analysis / IHT] [Air-SS-2625]

The HMI shall utilise inputs from an MCDU that conforms to ARINC739A.
[Analysis / IHT] [Air-SS-2626]

The pilot shall be able to use the MCDU to control the actions of the MA-AFAS equipment.
[Demonstration / IHT] [Air-SS-2627]

The HMI shall use the ATC lamp on the MCDU to indicate that there is an unacknowledged CPDLC message.
[Demonstration / IHT] [Air-SS-2628]

The HMI shall use the MSG lamp on the MCDU to indicate that there is an unacknowledged MA-AFAS generated alert message.
[Demonstration / IHT] [Air-SS-2629]

3.2.7.1.2 Navigation Display Unit

The MA-AFAS will be capable of providing information to the operator by means of a high resolution colour display unit. Under normal circumstances, this display unit will be provided by an Electronic Flight Instrument (EFI) system as defined in ARINC 725. For the MA-AFAS trials, however, the Airborne Equipment will contain a graphics facility that will drive a standard colour display unit.

The system shall be capable of using a high resolution colour graphics display as the Navigation Display (ND).
[Demonstration / IHT] [Air-SS-2632]

The system shall be able to generate a Traffic Situation Display (TSD) on the ND.
[Demonstration / IHT] [Air-SS-2633]

The TSD shall be able to graphically depict the current Air Traffic situation using the data in the surveillance database.
[Demonstration / IHT] [Air-SS-2634]

The TSD shall be able to depict the current ownship position and route in relation to the other traffic objects displayed.
[Demonstration / IHT] [Air-SS-2635]

The system shall use the ND to provide graphical support to the pilot in the definition of the ownship route.
[Demonstration / IHT] [Air-SS-2636]

The system shall use the ND to display information associated with the Trajectory Generation function.
[Demonstration / IHT] [Air-SS-2637]

The system shall use the ND to display information associated with the Conflict Detection and Resolution function.
[Demonstration / IHT] [Air-SS-2638]

The system shall use the ND to display information associated with the Taxi Management function.

[Demonstration / IHT] [Air-SS-2639]

3.2.7.1.3 Cursor Control Device

When used in conjunction with the ND, the CCD will provide the operator with a Graphical User Interface (GUI) for the control of the system functionality.

The system shall include a Cursor Control Device.

[Inspection / DESN] [Air-SS-2642]

The Cursor Control Device shall comprise a roll ball and two buttons; Action and Menu.

[Inspection / DESN] [Air-SS-2643]

3.2.7.2 Control of System Functionality

In the main, the operator will have the ability to control the system using either the MCDU or the GUI. The input and viewing of alphanumeric data will, however, only be available via the MCDU.

The pilot shall be able to use the CCD in conjunction with the ND to select an object.

[Demonstration / IHT] [Air-SS-2646]

Information about a selected object shall be available for display on the MCDU.

[Demonstration / IHT] [Air-SS-2647]

Taxi Management functions shall be controlled using the MCDU and the ND/CCD.

[Demonstration / IHT] [Air-SS-2648]

Conflict Detection and Resolution functions shall be controlled using the MCDU. This does not preclude the use of the ND/CCD if deemed to be appropriate.

[Demonstration / IHT] [Air-SS-2649]

Trajectory Generation and Negotiation funnctions shall be controlled using the MCDU. This does not preclude the use of the ND/CCD if deemed to be appropriate.

[Demonstration / IHT] [Air-SS-2650]

The communications facilities of the system shall be controlled using the MCDU. This does not preclude the use of the ND/CCD if deemed to be appropriate.

[Demonstration / IHT] [Air-SS-2651]

3.2.7.3 Alert Display

Alert information shall be displayed to the pilot on the MCDU.

[Demonstration / IHT] [Air-SS-2653]

The ND shall be used to graphically announce alerts generated by the Conflict Detection function.

[Demonstration / IHT] [Air-SS-2654]

3.2.8 Communications

3.2.8.1 Datalink Services

3.2.8.1.1 ATN Services

3.2.8.1.1.1 Context Management

The aircraft equipment shall provide the specific Context Management (CM) services required to support MA-AFAS as defined in the EUROCAE WG53 Baseline 1 subset of the ATN SARPS.

[Analysis / DESN] [Air-SS-1195]

3.2.8.1.1.2 Controller Pilot Datalink Communications

The aircraft equipment shall provide the specific Controller Pilot Datalink Communications (CPDLC) services required to support MA-AFAS as defined in the ATN SARPS.

[Analysis / DESN] [Air-SS-1196]

The aircraft equipment shall support EUROCAE WG53 Baseline 1 CPDLC services

[Analysis / DESN] [Air-SS-2522]

3.2.8.1.1.3 Flight Information Services

The aircraft equipment shall provide the Flight Information Services (FIS) defined in the ATN SARPS.

[Analysis / Post MA-AFAS] [Air-SS-1197]

3.2.8.1.1.4 Automatic Dependent Surveillance

The aircraft equipment shall provide the specific Automatic Dependent Surveillance (ADS) services required to support MA-AFAS as defined in the EUROCAE WG53 Baseline 1 subset of the ATN SARPS.

[Analysis / IHT] [Air-SS-1198]

3.2.8.1.2 ODIAC Services

3.2.8.1.2.1 Datalink Logon

The current procedures for voice communications require the parties involved in any dialogue to state their ICAO identifiers. This identifier is repeated at the beginning of every single message exchanged. Normally, full authentication of identities of the communicating parties cannot be accomplished. A data link infrastructure allows for improved authentication capabilities at the moment of the establishment of communications.
The Data Link Logon (DLL) Service is aimed at ensuring that all necessary technical and operational prerequisites for the operational usage of data link services are effected.

The aircraft equipment shall be capable of generating a DLL request that is compliant with the ATN SARPS Context Management service.

[Analysis / TT-B] [Air-SS-446]

The aircraft equipment shall be capable of decoding a DLL response message that is compliant with the ATN SARPS Context Management service.

[Analysis / TT-B] [Air-SS-462]

An information alert shall be generated if a requested service is not available.

[Demonstration / IHT] [Air-SS-466]

3.2.8.1.2.2 Logical Acknowledgement Messages

A logical acknowledgement (LACK) message shall be sent by the aircraft equipment whenever an acknowledgement has been requested within a received message or a transmission is mandated within the service description of ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-1188]

3.2.8.1.2.3 ATC Communications Management Service

Currently, when a flight is about to be transferred from one ATSU sector to another ATSU sector, the pilot is instructed to change to the voice channel of the next sector.
The ATC Communications Management (ACM) Service provides automated assistance to the pilot and Air Traffic Controllers for conducting the transfer of all ATC communications for both the voice channel and the data channel.

The aircraft equipment shall be capable of decoding a Voice Change Instruction (VCI) message as defined by ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-947]

An information alert shall be generated upon receipt of a VCI message.

[Demonstration / TT-B] [Air-SS-946]

The aircraft equipment shall be capable of decoding an End Service (ES) message as defined by ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-1190]

An information alert shall be generated upon receipt of a ES message.

