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D32 - Annex A
Boscombe Down Flight Test Scenario

AUTHOR : QINETIQ (UK)

PROJECT CO-ORDINATOR : BAE SYSTEMS

PRINCIPAL CONTRACTORS :
NLR (Netherlands)
QINETIQ (UK)
EEC (France)
Airtel ATN Ltd (Ireland)
ETG (Germany)

ASSISTANT CONTRACTORS:
Alenia Difesa (Italy)
DLR (Germany)
Indra Sistemas (Spain)
SCAA (Sweden)
Skysoft (Portugal)
Stasys Limited (UK)
AMS (Italy)
Frequentis (Austria)
NATS (UK)
SC-TT (Sweden)
SOFREAVIA (France)
Thales ATM (France)

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Prepared by
Title R A Harlow
Signature
Date 15th May 2003
Location QinetiQ Bedford, UK

Authorised by
Title R.Espin
Signature
Date 15th May 2003

Principal authors
Name R.A.Harlow
Appointment Technical Manager
Location QinetiQ
Bedford, UK

Name
Appointment
Location
Record of changes

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1 INTRODUCTION

An overall description of the integration, verification and validation testing of the MA-AFAS Avionics Package is given in the Simulation and Flight Test Plan Document (D32). All ground and airborne platforms are covered, including an overview of the flight tests to be carried out using the BAC 1-11 aircraft at Boscombe Down, the ATTAS aircraft at Braunschweig and both aircraft at Ciampino, Rome. Full details of the integration testing, verification and validation flying at these three sites are defined in separate Annexes to D32. An additional Annex covers the simulator assessment using Airline pilots at Amsterdam.

D32-Annex A, this document, defines the detailed testing of the Avionics Package to be carried out at Boscombe Down using the BAC 1-11 aircraft in conjunction with ground platforms at Bretigny for the CDTI/ASAS Theme, and at Boscombe Down for the Precision Approach, AOC and Taxi Themes.

Within each MA-AFAS Theme a number of functions have been designated for full assessment in flight, while other functions will be flight proved but not fully assessed because of the limited flight hours available. Both groups are defined in section 2. The assessment requirements are specified in section 3 and details of the routes to be flown are given in section 4. Full details of the ground and airborne testing requirements are given in sections 5 and 6 respectively, with the planned sequence of events for each individual flight being set out in section 7. All data recording requirements are defined in section 8, and finally the intended timescales covering all aspects of the MA-AFAS trials at Boscombe Down are specified in section 9.

This document deals with the testing, verification and validation of the Flight Version of the MA-AFAS Avionics Package. Because of the novelty of most of the functionality, requiring new software design and coding, problems may be encountered during the early testing phase using ground simulators. This could result in modifications to some of the functions, or in the worst case to some functions not being available for flight testing. Such changes will be incorporated into this document. Similarly, functional changes in the ground systems required for supporting the flight tests, and in aircraft and ground system availability, will also be taken into account. As a result this document is being treated as a ‘live’ document with re-issues as and when necessary throughout the period leading up to, and during, the Boscombe flight trials.
2 THEMES AND FUNCTIONS

This chapter defines the individual functions within each of the MA-AFAS themes designated for full assessment in flight, and also those functions that will be proved to operate satisfactorily in flight but with insufficient runs to allow full assessment.

2.1 THEMES

The following five themes were defined in the MA-AFAS project:-

- En-route 4D Navigation
- CDTI/ASAS
- Taxi Management
- Precision Approach and Departure
- AOC

In addition to the functions within each of these Themes, there are a number of enabling facilities common across all Themes, or required to support particular functions. These are listed below:-

- Communications - Data Link (VDL Mode 4)
- Communications - Voice (VHF radio)
- Cockpit HMI - includes MCDU, Navigation Display, Cursor Control Device, Displays Selection Panel, AFCS Control Panel
- TIS-B - broadcast of traffic data compiled on the ground (Radar + ADS-B) for ASAS and Taxi Applications
- FIS-B - broadcast Flight Information Service, independent from all other MA-AFAS functions

N.B. Flight trials in the BAC 1-11 should use data link communications whenever possible, as it is only in the airborne environment that link performance representative of operational conditions can be determined.

2.2 FUNCTIONS TO BE ASSESSED IN FLIGHT

A total of 32 hours are planned to be available for the flight trials at Boscombe Down. Six or more flights are expected to be necessary to verify that all available functions are operating correctly and can be satisfactorily controlled by the pilots in real flight conditions. The remaining time will be used to assess a limited number of the available MA-AFAS functions in order to provide objective measurements of the performance obtained.

Listed below are the functions chosen for the assessment flights:-

2.2.1 En-Route 4D Navigation

The ability to generate and control the aircraft to a 4D trajectory is an essential requirement for operation of most of the MA-AFAS functions. The trajectories generated and the accuracy with which the aircraft is controlled to them should be assessed to provide figures for use in future 4D Trajectory Negotiation scenarios.
(which was originally part of MA-AFAS functionality but was dropped through lack of ground support facilities).

### 2.2.2 CDTI/ASAS (Partial Delegation)

Cockpit Display of Traffic Information (CDTI), shows the position of surrounding traffic on the Navigation Display, and thus enhances the crew’s situational awareness. CDTI is a component part of all ASAS functionality.

The Airborne Separation Assurance System (ASAS) provides the pilot with early warning of any conflicting aircraft, allowing the conflict to be resolved on board the aircraft in a strategic, rather than tactical way (ACAS operates on a shorter timescale and will be retained as an independent backup system). Although originally included in the MA-AFAS functionality, the use of ASAS in a Free Flight Airspace environment was not implemented because of the complexity involved and lack of project time. However, ASAS is also applicable in Managed Airspace for reducing controller workload, and therefore offers the possibility of increased traffic throughput. This aspect of ASAS, called Partial Delegation, will be assessed in flight. The functions expected to be implemented are listed below (full descriptions of each function are given in a separate document titled “Technote MAT0015, Issue 3”):

- **Longitudinal Spacing**
  - Merge Behind at Waypoint - using Distance Spacing
  - Change Spacing

- **Lateral Spacing**
  - Pass Behind, then resume to Waypoint

### 2.2.3 Taxi Management

The main assessment of the Taxi Management theme will be carried out in the ATTAS aircraft using an Advanced Surface Movement and Control System at DLR Braunschweig in Germany. However, the ATTAS taxi system is not cleared for flight, leaving only the BAC 1-11 to operate the Taxi Management theme during the MA-AFAS trials in Rome. Therefore it is essential to check, and assess where possible, the taxi functions available at Boscombe (CDTI and Runway Incursion not available).