[Demonstration / TT-B] [Air-SS-1191]

The aircraft equipment shall enable the pilot to generate and transmit a pilot acknowledgement message (PAM) as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-948]

The aircraft equipment shall enable the pilot to generate and transmit a "Monitoring R/T" message as defined by ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-949]

3.2.8.1.2.4 Clearances

3.2.8.1.2.4.1 Departure Clearance Service

A flight due to depart from an airfield must first obtain departure information and clearance from the Controlling Air Traffic Services Unit (C-ATSU). The Departure Clearance (DCL) Service provides automated assistance for requesting and delivering departure information and clearance.

The aircraft equipment shall enable the pilot to generate and transmit a DCL request message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-965]

The aircraft equipment shall be capable of decoding a DCL message as defined within ODIAC AGC-ORD-01.

[Demonstration / IHT] [Air-SS-963]

An information alert shall be generated upon receipt of a DCL message.

[Demonstration / TT-B] [Air-SS-962]

The aircraft equipment shall enable the pilot to generate and transmit a PAM as defined in ODIAC AGC-ORD-01 in response to a DCL message.

[Demonstration / TT-B] [Air-SS-964]

3.2.8.1.2.4.2 Ground Movement Clearances

Note that not all of the services specified in this paragraph are defined in ODIAC AGC-ORD-01. It is anticipated that within the lifespan of MA-AFAS these issues will be addressed and the documents revised.

The ground movement clearances is responsible for the generation of taxi route information and any associated clearances.

The aircraft equipment shall be capable of decoding taxi route information messages.

[Analysis / IHT] [Air-SS-87]

The aircraft equipment shall be capable of decoding taxi route clearance messages.

[Analysis / IHT] [Air-SS-316]

An advisory alert shall be generated upon receipt of a taxi route message.

[Demonstration / TT-D] [Air-SS-1189]

The aircraft equipment shall enable the pilot to generate and transmit a PAM as defined in ODIAC AGC-ORD-01 in response to the receipt of a taxi route clearance message.

[Demonstration / TT-D] [Air-SS-956]

The aircraft equipment shall enable the pilot to generate and transmit a Push Back Request message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-D] [Air-SS-1213]

The aircraft equipment shall be capable of decoding a Push Back Clearance (PBC) message as defined within ODIAC AGC-ORD-01.

[Demonstration / IHT] [Air-SS-1214]

The aircraft equipment shall enable the pilot to generate and transmit a PAM as defined in ODIAC AGC-ORD-01in response to the receipt of a PBC message.

[Demonstration / TT-D] [Air-SS-1215]

The aircraft equipment shall enable the pilot to generate and transmit a Start Up Request message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-D] [Air-SS-1216]

The aircraft equipment shall be capable of decoding a Start Up Clearance (SUC) message as defined within ODIAC AGC-ORD-01.

[Demonstration / IHT] [Air-SS-1217]

The aircraft equipment shall enable the pilot to generate and transmit a PAM as defined in ODIAC AGC-ORD-01in response to the receipt of a SUC message.

[Demonstration / TT-D] [Air-SS-1218]

3.2.8.1.2.4.3 ATC Clearances and Information Service

An aircraft under the control of an ATSU transmits reports, makes requests and receives clearances, instructions and notifications.
The ATC Clearances and Information (ACL) Service specifies the aircraft/C-ATSU dialogue procedures to be followed to perform these exchanges via air/ground data communications. It further describes the rules for the combination of voice and data link communications and abnormal mode requirements and procedures.

The message elements that can be used to compose ACL messages have been grouped in five classes in ODIAC AGC-ORD-01, according to the criticality of the information exchanged. For the MA-AFAS trials, it is expected that the aircraft equipment will need to be capable of handling all of these message types.

The aircraft equipment shall be capable of generating all ACL downlink message types identified in ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-550]

The aircraft equipment shall be capable of decoding all ACL uplink message types identified in ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-476]

3.2.8.1.2.4.4 Downstream Clearances Service

The pilot in some specific instances needs to obtain clearances or information from ATSUs whose sectors the aircraft intends to fly through but for which clearances have not yet been obtained. Such ‘downstream’ clearances and information are often provided through ground/ground co-ordination, but are also obtained via direct contact with the ‘Downstream’ ATSU (D-ATSU) in certain circumstances e.g., when ground/ground communication are unavailable or inefficient, due to the size of the airspace, the complexity of the route structure, or meteorological conditions.
The Downstream Clearance (DSC) Service provides assistance for requesting and obtaining D-ATSU clearances or information using air/ground data link.

The aircraft equipment shall enable the pilot to generate and transmit a DSC request message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-967]

The aircraft equipment shall be capable of decoding a DSC message as defined within ODIAC AGC-ORD-01.

[Demonstration / IHT] [Air-SS-968]

An information alert shall be generated upon receipt of a DSC message.

[Demonstration / TT-B] [Air-SS-970]

The aircraft equipment shall enable the pilot to generate and transmit a PAM as defined in ODIAC AGC-ORD-01in response to a DSC message.

[Demonstration / TT-B] [Air-SS-971]

3.2.8.1.2.5 Route Management Services

3.2.8.1.2.5.1 Flight Plan Consistency

Flight Plan Consistency (FLIPCY) provides a means of detecting significant discrepancies between airborne and ATC FDPS planned flight plans by downlinking the horizontal profile and the RFL held in the airborne equipment. The downlinked data are checked by the FDPS and if necessary, appropriate procedural action is taken.

There are plans to expand the FLIPCY facility to 3D and 4D operation. The MA-AFAS will need to be capable of expansion to address these new requirements once they have been fully defined.

The aircraft equipment shall be capable of decoding a trajectory request message as defined within ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-1013]

The aircraft equipment shall be capable of automatically generating and transmiting a trajectory intent message, as defined in ODIAC AGC-ORD-01, on receipt of a trajectory request message.

[Demonstration / TT-B] [Air-SS-1014]

3.2.8.1.2.5.2 Dynamic Route Availability

Dynamic Route Availability (DYNAV) allows the ATC FDPS to uplink the proposal of the route modifications to the pilot. The conditional or direct routes that were previously unavailable due to constraints arising from the Flexible Use of Airspace (FUA) may be indicated as available after the constraints have been removed.

The aircraft equipment shall be capable of decoding a route change request message as defined within ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-1019]

An information alert shall be generated upon receipt of a route change request message.

[Demonstration / TT-B] [Air-SS-1021]

The aircraft equipment shall enable the pilot to generate and a transmit a PAM as defined in ODIAC AGC-ORD-01in response to a route change request.

[Demonstration / TT-B] [Air-SS-1022]

3.2.8.1.2.5.3 Pilot Preferences Downlink

The pilot may have preferences on the way the flight is to be conducted for various operational reasons. In order to elaborate pertinent control strategies, Controllers need to be aware of these preferences.
The Pilot Preferences Downlink (PPD) Service allows the pilot in all phases of a flight to provide the Controller with information not available in the filed flight plan (e.g. maximum flight level) as well as requests for modification of some flight plan elements (e.g. requested flight level). It automates the provision to Controllers of selected pilot preferences even before the aircraft reaches their sector.

The aircraft equipment shall enable the pilot to generate and transmit a PPD message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-1012]

3.2.8.1.2.5.4 Common Trajectory Co-ordination

The purpose of Common Trajectory Co-ordination (COTRAC) is to establish and agree trajectory contracts between the pilot and controllers using graphical interfaces, air and ground data communications and automation systems and in particular a Flight Management System, by means of a structured negotiation method in order to significantly enhance ATM capacity and flexibility.
The co-ordination of trajectories can be performed more effectively by involving Airline operations directly or through Collaborative Decision Making and maximising ground/ground data communications to reduce costs.
Ground automation tools such as conflict detection, arrival managers, monitoring aids, can be enhanced through the availability of accurately predictable trajectories.
COTRAC will also contribute to the optimal use of the Flexible Use of Airspace (FUA) and Area Navigation (RNAV) concepts.
This service is still under development.

The aircraft equipment shall be capable of decoding a trajectory request message as defined within ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-1095]

An information alert shall be generated upon receipt of a trajectory request message.

[Demonstration / TT-B] [Air-SS-1096]

The aircraft equipment shall enable the pilot to generate and transmit a trajectory intent message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-1097]

The aircraft equipment shall be capable of decoding a trajectory modification message as defined within ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-1098]

An information alert shall be generated upon receipt of a trajectory modification message.

[Demonstration / TT-B] [Air-SS-1099]

The aircraft equipment shall enable the pilot to generate and transmit an acknowledgement message (ACK) as defined in ODIAC AGC-ORD-01.

[Analysis / TT-B] [Air-SS-1219]

The aircraft equipment shall enable the pilot to generate and transmit a trajectory change confirmation message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-1100]

3.2.8.1.2.6 Flight Information Services

The aircraft equipment 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.

[Analysis / TT-B] [Air-SS-2523]

The content of Flight Information Service (FIS) downlink messages generated within the aircraft equipment shall be compliant with the NUP FIS-B Service Description Options 2 and 3.

[Analysis / TT-B] [Air-SS-1001]

Note: The NUP FIS-B Service Description Option 4 is not adopted in MA-AFAS due to its increased spectrum usage (resemblance to the inefficient FIS-C).

3.2.8.1.2.6.1 Datalink Operational Terminal Information Service

The Datalink Operational Terminal Information Services(D-OTIS) provide automated assistance in requesting and delivering compiled meteorological and operational flight information for airports to the aircraft.

The aircraft equipment shall enable the pilot to generate and transmit a D-OTIS request message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-988]

The aircraft equipment shall be capable of decoding a D-OTIS delivery message as defined within ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-989]

An information alert shall be generated upon receipt of a D-OTIS delivery message from an airport specified by the pilot.

[Demonstration / TT-B] [Air-SS-990]

The aircraft equipment shall enable the pilot to generate and transmit a D-OTIS termination message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-994]

3.2.8.1.2.6.2 Datalink Runway Visual Range Service

The Datalink Runway Visual Range (D-RVR) service provides automated assistance in requesting and delivering the instantaneous RVR.

The aircraft equipment shall enable the pilot to generate and transmit a D-RVR request message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-996]

The aircraft equipment shall be capable of decoding a D-RVR delivery message as defined within ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-997]

An information alert shall be generated upon receipt of a D-RVR delivery message from an airport specified by the pilot.

[Demonstration / TT-B] [Air-SS-998]

The aircraft equipment shall enable the pilot to generate and transmit a D-RVR termination message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-1000]

3.2.8.1.2.6.3 Datalink Significant Meteorological Information Service

The Data Link Significant Meteorological Information (D-SIGMET) service provides automated assistance in requesting and delivering SIGMET information.

The aircraft equipment shall enable the pilot to generate and transmit a D-SIGMET request message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-1003]

The aircraft equipment shall be capable of decoding a D-SIGMET delivery message as defined within ODIAC AGC-ORD-01.

[Analysis / IHT] [Air-SS-1004]

An information alert shall be generated upon receipt of a D-SIGMET delivery message.

[Demonstration / TT-B] [Air-SS-1005]

The aircraft equipment shall enable the pilot to generate and transmit a D-SIGMET termination message as defined in ODIAC AGC-ORD-01.

[Demonstration / TT-B] [Air-SS-1007]

3.2.8.1.2.7 Pilot Acknowledgement Messages

The system shall issue an advisory alert if the pilot fails to send a required PAM within 5 minutes of receiving the data transmission.

[Demonstration / TT-B] [Air-SS-2537]

3.2.8.1.3 ATS Microphone Check

An advisory alert shall be generated upon receipt of a request for a microphone check.

[Demonstration / TT-B] [Air-SS-1225]

3.2.8.2 VDL Mode 4 Services

3.2.8.2.1 Surveillance Services

3.2.8.2.1.1 Traffic Information Service Broadcast

The Traffic Information Service Broadcast (TIS-B) is a broadcast surveillance service in which surveillance information is transmitted from a ground station to airborne systems in order to provide an air situation picture. The service is intended to augment the ADS-B service by providing information about non ADS-B equipped aircraft or equipped aircraft for which a signal is not available or is degraded.

The aircraft equipment shall be capable of decoding TIS-B messages that have been defined in accordance with the TIS-B description.

[Analysis / TT-B] [Air-SS-193]

3.2.8.2.1.2 Automatic Dependent Surveillance Broadcast

The aircraft equipment shall be capable of decoding of ADS-B messages defined in accordance with AMCP/7-WP/81.

[Analysis / IHT] [Air-SS-194]

The aircraft equipment shall be capable of generating and transmitting ADS-B messages defined in accordance with AMCP/7-WP/81.

[Analysis / FT-R] [Air-SS-195]

Intent data shall be transmitted as defined in AMCP/7-WP/81, for a maximum of the next 4 Trajectory Change Points using the 2-slot TCP method.

[Analysis / FT-R] [Air-SS-226]

The Trajectory Change Points shall be used whether they are cleared or not cleared, provided the aircraft is being controlled to that trajectory, i.e. the AFCS is set to FMS mode.

[Analysis / IHT] [Air-SS-2526]

If less than 4 TCPs are fully defined, then the parts of the TCPs that cannot be defined shall be set to values to indicate their unavailability.

[Analysis / IHT] [Air-SS-2527]

3.2.8.2.2 Navigation Services

3.2.8.2.2.1 Ground Based Regional Augmentation System

GRAS comprises a network of ground-monitoring stations calculate corrections. These calculations are uplinked to the aircraft via a VHF system on the ground, as per GBAS. Whilst these corrections are intended to be available at distances further than those provided by GBAS, GRAS does not have the large coverage footprint of SBAS.

Two of the candidate concepts for GRAS are VDL4 and Extended GBAS(PVT)).

Note: The inclusion of GRAS as part of the MA-AFAS system will be addressed at the design stage, but GRAS will not be included in the trials.

The aircraft equipment shall be capable of decoding all service levels of GRAS transmissions.

[Analysis / FT-R] [Air-SS-980]

3.2.8.2.3 Flight Information Broadcast Services

The aircraft equipment shall be capable of decoding FIS-B messages that have been defined in accordance with the FIS-B description.

[Analysis / IHT] [Air-SS-1202]

The aircraft equipment shall be capable of compiling and transmitting a request for data in accordance with the FIS-B description.