- **Map Display** - provides detailed airport map on Navigation Display
- **Taxi Clearances** - uplink of taxi route, displayed on airport map.
- **CPDLC Messages** – uplink and downlink
- **Runway Alert** - produces warning when own aircraft nears any runway

### 2.2.4 Precision Approach and Departure

- Curved STAR (SBAS) to long (8nm) straight approach (GBAS)
- Curved STAR (SBAS) to short (4nm) straight approach (GBAS)
- Curved SID (GBAS to SBAS)
2.2.5 AOC

The Airline Operations Centre (AOC) theme covers data link transfer of operational messages and data between AOC and individual aircraft in their fleet. In future Air Traffic Management Systems it is intended to have a much closer tie-up between Air Traffic Control, AOC and the aircraft in order to optimise overall fleet utilisation.

The independent nature of this theme allows AOC to be tested in conjunction with any other theme during flight or ground operation. Therefore the full AOC functionality will be assessed. Two forms of contract can be set up over the datalink. The first, Periodic, allows particular messages to be passed at specified regular time intervals. The second, Demand, provides for messages to be passed only when demanded by the aircraft or ground AOC user. The AOC messages fall into four categories and these are listed below together with a description of the messages expected to be available in each category:-

Category 1 – FLIGHT PLAN

FMS Meteo - uplink
The Forecast Meteo data in a grid format covering the route to be flown can be uplinked while the aircraft is at the gate and also at any time during the flight. The Meteo data is loaded into a data base for use by the trajectory generator.

Meteo Report Request - downlink
The pilot can request an uplink of either TAF, METAR or SIGMET information as and when required.

TAF - uplink
The Aerodrome Forecast information can be uplinked in response to a pilot request.

METAR - uplink
The Aerodrome Meteo Report can be uplinked in response to a pilot request.

SIGMET - uplink
Significant Meteo Information can be uplinked in response to a pilot request.

Loadsheet - uplink
The ground generated Load Sheet can be uplinked to the aircraft while at the gate and displayed on the MCDU.

Loadsheet Acknowledgement - downlink
The pilot is required to downlink acknowledgement of receiving a Loadsheet.

Slot Allocation - uplink
AOC can uplink Expected Off Block Time (EOBT) and Calculated Take-off Time.

Company Flight Plan - uplink
The Company Flight Plan, generated on the ground, can be uplinked to the aircraft while positioned at the gate. It is reviewed by the pilot and loaded into the FMS.

Category 2 – MAINTENANCE

Snag Report - downlink
Aircraft system status and on-board faults can be downlinked to the AOC facility.
APU Request - uplink
AOC can request an APU status report at any time.

APU Response - downlink
The aircraft will downlink a response to an APU Request if unable to provide an immediate APU Report. Available, but unlikely to be used in the BAC 1-11.

APU Report - downlink
The current APU status will be downlinked in response to an AOC request. This will be a fixed message from the IHTP because the FMS has no access to the APU in the BAC 1-11.

Engine Status Request - uplink
AOC can request an Engine Status report at any time.

Engine Status Response - downlink
The aircraft will downlink a response to an Engine Status Request if unable to provide an immediate Engine Status Report. Available, but unlikely to be used in the BAC 1-11.

Engine Status Report - downlink
The current engine status will be downlinked in response to an AOC request. This will be a fixed message from the IHTP because the FMS has no access to engine status data in the BAC 1-11.

Category 3 – COLLABORATIVE DECISION MAKING

Constraints List - uplink
In future ATM systems it is expected that AOC will participate with ATC and the aircraft in determining the optimum routing, destination, etc., when unexpected events occur during flight. A constraint list can be uplinked for insertion into the FMS, allowing the pilot to then negotiate with ATC a revised route as proposed by AOC.

Constraints Acceptance - downlink
The pilot is required to respond to a Constraints List uplink (using Accept, Reject or Modified options).

Trajectory Downlink - downlink
The Active or Non-Active Trajectory agreed with ATC will be downlinked to AOC.

Category 4 – ASSET MANAGEMENT

Initialising Message - downlink
A downlink is required from the aircraft to initialise (register) AOC datalink communications.

Free Text - uplink and downlink
This function allows the pilot to downlink free text messages constructed on the MCDU to AOC, and to read on the MCDU any uplinked free text messages from AOC.
Aircraft Meteo Report Request - uplink
AOC can request the aircraft’s Meteo information at any time.

Aircraft Meteo Report Response - downlink
The aircraft will downlink a response to an Aircraft Meteo Report Request if unable to provide an immediate Aircraft Meteo Report. Available, but unlikely to be used in the BAC 1-11.

Aircraft Meteo Report - downlink
The meteo conditions currently being experienced by the aircraft will be downlinked in response to an AOC request.

4D Trajectory Request - uplink
AOC can request the downlink of the aircraft’s 4D Trajectory (Active or Non-Active) at any time.

4D Trajectory Data - downlink
The Active or Non-Active 4D Trajectory can be downlinked in response to a request from AOC, at any time the pilot wishes.

OOOI - downlink
Each of the required events will be triggered at the appropriate points during each flight.
Out - when the aircraft door is closed (manually triggered through the IHTP).
Off - when the aircraft leaves the ground (“Aircraft on Ground” becomes False).
On - when the aircraft touches down (“Aircraft on Ground” becomes True).
In - when the main door is opened (manually triggered through the IHTP).

Flight Progress Request - uplink
AOC can request a Flight Progress Report from the aircraft at any time.

Flight Progress Response - downlink
A downlink from the aircraft in response to a Flight Progress Request when unable to provide an immediate Flight Progress Report. Available, but unlikely to be used in the BAC 1-11.