[Demonstration / TT-B] [Air-SS-2562]

An information alert shall be generated upon receipt of a FIS-B message if the pilot has made a request for the information.

[Demonstration / TT-B] [Air-SS-1232]

3.2.8.3 Datalink Availability

The VHF datalink mode 2 communications channel shall be available when the aircraft equipment is in operate state and the VHF radio equipment status shows that the equipment is operational.

[Demonstration / TT-B] [Air-SS-559]

The VHF datalink mode 4 communications channel shall be available when the aircraft equipment is in operate state and the VHF radio equipment status shows that the equipment is operational.

[Analysis / TT-B] [Air-SS-950]

If the aircraft equipment includes a satellite communications capability, then it shall be available when the aircraft equipment is in operate state and the satellite receiver status shows that the equipment is operational.

[Demonstration / Post MA-AFAS][Air-SS-1177]

3.2.8.4 Airline Operations Centre

3.2.8.4.1 Uplinks

The data links to be used for AOC communications shall be ATN GACS (TBC) and VDL4 IP (TBC).

[Analysis / DESN] [Air-SS-2528]

For AOC Communications, the GACS interface shall be used regardless of the data link being used.

[Demonstration / TT-B] [Air-SS-2593]

The aircraft equipment shall be capable of decoding a flight plan from the AOC that has been transmitted over datalink.

[Demonstration / TT-B] [Air-SS-1180]

The aircraft equipment shall be capable of decoding a slot number from the AOC that has been transmitted over datalink.

[Demonstration / TT-B] [Air-SS-2538]

The aircraft equipment shall be capable of decoding weather data from the AOC that has been transmitted over datalink.

[Demonstration / TT-B] [Air-SS-2539]

The aircraft equipment shall be capable of decoding aeronautical data from the AOC that has been transmitted over datalink.

[Demonstration / TT-B] [Air-SS-2540]

3.2.8.4.2 Downlinks

The aircraft equipment shall be capable of transmitting 4D trajectory data to an AOC over a datalink.

[Analysis / TT-B] [Air-SS-1181]

The aircraft equipment shall be capable of transmitting Meteorological data to an AOC over a datalink.

[Analysis / TT-B] [Air-SS-1182]

The aircraft equipment shall be capable of transmitting aircraft systems messages to an AOC over a datalink.

[Analysis / TT-B] [Air-SS-1183]

The aircraft equipment shall be capable of transmitting fleet management messages to an AOC over a datalink.

[Analysis / TT-B] [Air-SS-1186]

3.2.8.5 Ground Based Augmentation System

The Ground Based Augmentation System (GBAS) uses a monitoring station on the ground to calculate the corrections necessary for each GNSS satellite's pseudorange measurement processed. These corrections are then transmitted over a VHF link to all users within line of sight of the transmitter.

The aircraft equipment shall be capable of decoding GBAS messages.

[Analysis / FT-B] [Air-SS-973]

3.2.8.6 Satellite Based Augmentation System

In Europe, the Satellite Based Augmentation System (SBAS) under development is called the European Geostationary Navigation Overlay Service (EGNOS).EGNOS will deploy an extensive network of GPS and GLONASS monitoring stations, spread throughout Europe and beyond to maximise the number of satellites in view and to maximise the area for which the GPS/GLONASS signal's ionospheric error component can be calculated. The data is logged, and errors in the estimated position calculated by comparison with the known position. These errors are sent to a central processing facility, which calculates corrections. These corrections are then uplinked to geo-stationary satellites, which simply rebroadcast these corrections at GPS frequencies over the footprint of the geostationary satellite.

The aircraft equipment shall be capable of decoding SBAS messages.

[Analysis / TT-B] [Air-SS-2517]

3.3 External Interface Requirements

3.3.1 Interface Identification

The external interfaces to the MA-AFAS aircraft equipment are shown in the following figure. The detailed requirements for each interface are given in the following paragraphs.

Note that for the MA-AFAS trials, not all interfaces defined here will be included owing to the restricted availability of the interfaces within the trials environments. For example, there will not be any Head Up Display or Weather Radar fitted.These limitations will be identified in lower level documentation.

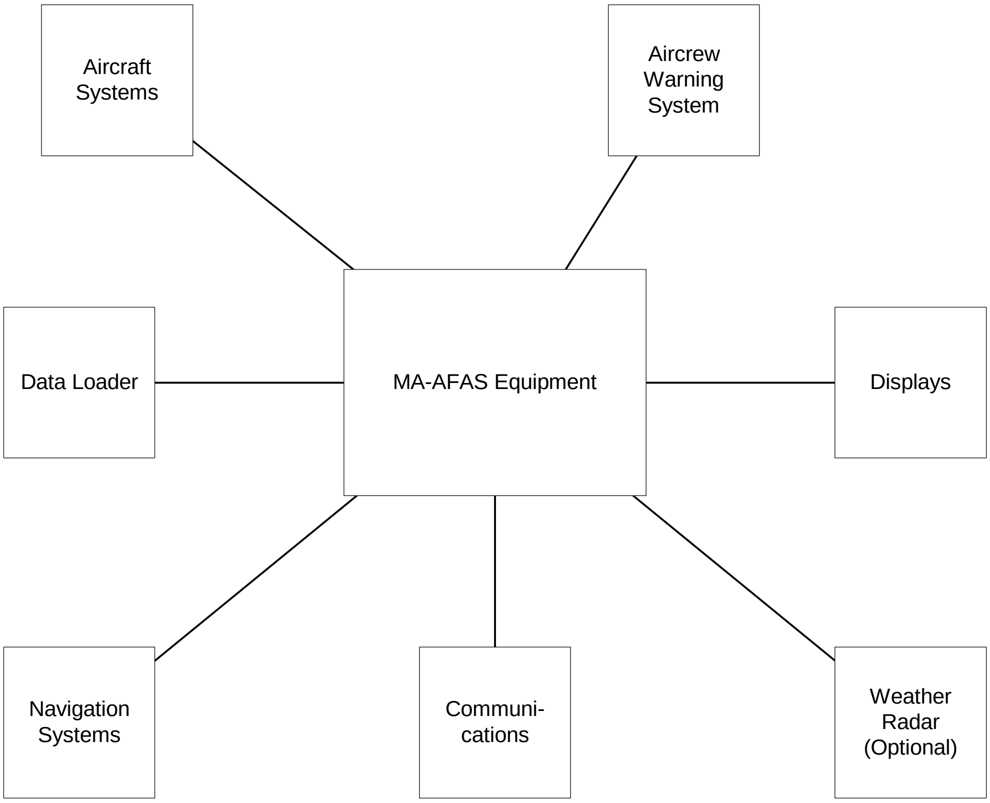


Figure 3 MA-AFAS Airborne Equipment Interfaces

As an aid to testing and integration, the trials avionics will provide an ethernet connection. All the interfaces identified in this section will be able to be configured such that the data is carried on the common ethernet link rather than the defined dedicated link. To minimise the impact of utilising a different physical link, any data formatting will remain as defined herein.

3.3.2 Aircrew Warning System Interface

The aircraft equipment shall be capable of sending data to the Aircrew Warning System (AWS) through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-393]

3.3.3 Display Interfaces

3.3.3.1 Primary Flight Display Interface

The aircraft equipment shall be capable of sending data to a primary flight display through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-390]

3.3.3.2 Navigation Display Interface

The aircraft equipment shall be capable of sending data to a navigation display through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-391]

3.3.3.3 Head Up Display Interface

The aircraft equipment shall be capable of sending data to a head up display through an ARINC 429 compliant interface.

[Analysis / Post MA-AFAS] [Air-SS-392]

3.3.4 Weather Radar Interface

The aircraft equipment shall be capable of receiving weather information from a Weather Radar System (WRS) through an ARINC 429 compliant interface.

[Analysis / Post MA-AFAS] [Air-SS-389]

3.3.5 Communications Interfaces

3.3.5.1 VHF Datalink Mode 2 Interface

The aircraft equipment shall be capable of sending ATN messages through a VDL Mode 2 link.

[Analysis / TT-B] [Air-SS-1205]

The aircraft equipment shall be capable of receiving ATN messages on a VDL Mode 2 link.

[Analysis / TT-B] [Air-SS-1206]

3.3.5.2 VHF Datalink Mode 4 Interface

The aircraft equipment shall be capable of sending ATN messages through a VDL Mode 4 link.

[Analysis / TT-B] [Air-SS-403]

The aircraft equipment shall be capable of receiving ATN messages on a VDL Mode 4 link.

[Analysis / TT-B] [Air-SS-404]

The aircraft equipment shall be capable of sending IP messages through a VDL Mode 4 link.

[Analysis / TT-B] [Air-SS-1207]

The aircraft equipment shall be capable of receiving IP messages on a VDL Mode 4 link.

[Analysis / TT-B] [Air-SS-1208]

The aircraft equipment shall be capable of receiving the VDL mode 4 services defined in paragraph 3.2.8.2.

[Analysis / TT-B] [Air-SS-1241]

3.3.5.3 Satellite Communications Interface

The aircraft equipment shall be capable of sending ATN messages through a satellite communications link.

[Analysis / Post MA-AFAS] [Air-SS-397]

The aircraft equipment shall be capable of receiving ATN messages from a satellite communications link.

[Analysis / Post MA-AFAS] [Air-SS-402]

3.3.6 Navigation Systems Interfaces

3.3.6.1 Distance Measuring Equipment

The aircraft equipment shall be capable of receiving data from distance measuring equipment (DME) through an ARINC 429 compliant interface.

[Analysis / Post MA-AFAS] [Air-SS-375]

3.3.6.2 Instrument Landing System

The aircraft equipment shall be capable of receiving data from ILS equipment through an ARINC 429 compliant interface.

[Analysis / Post MA-AFAS] [Air-SS-376]

3.3.6.3 Global Navigation Satellite System

The aircraft equipment shall be capable of receiving data from a GNSS sensor through an ARINC 429 compliant interface.

[Analysis / TT-B] [Air-SS-377]

3.3.6.4 Satellite Based Augmentation System

The aircraft equipment shall be capable of receiving data from an EGNOS compatible receiver.

[Analysis / TT-B] [Air-SS-396]

3.3.6.5 Ground Based Augmentation System

It is assumed that the operation of GBAS will be compliant with the GNSS SARPS.

The aircraft equipment shall be capable of receiving GBAS transmissions on a VHF link.

[Analysis / TT-B] [Air-SS-400]

3.3.6.6 Ground Based Regional Augmentation System

The aircraft equipment shall be capable of receiving GRAS transmissions on a VHF link.

[Analysis / TT-R] [Air-SS-401]

3.3.7 Data Loader Interface

The aircraft equipment shall be capable of receiving data from a Data Loading Device through an ARINC 429 compliant interface.

[Analysis / Post MA-AFAS] [Air-SS-384]

The aircraft equipment shall be capable of sending data to a Data Loading Device through an ARINC 429 compliant interface.

[Analysis / Post MA-AFAS] [Air-SS-385]

3.3.8 Aircraft Systems Interfaces

3.3.8.1 Automatic Flight Control System

The aircraft equipment shall be capable of sending guidance to the AFCS through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-388]

The aircraft system shall be capable of receiving status and mode information from the AFCS via an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-2551]

3.3.8.2 Inertial Reference System

The aircraft equipment shall be capable of receiving data from an Inertial Reference System (IRS) through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-378]

3.3.8.3 Attitude and Heading Reference System

The aircraft equipment shall be capable of receiving data from an Attitude and Heading Reference System (AHRS) through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-379]

3.3.8.4 Air Data Computer

The aircraft equipment shall be capable of receiving data from an Air Data Computer (ADC) through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-406]

3.3.8.5 Weight and Balance System

The aircraft equipment shall be capable of receiving data from a Weight and Balance System (WBS) through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-380]

3.3.8.6 Engine Management System

The aircraft equipment shall be capable of receiving data from an Engine Management System (EMS) through an ARINC 429 compliant interface.

[Analysis / IHT] [Air-SS-2470]

3.3.9 Power Interface

The MA-AFAS Trials system will be operated in a number of different environments, with differing power sources. This specification will identify those power requirements that apply to a production system only. Any power conditioning for trials fit will be identified in lower level documentation.

The system shall operate from a power source of 115VAC, 400Hz single phase that has been designed for Category A equipment as per ARINC 413A.

[Demonstration / Post MA-AFAS][Air-SS-1564]

3.3.10 Ethernet

As an aid to testing and integration with other ground based and airborne rigs, the MA-AFAS Trials equipment will incorporate an ethernet connection which will be used to convey data between the systems in the place of any of the defined links. A facility will be provided that allows the configuration of each data link to be chosen.

The aircraft equipment shall incorporate a 10BaseT ethernet connection that conforms to ARINC 646.

[Inspection / IHT] [Air-SS-2583]

All external interfaces listed above shall be able to be performed on the common Ethernet bus as a case by case configuration selection.

[Demonstration / IHT] [Air-SS-2585]

The ethernet interface shall provide a port for use by the test and software development tools used by the MA-AFAS developers. Note that this will allow the loading of data to the system that would normally be transported via the data loader interface.

[Demonstration / IHT] [Air-SS-2602]

3.4 Internal Interface Requirements

For the purposes of this specification, the MA-AFAS aircraft equipment includes a Flight Management Unit (FMU) a Communications Management Unit (CMU), a Multi-purpose Computer Display Unit (MCDU) and a Cursor Control Device (CCD).

3.4.1 FMU to CCD Interface

Initially, the CCD will be a standard trackball (as used on PCs) that interfaces to the avionics rack via an RS232 port on the FMU processor. Later on, the system will need to be able to utilise one, or two, CCDs that conform to ARINC702A.

The FMU shall be capable of receiving input data from a trackball using an RS232 input port.

[TBD / TBD] [Air-SS-2578]

The FMU shall be capable of receiving input data from up to two independently operated CCDs as defined in ARINC 702A.

[Analysis / Post MA-AFAS] [Air-SS-383]

3.4.2 FMU to MCDU Interface

The interface between the FMU components and the MCDU components of the aircraft equipment shall be compliant with the ARINC 429 standard.

[Analysis / DESN] [Air-SS-369]

The FMU shall be capable of receiving input data from up to three independently operating MCDUs.