Flight Progress Report - downlink
Aircraft present position, planned 4D route and estimated time of arrival can be downlinked in response to an AOC request.

2.3 FUNCTIONS TO BE PROVED IN FLIGHT
Because of the limited flight hours available, it will not be possible to carry out sufficient numbers of runs on many functions to enable performance assessment figures to be obtained. However, the functions listed below will be tested in flight to establish that they performed in accordance with the design and that they meet with pilot approval in terms of operational usability. Where possible objective measurements will be taken, but the results will be mainly based on pilot subjective opinion.
2.3.1 CDTI/ASAS (Partial Delegation)

**Longitudinal Spacing**

Merge Behind at Waypoint – using Time spacing

**Lateral Spacing**

Resume when Clear of Target

(See Technote MAT0015, Issue 3 for a full description of the above Partial Delegation functions).

2.3.2 Precision Approach and Departure

Curved STAR (SBAS) to short (2nm) straight approach (GBAS) with 4.5 degree glidepath – to check procedure expected to be flown during Rome flight trials.
3 ASSESSMENT REQUIREMENTS

This chapter provides a definition of the MA-AFAS FMS assessment requirements for each function being flown in the BAC 1-11. The requirements cover some aspects of the enabling facilities utilised by the functions, but general assessment requirements not covered by any of the functions are defined in specific enabling facility sub-chapters. The requirements are objective wherever possible, but subjective pilot opinion in terms of ease of use, satisfactory operation, adequate information display and warnings etc., also form an important part of the assessment process.

3.1 EN-ROUTE 4D NAVIGATION

3.1.1 4D Trajectory Generation

Assess crew work involved in setting up the Constraint List for which a trajectory is required (Loading Company Route, AOC up-link, manual insertion of Departure and Destination Airports, Waypoints, SID and STAR, Cruise Flight Level, Phase table selections) both before and during flight. Determine ability to check correctness of Constraint List prior to trajectory generation.

Trajectory generation is to be assessed in real time by the pilot checking the generated trajectory against the Constraint List. (Check that the constraints have been preserved as expected, the trajectory between the constraints has an acceptable shape, the aircraft flight envelope does not appear to be exceeded, and that there is no visible conflict with the ground or other traffic). If trajectory generation fails, establish whether annunciated errors provide adequate indication of why the failure has occurred.

The pilots will provide subjective feedback on ease of use, workload impact, trajectory presentation, and timeliness of generation.

After flight, the recorded constraints and resulting trajectories will be examined offline for correct use of constraints, correct incorporation of weather data and aircraft phase data, and optimum 4D trajectory generation.

3.1.2 4D Guidance

The 4D Guidance function will be assessed by the pilots during each flight. They will observe the short-term stability of the aircraft control, noting any oscillatory lateral and vertical motion, and throttle hunting, and also the long-term performance in terms of how accurately the active trajectory is maintained. They will also note any transients during trajectory activation, MFMS engagement, MFMS enactment of tactical commands, precision approach engagement, and general levels of comfort. Speedbrake prompting will be assessed for ease of use, especially with regard to frequency of application and re-application. Finally, the pilots will note the speed of response of the system to commanded changes in mode, including activation after automatic re-generation, and activation of tactical commands.

The 4D Guidance function will be assessed off line after flight by comparing the recorded aircraft 4D position, heading, speed, and body rates with the recorded trajectory throughout the flight. A profile of errors will be produced and related to pilot actions, ASAS manoeuvres, automatic trajectory re-generations, passing trajectory points, meteorological effects, precision approach transitions, and autopilot mode selections. Quantitative analysis will be performed to establish stability of
control of pitch, roll, and throttle commands through the full flight regime, as well as system delays in responding to commanded mode changes, including activation and change of trajectory and activation of tactical commands.

3.2 CDTI/ASAS (PARTIAL DELEGATION)

Many operating features are common to all Partial Delegation functions and the assessment requirements for these common features are defined here. The assessment requirements for features specific to each individual function are specified in the subsequent sub-chapters.

Instruction Delivery via Data Link – check satisfactory alerting, adequate display and unambiguous meaning of message.

Target Identification – check ease of target recognition and selection on ND.

Setting Up and Initiation of Delegated task – check ease of parameter input, suitable display of trajectory, confidence in proposed solution and satisfactory acceptance of delegation.

Monitoring of FMS performance – check adequate display of progress relative to target, confidence in outcome and satisfactory resume manoeuvre.

Ending Delegation, Resumption of Route – check smooth re-join of route and clear responsibility shift back to controller.

Check that crew workload is acceptable for each phase of flight.

3.2.1 Longitudinal Spacing

Merge Behind at Waypoint

Check satisfactory lateral manoeuvring together with acceptable speed control and throttle activity during capture of the required spacing.

Determine accuracy of spacing at Merge Waypoint and check satisfactory reversion to Remain Behind.

3.2.2 Lateral Spacing

Pass Behind

Check suitability of Initial Heading, smoothness and relevance of track corrections and determine accuracy of spacing achieved.

Resume when Clear of Target

Determine accuracy of spacing achieved.

3.3 TAXI MANAGEMENT

The main Taxi Management assessment will be conducted in the ATTAS aircraft at Braunschweig using their Surface Movement, Guidance and Control System. Therefore only limited assessment will be carried out at Boscombe. Runway Incursion and CDTI functions will not be available.

3.3.1 Map Display

Verify that the taxi map is coherent to the actual layout of the airport. The aircraft position shown on the display shall be compared to the actual position in the real world.
The crew shall provide comments on the value of the displayed information, and if low visibility conditions are experienced, it shall be determined to what extent crew orientation and situation awareness are enhanced. Also required is an indication on how quickly the pilot can retrieve the necessary information from the taxi map display (head-down time).

3.3.2 Taxi clearances

A goal of these tests is to check how much the pilot workload can be reduced with this application. Also, the crew should provide information on how well the system helps in understanding and following the taxi route.

3.3.3 Taxi CPDLC Messages

The crew should provide an indication of how much benefit they see in the CPDLC system and it should be noted if the crew prefers sending a request via CPDLC or via voice if both are available.