[Analysis / Post MA-AFAS] [Air-SS-381]

The FMU shall be capable of sending data to up to three independently operating MCDUs.

[Analysis / Post MA-AFAS] [Air-SS-382]

3.4.3 FMU to CMU Interface

The interface between the FMU components and the CMU components of the aircraft equipment shall be compliant with the ARINC 429 standard as defined in section 4.3.11 of ARINC 702A.

[Analysis / Post MA-AFAS] [Air-SS-367]

3.4.4 FMU to FMU Interface

It shall be possible to transfer data between up to two other FMU components using an ARINC 429 compliant interface as defined in section 3.1 of ARINC 702A.

[Analysis / Post MA-AFAS] [Air-SS-387]

3.5 System Internal Data Requirements

3.5.1 Database Data

The system shall be capable of uploading, storing and using the following data:
[Analysis / DESN] [Air-SS-200]

3.5.1.1 Navigation Database

The system shall hold Navigation data as defined in ARINC 424.
[Analysis / DESN] [Air-SS-212]

3.5.1.2 Meteorological Database

The Meteorological database format shall contain the following elements:
Air Temperature and Pressure
Wind Speed and Direction
Altitude and position of data item
Validity of data indicator.
[Analysis / DESN] [Air-SS-213]

3.5.1.3 Aircraft Performance Database

The Aircraft Performance Database shall comprise the data specified in ARINC 702A.
[Analysis / DESN] [Air-SS-214]

3.5.1.4 Airport Surface Map Database

The Airport Surface Map Database shall comprise the data specified in ARINC 702A.
[Analysis / DESN] [Air-SS-215]

3.5.1.5 Route Information

The system shall store company route information uploaded from the data loader.
[Analysis / IHT] [Air-SS-2462]

The Company Route information shall comprise manually defined waypoints or Navigation Database waypoints.
[Analysis / IHT] [Air-SS-2463]

The system shall allow the storage of at least 400 individual routes, each of up to 100 waypoints.
[Analysis / IHT] [Air-SS-2464]

The system shall allow the storage of at least 4000 individual waypoints.
[Analysis / DESN] [Air-SS-2465]

3.5.1.6 Terrain and Obstacle Database

This section has been included for completeness but, as yet, no requirements for Terrain or Obstacle data have been identified for MA-AFAS.

3.5.1.7 Magnetic Variation

The system shall store Magnetic Variation Data as per ARINC 702A.

[Analysis / DESN] [Air-SS-216]

3.5.1.8 Airline Modifiable Database

The system shall be capable of storing Airline Modifiable Information (AMI) data in accordance with ARINC 702A.

[Analysis / DESN] [Air-SS-217]

3.5.1.9 Airspace Boundary Definitions

The Airspace Definitions database defines the airspace type that the aircraft occupies. Note that the data that comprises the Airspace Boundary Database may ultimately form part of the Navigation Database.

The system shall contain the boundary definitions for the airspace types (FFAS, MAS and UMAS).

[Analysis / DESN] [Air-SS-218]

3.5.1.10 Flight Phase Table

The database shall hold aircraft Flight Phase Table in a TBD format.

[Analysis / DESN] [Air-SS-2388]

3.5.1.11 Logged Data

The system shall store logged alert and communications data in non-volatile memory ready for downloading to the data loader.

[Analysis / IHT] [Air-SS-2467]

3.5.2 In Flight Data

The system will maintain an in-flight database that contains data gathered about the status of the aircraft and other traffic.

3.5.2.1 Surveillance Data

The system will compile the following surveillance data from transmissions received from the ADS-B and TIS-B facilities.

3.5.2.1.1 State Data

The database shall store traffic state data obtained from the ADS-B/TIS-B data transmissions.

[Analysis / DESN] [Air-SS-2487]

The system shall store smoothed traffic state data.

[Analysis / DESN] [Air-SS-2488]

3.5.2.1.2 Intent Data

The system shall store received traffic intent data.

[Analysis / DESN] [Air-SS-2489]

3.5.2.1.3 Proximity Data

In order to prioritise the importance of detected traffic objects, the system will determine the minimum time it will take for objects to reach the ownship PAZ if both the ownship and the object were to instantaneously turn towards each other. This (totally artificial) value will then be used to determine how often the Conflict Detection algorithm(s) will be run.

The system shall compute and store a Virtual Conflict Time for each traffic object in the Traffic database. The Virtual Conflict Time is defined as the distance between the ownship PAZ and a traffic object divided by the sum of their groundspeeds.

[Analysis / DESN] [Air-SS-2554]

3.5.2.2 Route Data

The system shall maintain a database of the active trajectory.

[Analysis / DESN] [Air-SS-2490]

3.5.2.3 Aircraft State Data

The system will maintain a database of the following state parameters for use within the MA-AFAS system:

3.5.2.3.1 Position Data

The system shall compute a best estimate of position using data from the following external systems:

INS and GNSS.

[Analysis / IHT] [Air-SS-2493]

The Data Manager function shall provide a Position Status that includes the following:

Error estimate
Position data source

[Analysis / IHT] [Air-SS-2495]

3.5.2.3.2 Altitude Data

The system shall maintain a database of aircraft altitude data (barometric and radar) obtained from the on-board sensors

[Analysis / DESN] [Air-SS-2496]

3.5.2.3.3 Attitude and Attitude Rate Data

The system shall maintain a database of aircraft attitude and attitude rate data obtained from the on-board sensors;

[Analysis / DESN] [Air-SS-2497]

3.5.2.3.4 Speed Data

The system shall maintain a database of aircraft velocity data (TAS, CAS, Mach and groundspeed) obtained from the on-board sensors.

[Analysis / DESN] [Air-SS-2498]

3.5.2.3.5 Heading and Track Data

The system shall maintain a database of aircraft heading and track (magnetic and true) obtained from the on-board sensors.

[Analysis / DESN] [Air-SS-2501]

3.5.2.3.6 Environmental Conditions Data

The system shall maintain a database of the environmental conditions (OAT, wind speed/direction) obtained from the ADC.

[Analysis / DESN] [Air-SS-2502]

3.5.2.3.7 Data Status

The system shall maintain a status for every item of data held in the database.

[Analysis / DESN] [Air-SS-2505]

3.5.2.3.8 System Status

The system shall compile a database of the reported status of each equipment that interfaces with the airborne equipment.

[Analysis / DESN] [Air-SS-2506]

3.5.2.4 SIGMET Data

The system shall maintain a database of significant weather received from the datalink.

[Analysis / DESN] [Air-SS-2507]

3.6 Adaptation Requirements

The system shall be capable of implementation in a 2 box solution (FMU & CMU) or as a single box.

[Inspection / DESN] [Air-SS-334]

The system shall be designed to allow the addition of dual or triple redundancy operation.

[Analysis / Post MA-AFAS] [Air-SS-335]

3.7 Safety Requirements

The factors that need to be considered for the certification of trials equipment are discussed in the following MA-AFAS documents:

MA-AFAS D15; Airworthiness and Operational Approval Requirements and Methods for MA-AFAS

MA-AFAS D45; Operational and Airworthiness JAA Approval Plan

A certification process shall be established that includes a full safety assessment for all aircraft equipment developed for the MA-AFAS flight trials.