3.3.4 Runway Alert

Comments from pilots about the value of this function are of major interest. In addition, the behaviour of the system shall be checked for different taxi speeds when the crew is intending to stop at the holding position, to verify that no nuisance alerts are generated under normal taxi conditions.

3.4 PRECISION APPROACH AND DEPARTURE

The objective is to demonstrate the complementary nature of SBAS and GBAS. SBAS provides navigation for en-route through to an approach capability. GBAS extends this approach capability. Thus for flights in poor weather there will be a changeover from one system to the other. Similarly, during departure there will be a changeover from GBAS to SBAS at some point along the SID. The nature of these changeovers requires investigation.

3.4.1 SBAS Curved STAR

Curved STARs will be flown to establish that the SBAS equipment is operating within specifications and standards.

The pilot’s opinion will be obtained concerning the adequacy of lateral and vertical path tracking and smoothness of transition from the curved STAR on to straight final approach, for both 8nm and 4nm final approaches.

The recorded data will be analysed post flight to determine the performance and accuracy of the total system (i.e. SBAS plus FMS/autopilot) throughout the curved STAR.

3.4.2 GBAS Straight Approach

During the final straight approaches (all with 3 degree glidepaths), the guidance will switch from SBAS to GBAS to give increased accuracy, and from FMS/autopilot to autopilot only for integrity reasons.

The pilot’s opinion will be obtained concerning the smoothness of transition from SBAS to GBAS, the adequacy of lateral and vertical path tracking throughout the final approach, and the accuracy of aircraft position and stability at decision height with regard to making a successful manual landing.
The recorded data will be analysed post flight to determine the performance and accuracy of the total system (i.e. GBAS plus autopilot) throughout the straight approach.

3.4.3 Curved SID
After take-off the aircraft will follow a curved SID using GBAS guidance initially, and then transitioning to SBAS guidance.

The pilot’s opinion will be obtained concerning the smoothness of transition from GBAS to SBAS and the adequacy of lateral and vertical path tracking throughout the SID.

The recorded data will be analysed post flight to determine the performance and accuracy of the total system (i.e. GBAS/SBAS plus FMS/autopilot) throughout the curved SID.

3.5 AOC
The following Assessment Requirements are common to all AOC functions:-

- Ease of requesting information (MCDU pages, etc.)
- Satisfactory alerting to incoming messages
- Adequate display of messages
- Ease of implementing or acknowledging messages
- Satisfactory queuing and access of messages
- Ease of recalling messages
- Adequate rates achievable for Periodic messages

The crew shall provide comments on the value of AOC information and available services.

Any reduction in crew workload with regard to pre-flight and in-flight procedures shall be determined.

3.6 COMMUNICATIONS
The VDL Mode 4 data link system needs to be assessed in terms of its overall communications capability (impact on specific MA-AFAS functions has been included in the function requirements). The following need to be determined for both point to point operation and for broadcast operation:-

- Integrity of message transmission
- Success rate (any lost messages)
- Transmission times for uplink and downlink messages of all sizes
- Impact of increased loading on integrity, success rate and transmission times

3.7 COCKPIT HMI
Assessment requirements for the HMI facilities provided for MA-AFAS functions are covered in the appropriate sub-chapter. The following general issues also need to be assessed:-

- Clashes or interactions between HMI requirements of different functions
Overall control of information displayed on Navigation Display (ND)
Mis-match between ND information and MCDU information
Satisfactory operation of the MCDU page selection, menu, inputting, etc.
Ease, speed and accuracy of operating the Cursor Control Device (Roller Ball)

3.8 TIS-B
The TIS-B function shall be assessed in the following way:-
   Completeness of data broadcast
   Frequency of broadcast
   Latency of data broadcast

3.9 FIS-B
The FIS-B function shall be assessed in the following way:-
   Ease of requesting information (MCDU pages, etc.)
   Satisfactory alerting to incoming messages
   Adequate display of messages
   Ease of implementing request message
   Satisfactory queueing and access to messages
   Ease of recalling messages

The crew shall provide comments on the value of the FIS-B information and available services.
Any reduction in workload during ground and flight operation shall be determined.
4 ROUTES

This section defines the routes to be used for testing and assessing the MA-AFAS FMS functionality. They are entirely within UK lower airspace and Airways Coordination Notice (ACN) clearances will be obtained to give maximum chance of uninterrupted operation.

4.1 TEST AND ASSESSMENT ROUTES

4.1.1 Initial Route Map

The route has been designed to enable the ASAS Partial Delegation functions to be tested and assessed using simulated traffic as target aircraft. This involves the BAC 1-11 manoeuvring laterally while at Cruise Flight Level for the Lateral Spacing and Merge Behind functions. The interactions with target aircraft are planned at specified positions along the route (Pass Behind on legs EEE to FFF, GGG to HHH and III to JJJ, with a Merge Behind on leg JJJ to KKK). Unpredictable meteo conditions or deviations from the planned route caused by other live traffic in the area, will cause variations in the start and finish positions of each interaction.

The route will also be used to determine 4D Navigation accuracy, AOC functional performance and VDL Mode 4 communications performance. Taxi Management functionality will be assessed during all taxi operations at Boscombe Down.

For the initial test flights a shortened form of the route will be used, with the aircraft remaining to the East of airway A25.
4.1.2 Waypoint List (Initial Route)

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<td>N50 55.0</td>
<td>W002 20.0</td>
<td></td>
</tr>
<tr>
<td>AAA</td>
<td>N50 53.3</td>
<td>W002 55.1</td>
<td></td>
</tr>
<tr>
<td>BBB</td>
<td>N51 04.9</td>
<td>W003 00.0</td>
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</tr>
<tr>
<td>CCC</td>
<td>N51 23.3</td>
<td>W003 00.0</td>
<td></td>
</tr>
<tr>
<td>DDD</td>
<td>N51 23.0</td>
<td>W002 28.3</td>
<td></td>
</tr>
<tr>
<td>EEE</td>
<td>N51 12.5</td>
<td>W002 11.9</td>
<td>Start of Pass Behind leg</td>
</tr>
<tr>
<td>FFF</td>
<td>N50 44.6</td>
<td>W003 10.0</td>
<td></td>
</tr>
<tr>
<td>GGG</td>
<td>N50 46.6</td>
<td>W003 46.8</td>
<td>Start of Pass Behind leg</td>
</tr>
<tr>
<td>HHH</td>
<td>N50 26.0</td>
<td>W005 01.8</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>N50 44.8</td>
<td>W005 37.5</td>
<td>Start of Pass behind leg</td>
</tr>
<tr>
<td>JJJ</td>
<td>N51 23.1</td>
<td>W005 07.8</td>
<td>Start of Merge Behind leg</td>
</tr>
<tr>
<td>KKK</td>
<td>N51 24.8</td>
<td>W003 32.3</td>
<td>Merge Point</td>
</tr>
</tbody>
</table>

4.1.3 Revised Route Map

The revised route was designed to keep the aircraft within a maximum range of 135 nm from Boscombe Down. This was necessary because the VDL4 link could not be reliably maintained at ranges greater than 135 nm. Simulated target aircraft were generated to give Pass Behind interactions on legs E to F, G to H, M to J and J to Z. Merge Behind manoeuvres were carried out on leg P to Q, and on leg S to T.
### 4.1.4 Waypoint List (Revised Route)

<table>
<thead>
<tr>
<th>Waypoint Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>KATE</td>
<td>N50 58.6</td>
<td>W001 43.1</td>
<td>End of SID</td>
</tr>
<tr>
<td>X</td>
<td>N50 53.6</td>
<td>W002 50.4</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>N51 04.9</td>
<td>W003 00.0</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N51 23.3</td>
<td>W002 55.2</td>
<td></td>
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<tr>
<td>D</td>
<td>N51 23.0</td>
<td>W002 28.3</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>N51 12.5</td>
<td>W002 11.9</td>
<td>Start of Pass Behind leg</td>
</tr>
<tr>
<td>F</td>
<td>N50 44.6</td>
<td>W003 10.0</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>N50 46.6</td>
<td>W003 46.8</td>
<td>Start of Pass Behind leg</td>
</tr>
<tr>
<td>H</td>
<td>N50 26.0</td>
<td>W005 01.8</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>N50 50.0</td>
<td>W005 13.0</td>
<td>Start of Pass Behind leg</td>
</tr>
<tr>
<td>J</td>
<td>N51 23.1</td>
<td>W005 07.8</td>
<td>Start of Pass Behind leg</td>
</tr>
<tr>
<td>Z</td>
<td>N51 24.4</td>
<td>W003 48.3</td>
<td>Merge Point (on second circuit)</td>
</tr>
<tr>
<td>P</td>
<td>N51 13.0</td>
<td>W003 38.0</td>
<td>Start of Merge Behind leg</td>
</tr>
<tr>
<td>Q</td>
<td>N50 24.5</td>
<td>W004 22.0</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>N50 25.0</td>
<td>W004 39.5</td>
<td>Merge Point</td>
</tr>
<tr>
<td>S</td>
<td>N50 42.5</td>
<td>W005 11.0</td>
<td>Start of Merge Behind leg</td>
</tr>
<tr>
<td>T</td>
<td>N51 20.0</td>
<td>W004 16.0</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>N51 24.8</td>
<td>W003 32.3</td>
<td></td>
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<td>C</td>
<td>N51 23.3</td>
<td>W003 00.0</td>
<td></td>
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<tr>
<td>A</td>
<td>N50 53.3</td>
<td>W002 55.1</td>
<td></td>
</tr>
<tr>
<td>AGIBS</td>
<td>N50 55.0</td>
<td>W002 20.0</td>
<td></td>
</tr>
<tr>
<td>DM005</td>
<td>N50 59.9</td>
<td>W001 42.8</td>
<td>Start of STAR to R/W 23</td>
</tr>
</tbody>
</table>

### 4.2 BOSCOMBE SIDS AND STARS

The following SIDS and STARS will be available in the FMS for departures and arrivals at Boscombe Down:

#### 4.2.1 SID Runway 23 (for Full Assessment Flights)
### 4.2.2 Waypoint List

<table>
<thead>
<tr>
<th>Waypoint Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO23</td>
<td>N51 09.0</td>
<td>W001 45.4</td>
<td>Nominal Take-off Point</td>
</tr>
<tr>
<td>ESPIN</td>
<td>N51 07.5</td>
<td>W001 48.4</td>
<td>2 NM Turn Radius</td>
</tr>
<tr>
<td>B3</td>
<td>N51 06.1</td>
<td>W001 46.9</td>
<td>Centre of Turn</td>
</tr>
<tr>
<td>WOLF</td>
<td>N51 04.4</td>
<td>W001 47.1</td>
<td></td>
</tr>
<tr>
<td>INGL</td>
<td>N51 03.2</td>
<td>W001 42.3</td>
<td></td>
</tr>
<tr>
<td>PRICE</td>
<td>N51 00.2</td>
<td>W001 40.2</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>N51 01.1</td>
<td>W001 43.8</td>
<td>Centre of Turn</td>
</tr>
<tr>
<td>KATE</td>
<td>N50 58.6</td>
<td>W001 43.1</td>
<td></td>
</tr>
</tbody>
</table>
4.2.3 SID R/W 23 (for Precision Departure Assessment Flights)

Notes:
1) GBAS & SBAS Required
2) Turn is an RF leg. RNP-RNAV Capable a/c only

SID    RWY    ROUTEING          ALTITUDES
RBN 1A  23    After DM004 commence RF leg turn to the left. Continue climb, levelling at FL40.  Cross DM005 at FL40

National Air Traffic Services Ltd.
23rd July 2002
4.2.4 Approach Runway 05  (If R/W 23 unavailable)

GNSS APPROACH  \[\text{XX105 TRIALS USE ONLY}\]  BOSCOMBE DOWN

RWY 05

<table>
<thead>
<tr>
<th>PRICE</th>
<th>TOD</th>
<th>INGL</th>
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<th>TD05</th>
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<tr>
<td>2.5 R</td>
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<td>1.5R</td>
<td>055M</td>
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</table>