[Analysis / CERT] [Air-SS-1024]

For the MA-AFAS flight trials, the aircraft equipment shall meet the safety requirements for Form 100 approval.

[Analysis / CERT] [Air-SS-1025]

3.8 Security and Privacy Requirements

In order to prevent unauthorised modifications to the database, the entry into the maintenance state will be password protected.

The airborne equipment shall be able to detect security breaches and alert the pilot with appropriate data security warnings in accordance with the requirements of ODIAC AGC-ORD-01.

[Analysis / Post MA-AFAS] [Air-SS-1027]

3.9 System Environment Requirements

As the airborne trials equipment is to be fitted to experimental aircraft, it must be shown to be airworthy. To support this, a product log book will be compiled in support of Product Airworthiness Approval.

Future in-service versions of the airborne equipment will meet the environment conditions set out in ED-14D, together with EU Safety, EMC and CE Marking Directives applicable at time product first enters service.

The trials equipment shall be capable of operation in the environment present in both the BAC1-11 and ATTAS trials aircraft.

[Analysis / CERT] [Air-SS-1245]

3.9.1 EMC Requirements

The system shall comply with EU directives and normal civilian SOFT levels for maximum EMC Radiated Emissions.

[Measurement / SOFT] [Air-SS-1530]

The system shall comply with EU directives and normal civilian SOFT levels for maximum EMC Conducted Emissions.

[Measurement / SOFT] [Air-SS-1531]

The system shall comply with EU directives and normal civilian SOFT levels for maximum EMC Radiated Susceptibility.

[Measurement / SOFT] [Air-SS-1532]

The system shall comply with EU directives and normal civilian SOFT levels for maximum EMC Conducted Susceptibility.

[Measurement / SOFT] [Air-SS-1533]

3.10 Computer Resource Requirements

3.10.1 Computer Hardware Requirements

The trials equipment for the Airborne Equipment shall be based on a VME rack architecture.

[Inspection / DESN] [Air-SS-2511]

The trajectory generation process shall complete within 5 seconds.

[Analysis / IHT] [Air-SS-174]

The timing of commands output to the AFCS for guidance purposes shall not be affected by processing load variations.

[Analysis / IHT] [Air-SS-175]

3.10.2 Computer Hardware Resource Utilisation Requirements

The average loading of any processor within the aircraft equipment shall be a maximum of 50% when measured over any 4 second time period.

[Analysis / Post MA-AFAS] [Air-SS-1038]

On initial entry into service, no more than 50% of the total storage allocated to the database held in the airborne equipment shall be utilised.

[Analysis / Post MA-AFAS] [Air-SS-1039]

3.10.3 Computer Software Requirements

All software used in MA-AFAS shall be developed in accordance with the MA-AFAS Software Development Plan.

[Analysis / CERT] [Air-SS-2563]

All new software shall be designed in accordance with the MA-AFAS Software Development Plan.

[Analysis / CERT] [Air-SS-1040]

3.10.3.1 Implementation Language

All new software shall be written in ANSI Standard C or C++.

[Analysis / DESN] [Air-SS-1032]

The style of the code shall be as defined in MA-AFAS Software Coding Standard.

[Analysis / CERT] [Air-SS-1041]

3.10.3.2 Software Adaptability

TBD

3.10.3.3 Software Safety Standards

The software developed for the airborne equipment shall conform to DO178B/ED12B Level C.

[Analysis / CERT] [Air-SS-1036]

3.10.4 Computer Communications Requirements

3.11 System Quality Factors

The overall system design shall ensure that the reliability, availability, continuity and maintainability targets identified as a result of the safety analysis are met.

[Analysis / CERT] [Air-SS-1042]

3.12 Design and Construction Constraints

Any non-trials aircraft equipment that is modified or developed under the MA-AFAS programme shall be compliant with the design and construction requirements of ARINC 600-12.

[Analysis / DESN] [Air-SS-1043]

3.13 Personnel Related Requirements

The airborne equipment shall be capable of operation by a single person.

[Demonstration / AS-B] [Air-SS-1044]

3.14 Training Related Requirements

TBD

3.15 Logistics Related Requirements

TBD

3.16 Other Requirements

None

3.17 Packaging Requirements

Any aircraft equipment that is modified or developed under the MA-AFAS program shall be packaged for transport in a manner suitable for transport as air cargo.

[Inspection / DESN] [Air-SS-1047]

Any aircraft equipment that is modified or developed under the MA-AFAS programme shall be marked in accordance with the CE marking directive, 93/68/EEC.

[Inspection / CERT] [Air-SS-1048]

Any aircraft equipment that is modified or developed under the MA-AFAS programme shall be marked in accordance with the low voltage marking directive, 73/23/EEC.

[Inspection / CERT] [Air-SS-1049]

Any aircraft equipment that is modified or developed under the MA-AFAS programme shall be marked in accordance with the EMC marking directive, 89/336/EEC.

[Inspection / CERT] [Air-SS-1050]

3.18 Precedence and Criticality of Requirements

All of the requirements detailed within this document shall be treated with equal precedence.

[Analysis / CERT] [Air-SS-1051]

In the event of a conflict between referenced documents, the following order of precedence shall be applied:

JAA regulations.
FAA regulations
ICAO standards.
ARINC standards.
Other standards (e.g. EUROCAE, RTCA, SAE).
MA-AFAS project documents.
Other documents.

[Analysis / CERT] [Air-SS-1053]

Where a conflict has been identified, then it shall be documented using the problem reporting facility.

[Analysis / CERT] [Air-SS-1054]

4 QUALIFICATION PROVISIONS

4.1 Validation Events

It is proposed that the following validation events are used to qualify the MA-AFAS system. The table also indicates the method of validation and verification that each event can support:

Event	Where / How	Code	Supports
Certification Documentation	BAE SYSTEMS	CERT	Inspection / Analysis
Operational Shadow ATC	Rome	SATC	Measurement / Demonstration / Inspection / Analysis
Flight Trials	Rome	FT-R	Measurement / Demonstration / Inspection / Analysis
Flight Trials	Boscombe Down	FT-B	Measurement / Demonstration / Inspection / Analysis
Flight Trials	Braunschweig	FT-D	Measurement / Demonstration / Inspection / Analysis
Taxi Trials	Rome	TT-R	Measurement / Demonstration / Inspection / Analysis
Taxi Trials	Boscombe Down	TT-B	Measurement / Demonstration / Inspection / Analysis
Taxi Trials	Braunschweig	TT-D	Measurement / Demonstration / Inspection / Analysis
Avionics Simulator Trials	BAC 1-11 Simulator	AS-B	Measurement / Demonstration / Inspection / Analysis
Avionics Simulator Trials	DLR ATTAS	AS-S	Measurement / Demonstration / Inspection / Analysis
Avionics Simulator Trials with PROVE Ground System	RTAVS	AS-P	Measurement / Demonstration / Inspection / Analysis
Avionics Simulator Trials	RTAVS	AS-R	Measurement / Demonstration / Inspection / Analysis

Safety Of Flight Tests	BAE SYSTEMS	SOFT	Measurement / Demonstration / Inspection / Analysis
Avionics In-house Test	BAE SYSTEMS	IHT	Measurement / Demonstration / Inspection / Analysis
Software Functional Tests	Various	SFT	Measurement / Demonstration / Inspection / Analysis
Software Module Tests	Various	SMT	Measurement / Demonstration / Inspection / Analysis
Design	Various	DESN	Inspection / Analysis
Not to be Verified	Pre-production Only	Post MA-AFAS	None

Table 2 Proposed Validation Events and Associated Methods

Definitions of the Validation Events are included in section 4.3 of document MA-AFAS D13.