Runway Track to 2000 QFE

Nm to Touchdown
4.2.5 Waypoint List

<table>
<thead>
<tr>
<th>Waypoint Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>KATE</td>
<td>N50 58.6</td>
<td>W001 43.1</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>N51 01.1</td>
<td>W001 43.8</td>
<td>Centre of Turn</td>
</tr>
<tr>
<td>PRICE</td>
<td>N51 00.2</td>
<td>W001 40.2</td>
<td></td>
</tr>
<tr>
<td>INGL</td>
<td>N51 03.2</td>
<td>W001 42.3</td>
<td></td>
</tr>
<tr>
<td>WOLF</td>
<td>N51 04.4</td>
<td>W001 47.1</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>N51 06.1</td>
<td>W001 46.9</td>
<td>Centre of Turn</td>
</tr>
<tr>
<td>ESPIN</td>
<td>N51 07.3</td>
<td>W00148.2</td>
<td>Centreline @ 2NM</td>
</tr>
<tr>
<td>TDO5</td>
<td>N51 08.7</td>
<td>W001 46.0</td>
<td>Nominal Touchdown Point</td>
</tr>
</tbody>
</table>

4.2.6 Steep Approach R/W 23 (Pre-Rome check)
## 4.2.7 Waypoint List

<table>
<thead>
<tr>
<th>Waypoint Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>KATE</td>
<td>N50 58.6</td>
<td>W001 43.1</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>N51 01.1</td>
<td>W001 43.8</td>
<td>Centre of Turn</td>
</tr>
<tr>
<td>PRICE</td>
<td>N51 00.2</td>
<td>W001 40.2</td>
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</tr>
<tr>
<td>MANS</td>
<td>N51 08.0</td>
<td>W001 35.7</td>
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<tr>
<td>B2</td>
<td>N51 08.9</td>
<td>W001 39.1</td>
<td>Centre of Turn</td>
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<tr>
<td>FELD</td>
<td>N51 10.8</td>
<td>W001 41.9</td>
<td>Centreline @ 2NM</td>
</tr>
<tr>
<td>TD23</td>
<td>N51 09.7</td>
<td>W001 44.2</td>
<td>Nominal Touchdown Point</td>
</tr>
</tbody>
</table>
4.2.8 R/W 23 SBAS - GBAS Approach 1A
4.2.9 R/W 23 SBAS - GBAS Approach 1B
4.2.10 SID R/W 05  (if R/W 23 not available)
5 GROUND TESTING REQUIREMENTS

The following ground tests have been defined to check that, as far as can be determined on the ground, the MA-AFAS FMS is ready for flight. The duration of each test is specified in the detailed test documentation. The aircraft will be positioned so that facilities such as data link ground stations are available as required.

The following initial conditions are assumed:-

The MA-AFAS FMS has successfully completed the simulation test scenarios at QinetiQ Bedford.

5.1 INSTALLATION CHECK

Check that all signal and power wiring is correct.

Ensure that MA-AFAS avionics rack, MCDU, Roller Ball and IHTP all install correctly in the aircraft.

5.2 FMS INITIALISATION AND OPERATION

5.2.1 Objective

Demonstrate that the FMS accepts valid initialisation parameters, generates trajectories and drives control surfaces and throttles in the correct sense.

5.2.2 Preparation & Infrastructure

In House Test Platform (IHTP)

Barometric Pressure Test Set

System powers up and recognises peripheral equipment.

5.2.3 Test

Carry out initialisation process to include:-

  Aircraft present position is correct
  Display Control Panel selections operate correctly
  MCDU operates correctly
  Rollerball drives map cursor correctly
  Autopilot control panel inputs and outputs operate correctly
  Navigation Display operates correctly
  Alternate Trajectory generates correctly

Use Pressure Test Set to provide suitable Altitude and Speed (as if aircraft airborne)

  Activate Trajectory
  Engage autopilot and autothrottle and check correct sense of control surface and throttle movements.

5.2.4 Success Criteria

FMS initialises correctly, generates and activates trajectory and drives control surfaces and throttles in correct sense.
5.3 VDL MODE 4 FUNCTIONAL CHECK

5.3.1 Objective
To demonstrate that the FMS communicates with the VDL mode 4 ground station.

5.3.2 Preparation & Infrastructure
FMS initialises and recognises presence of VDL mode 4 datalink.
VDL mode 4 ground network.

5.3.3 Test
Establish link from FMS to VDL mode 4 ground station.

5.3.4 Success Criteria
FMS communicates with the VDL mode 4 ground station.

5.4 VDL MODE 4 DOWNLINK CHECK

5.4.1 Objective
To demonstrate that the VDL mode 4 downlink operates correctly.

5.4.2 Preparation and Infrastructure
FMS communicates with the VDL mode 4 datalink.
VDL mode 4 ground network
ESCAPE ATC Simulator

5.4.3 Test
FMS establishes link to VDL mode 4, via the CMU and broadcasts correct ADS-B data.

5.4.4 Success Criteria
Correct ADS-B data received by ESCAPE.

5.5 VDL MODE 4 UPLINK CHECK

5.5.1 Objective
To demonstrate correct operation of the VDL mode 4 uplink.

5.5.2 Preparation & Infrastructure
FMS communicates with the VDL mode 4 datalink.
VDL mode 4 ground network
ESCAPE ATC Simulator

5.5.3 Test
ESCAPE generates and broadcasts TIS-B database
FMS receives correct TIS-B information;
Traffic information is correctly positioned on all display ranges, and rotates with compass heading when compass is slewed manually.

5.5.4 Success Criteria
TIS-B information is displayed correctly on the Navigation Display.
5.6 CDTI/ASAS

5.6.1 Objective
To check correct operation of CDTI and ASAS functions

5.6.2 Preparation & Infrastructure
IHTP traffic generator
FMS operating with aircraft model

5.6.3 Test
Traffic correctly displayed on ND
Target correctly selected through CDU and identified on ND
Required ASAS manoeuvre, spacing and resume waypoint selected on CDU
Suitable trajectory generated when requested on CDU
Aircraft follows trajectory when Executed on CDU

5.6.4 Success Criteria
Aircraft accurately follows trajectory and achieves required spacing from target
Original route successfully resumed at the nominated waypoint

5.7 TAXI MANAGEMENT CHECK

5.7.1 Objective
To check correct operation of taxi uplink and downlink message passing and display.

5.7.2 Preparation & Infrastructure
VDL mode 4 ground network
Taxi ground station

5.7.3 Test
Uplink Taxi Clearance message from Taxi ground station. Downlink pilot acceptance.
Exchange CPDLC Taxi messages between aircraft and Taxi ground station.

5.7.4 Success Criteria
All messages received and displayed correctly in aircraft and on Taxi ground station.

5.8 PRECISION APPROACH AND DEPARTURE

5.8.1 Objective
Integration tests are required to ensure that the MA-AFAS FMS works with the SBAS (storage of database) and GBAS/SBAS (reception of signal).

5.8.2 Preparation & Infrastructure
SBAS and GBAS User Platform (UP)

5.8.3 Test
Even though they are proven user platforms and are part of a proven installation, a check unit test of both the SBAS and the GBAS User Platform (UP) will be
conducted to ensure that the MA-AFAS FMS computes its navigation solution as designed.

5.8.4 Success Criteria
MA-AFAS FMS correctly computes aircraft position with SBAS and GBAS inputs.

5.9 AOC LOG-ON CHECK

5.9.1 Objective
To demonstrate that the FMS communicates with the AOC ground station.

5.9.2 Preparation & Infrastructure
VDL mode 4 ground network
AOC ground station

5.9.3 Test
FMS logs on to AOC application.

5.9.4 Success Criteria
FMS is able to communicate with AOC ground station.

5.10 AOC APPLICATION CHECK

5.10.1 Objective
To demonstrate correct operation of the AOC applications.

5.10.2 Preparation & Infrastructure
AOC check complete.
VDL mode 4 ground network
AOC ground station – with access to flight plan, slot allocation, meteo forecast and meteo report files
In House Test Platform (IHTP)

5.10.3 Test
FMS logs on to AOC application. Check reception, by the aircraft, of flight plan, FMS meteo and slot allocation
Uplink of Loadsheet from AOC ground station. Downlink pilot acceptance
Trigger OUT event through IHTP, check received by the AOC ground station
Trigger OFF event, check received by the AOC ground station
Exchange of Free Text messages between aircraft and AOC ground station
Downlink of pilot Meteo request. Check Meteo request reception by the AOC ground station. Check reception, by the aircraft, of requested meteo reports or not available message
Trigger SNAG event through the IHTP. Check reception of SNAG message by the AOC ground station. Downlink pilot generated SNAG Report, check received by the AOC ground station. Uplink ACMS requests (engine and APU) from AOC ground station
Uplink Flight Progress request from AOC ground station
Uplink Aircraft Meteo Report request from AOC ground station
Uplink 4D Trajectory request from AOC ground station
Uplink Constraints List from AOC ground station
Trigger ON event, check received by the AOC ground station
Trigger IN event through the IHTP, check received by the AOC ground station

5.10.4 Success Criteria
All messages received and displayed correctly in aircraft and on AOC ground station

5.11 VDL MODE 4 LINK LOADING CHECK

5.11.1 Objective
To demonstrate that the VDL mode 4 datalink and sub-network is able to accommodate required traffic loading.

5.11.2 Preparation & Infrastructure
VDL mode 4 functional check complete.
VDL mode 4 ground network
ESCAPE ATC Simulator
AOC ground station
Taxi ground station

5.11.3 Test
Enable simultaneous ADS-B reports to ESCAPE and the reception of TIS-B reports from ESCAPE
AOC application used to exchange free text, CPDLC and Flight Plan information together with contracted Flight Progress Report at 10 second intervals.
Taxi messages to be exchanged between aircraft and Taxi ground station
Tests to be conducted for at least 10 minutes

5.11.4 Success Criteria
ADS-B, TIS-B, AOC and Taxi messages all received and updated correctly.
Message transit times within acceptable limits.

5.12 FIS-B

5.12.1 Objective
To demonstrate that the FIS-B application operates correctly

5.12.2 Preparation & Infrastructure
FIS-B check complete
In House Test Platform (IHTP)

5.12.3 Test
Trigger, through the IHTP, the generation and transmission of FIS-B reports
Check message reception by the aircraft
Downlink a pilot FIS-B report request
Check reception, by the aircraft, of the requested meteo report(s)

5.12.4 Success Criteria
All messages received and displayed correctly
6 AIRBORNE TESTING REQUIREMENTS

The following airborne test procedures will be carried out to verify that each of the specified MA-AFAS functions operate correctly and can be satisfactorily controlled and monitored by the pilot in real flight conditions. The particular functional test flights during which each function will be verified are defined in Section 7.

6.1 EN-ROUTE 4D NAVIGATION

6.1.1 Objective
This test will verify that the FMS 4D navigation and guidance functionality operates correctly in the airborne environment.

6.1.2 Requirements
VDL mode 4 ground network
Initialisation verification checks and ground tests completed successfully.

6.1.3 Test
4D route flight profile is to include:
SID;
Continuous climbs + step climbs;
Continuous descents + step descents;
Level flight;
Cruise;
Turns to left and right;
STAR.

6.1.4 Success Criteria
FMS generates correct trajectories and provides correct guidance (including regeneration), within specified tolerances, along the activated route.

6.2 ASAS LONGITUDINAL SPACING FUNCTIONS

6.2.1 Objectives
To verify the operation of the ASAS Longitudinal Spacing functions.

6.2.2 Requirements
VDL mode 4 ground network
ESCAPE ATC Simulator

6.2.3 Test
Escape is required to generate leading target aircraft such that the BAC 1-11 should be able to achieve the required spacing at a pre-defined waypoint for Merge Behind.
Identify Target aircraft and implement delegation
Capture and then maintain required distance or time spacing in level flight and in descent.
Deliberately infringe spacing minimum and maximum to check alerting.
6.2.4 Success Criteria
ASAS Longitudinal Spacing functions identify target aircraft and successfully acquire and maintain the cleared spacing throughout level and descent phases of flight. CDTI correctly displays target aircraft and all appropriate alerts.