4.2 Validation Methods

The validation methods that will be employed during the MA-AFAS programme are defined as follows:

Method	Definition	
Measurement	A test that produces a measurable result (volts, seconds, feet, metres, counts, etc.) from the system or unit under test that is compared with acceptable limits stated in the test.	Most desirable method
Demonstration	A test that produces an event or sequence of events that can be witnessed by the test operator and recorded as meeting the expected events stated in the test.	Less desirable than Measurement
Inspection	A procedure that allows an operator to confirm using his senses that an item has been implemented according to its specification (colour, finish, build quality, iteration limit, labelling, completeness, etc.) and recording this fact.	Less desirable than Measurement
Analysis	Application of mathematics or other rational procedure to verify that an implementation will satisfy its requirements under stated conditions.	Less desirable than Demonstration and Inspection
Similarity	Comparison of a new implementation with an existing one that met similar requirements.	Least desirable method

Table 3 Validation Method Definitions

4.3 Validation Cross-Reference

Since the master copy of this document is held within the MA-AFAS project element of the DOORS database, the cross reference data are held as attributes to each individual requirement. It is therefore possible to present the data with each requirement throughout this specification and also produce a separate Verification Cross Reference Matrix (VCRM) table if required. For this reason, validation data is shown on the line immediately following the statement of the requirement.

4.4 Certification

Certification of the system shall be in accordance with the Certification Plan; MA-AFAS D45.

[Inspection / CERT] [Air-SS-1524]

5 REQUIREMENTS TRACEABILITY

The master copy of this document is held as a formal module within a DOORS project database. Traceability of the requirements within this document to those of the MA-AFAS D13 parent document form part of this database and are thus not tabulated here.

Printouts of the traceability material may be obtained from the DOORS Project Administrator for MA-AFAS.

6 NOTES

6.1 Abbreviations

ACL	ATC Clearance and Information Services
ACM	ATC Communications Management Services
ADC	Air Data Computer
ADS-B	Automatic Dependent Surveillance – Broadcast
AFCS	Automatic Flight Control System
AOC	Airline Operations Centre
ASAS	Airborne Separation Assurance System
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
CAS	Calibrated Airspeed
CCD	Cursor Control Device
CDTI	Cockpit Display of Traffic Information
CMU	Communications Management Unit
CPDLC	Controller Pilot Data Link Communications
D-ATIS	Data-link Automatic Terminal Information Services
DCL	Departure Clearance Service
DLL	Data Link Logon
DSC	Downstream Clearance
ECAC	European Civil Aviation Conference
EGNOS	European Geostationary Navigation Overlay Service
EMS	Engine Management System
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 Application Communication Service
GBAS	Ground Based Augmentation System
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HMI	Human Machine Interface
HUD	Head Up Display
ILS	Instrument Landing System

IP	Internet Protocol
LACK	Logical ACKnowledgement
MA-AFAS	More Autonomous - Aircraft in the Future Air Traffic Management System
MAS	Managed Air Space
MCDU	Multi-Function Computer Display Unit
MLS	Microwave Landing System
ND	Navigation Display
OAT	Outside Air Temperature
ODIAC	Operational Development of an Integrated Surveillance and Air/Ground Communications
OSED	Operational Services and Environment Definition
PAM	Pilot Acknowledgement Message
PAZ	Protected Airspace Zone
PFD	Primary Flight Display
RFL	Required Flight Level
SBAS	Satellite Based Augmentation System
SID	Standard Instrumented Departure
STAR	STandard Arrival Route
SUA	Special Use Airspace
TAS	True Airspeed
TBC	To Be Confirmed
TBD	To Be Defined
TIS-B	Traffic Information Service – Broadcast
TMA	Terminal Manoeuvring Area
UMAS	Unmanaged Air Space
VCRM	Verification Cross Reference Matrix
VDL	VHF Data Link
VHF	Very High Frequency

6.2 Glossary of Terms

Active Trajectory - The current trajectory being used to guide the aircraft.

Advisory Alert - Alert level for operational or aircraft systems conditions which require crew awareness and may require crew action.

Abnormal Alert - Alert level for abnormal operational or aircraft systems conditions which require immediate crew awareness and subsequent corrective or compensatory crew action.
Will not be generated by MA-AFAS equipment.

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 provide more optimum operation for all parties. The goal of CDM is to enable the corresponding actors to improve mutual knowledge of the forecast/current situations, of each others constraints, preferences and capabilities, so as to pro-actively resolve potential problems, in which the person best able to make the decision is the one who does so.

Conflict - A conflict occurs when a traffic object impinges upon the Protected Airspace Zone of the aircraft.

Constraints - A constraint is a condition that should be met by the trajectory. Typical constraints are a position, position and time, altitude, an arrival or departure procedure.

Emergency Alert - Alert level for emergency operational or aircraft systems conditions which require immediate corrective or compensatory action by the crew.
Will not be generated by MA-AFAS equipment.

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 European Civil Aviation Conference (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 3D or 4D routings. Responsibility for separation 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.
Aircraft will be able to choose their own trajectories, selected either for short-term, long-term or strategic reasons, in which aircraft operators will benefit in terms of economy and flexibility, subject to notification to ATM, in which 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.

Information Alert - Alert level for operational or aircraft systems conditions which require flight deck indication but not necessarily as part of the integrated alerting system.

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, 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. This includes take-off, climb, cruise, descent and approach

Pilot Decision Time - This is the time that the pilot requires to decide whether to accept the systems proposals with regard to a revised trajectory.

Proposed Trajectory - an alternative trajectory computed as a modification to the active trajectory.

Protected Airspace Zone - This is a defined area surrounding the aircraft which is reserved for aircraft 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 - This is the action of keeping an agreed distance or time behind a specified aircraft, thereby following its trajectory at a constant offset. Sometimes referred to as Station Keeping.

Strategic Request - This is a request that has a definite end point or end time.

Tactical Request - This is an open ended ATC command such as heading commands e.g. “Fly heading 180” or an altitude commands e.g. “Climb FL360”.

Traffic - Objects that have been identified to the airborne equipment by means of ADS or TIS transmissions.

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 basically the same as today’ s “Outside Controlled Airspace” and subject to similar rules as those applied now (Rules of the Air).
There will be no interaction with ATM for aircraft operating in UMAS, except for those flights that wish to notify their presence either by filing a flight plan (in the air or on the ground) or by broadcasting their position (and perhaps intentions) by electronic means. ATS, in particular, Flight Information Services, may be provided to aircraft in UMAS on request.

Virtual Conflict Time - This is the time that it would take for a conflict to occur if the ownship and a traffic object were to instantaneously turn toward each other. It is defined as the distance between the ownship PAZ and a traffic object divided by the sum of their groundspeeds.