6.3 ASAS LATERAL SPACING FUNCTIONS

6.3.1 Objectives
This test will verify the Lateral Spacing functions and the ability to construct 4D trajectories to obtain the required spacing.

6.3.2 Requirements
VDL mode 4 ground network
ESCAPE ATC Simulator

6.3.3 Test
Escape is required to position target aircraft such that the BAC 1-11 should be able to pass behind the target at the required spacing distance.

6.3.4 Success Criteria
Lateral Crossing functions successfully predict 4D trajectories and achieve required spacing during crossing manoeuvres.

6.4 TAXI MANAGEMENT FUNCTIONS

6.4.1 Objectives
This test will verify the operation of taxi management functions (Map, Taxi Clearances and Runway Alert) during departure and arrival operations.

6.4.2 Requirements
Initialisation verification checks and ground tests successfully completed.

6.4.3 Test
Check correct display of aircraft position and orientation on Map
Check correct display of Taxi Route Clearance
Check CPDLC message uplinks and downlinks
Follow specified taxi route to departure runway at normal taxi speeds. Select range scales and Map display options as required.
Check Runway Alert operation
Select Taxi Display in flight
Select Taxi Display after touchdown.
Exit runway and follow specified taxi route to stand. Select range scales as required.
Check CPDLC message uplinks and downlinks.

6.4.4 Success Criteria
Aircraft position and orientation correctly displayed on the Taxi Map. Correct Map presentation when selected with aircraft airborne. Correct alerting on nearing runway during taxiing. Correct operation of CPDLC messages and Taxi Route Clearances.
6.5 SBAS STAR INTO GBAS PRECISION APPROACH

6.5.1 Objectives
To determine the performance achieved when using SBAS guidance for flying a curved STAR and transitioning to GBAS during final approach.

6.5.2 Requirements
NATS GBAS ground system
SBAS

6.5.3 Test
Two STARs followed by Precision Approach procedures have been designed for Runway 23 at Boscombe Down, one joining the extended runway centreline at 8nm, the second joining at 4nm.

The approach procedure will be coded into a format suitable for loading into the GBAS ground station and the SBAS database.

The truth track ground data logger will be switched on.

The aircraft truth track data logger will be switched on.

The main actions required when performing the test are to:

- Join and fly the appropriate curved STAR using SBAS guidance through FMS/autopilot.
- Transition to GBAS guidance through the autopilot during final approach.
- Monitor progress and performance on ND down to Decision Height.

6.5.4 Success Criteria
The aircraft is accurately guided along a curved STAR joining a straight precision approach path, supported by GBAS and SBAS as appropriate, down to the Decision Height. Acceptable transitions from SBAS to GBAS and from FMS/autopilot control to autopilot only.

6.6 GBAS TO SBAS DEPARTURE

6.6.1 Objectives
To determine the performance achieved when using GBAS guidance for the initial departure on a curved SID and then transitioning to SBAS guidance.

6.6.2 Requirements
NATS GBAS ground system
SBAS

6.6.3 Test
Generate trajectory prior to take-off
Engage autopilot and FMS during initial climb

Monitor lateral, vertical and speed performance throughout the departure procedure, including the transition from GBAS to SBAS guidance
6.6.4  Success Criteria
Accurate and smooth control to the SID procedure with smooth transition from GBAS to SBAS guidance

6.7  AOC FUNCTIONS

6.7.1  Objectives
To determine the usefulness and usability in the cockpit and on the ground of all AOC functions at appropriate times throughout each flight.

6.7.2  Requirements
VDL mode 4 ground network
AOC simulator (AGP)
In House Test Platform (IHTP) – for OOOI and Maintenance messages

6.7.3  Test
The AOC ground station will be used to send all uplink messages and to respond to all downlink messages (as listed in Section 2.2.5).
The cockpit crew will initiate downlink requests as and when required, and will respond to uplink messages when necessary.
Appropriate messages will be passed at relevant times during each flight.
Both types of AOC message passing will be exercised (Demand and Periodic).

6.7.4  Success Criteria
All AOC messages received correctly at their intended destination.
Any message delays within acceptable limits.
Suitable interfacing for control and display in cockpit, and acceptable workload.

6.8  FIS-B

6.8.1  Objectives
To evaluate the viability and usefulness of the FIS-B function in the cockpit

6.8.2  Requirements
On-board IHTP

6.8.3  Test
The IHTP will be used to simulate the periodical broadcast of FIS-B reports and to respond to pilot generated FIS-B report requests
The cockpit crew will initiate FIS-B report requests as and when required

6.8.4  Success Criteria
All FIS-B messages received correctly at their intended destination
Any message delays within acceptable limits
Suitable interfacing for control and display in cockpit, and acceptable workload
7 FLIGHT TRIALS

The initial flight trials are intended to focus on the verification of as many as possible of the available MA-AFAS functions in the real airborne environment. Because of the limited flight hours available, subsequent trials will carry out validation assessment of only a sub-set of the total MA-AFAS functions. The functions selected include those envisaged for the final ‘gate-to-gate’ validation trials using the MEDUP infrastructure, combined with the ATTAS aircraft, at Ciampino in Italy.

The trials will be conducted within the UK FIR operating from Boscombe Down airfield. The test routes are arranged so as to minimise the use of airways, but in order to achieve the required length and flexibility of routing, airway crossings are necessary. The routes will be negotiated with ATC and all necessary Airways Coordination Notices (ACN’s) will be obtained.

Although it had always been planned to deliver the MA-AFAS functionality in a series of software “builds”, the original timescales provided a final build with full functionality prior to the start of flight trials. This build would have been fully tested in the laboratory and in the RTAVS cockpit simulator, including end-to-end checks with the ESCAPE ATC simulator at Bretigny, before installation on the aircraft.

Software integration at Rochester fell significantly behind schedule, resulting not only in delays to each software build, but also in changes to the functionality to be included in each build.

The latest timescales are as follows:-

- Build C - delivered 21 October, 2002
- Build D1 - delivered 17 January, 2003
- Build D2 - delivered 3 February, 2003
- Build D3 - delivered 17 February, 2003
- Build E1 - 03 March, 2003
- Build E2 - 17 March, 2003 (fault correction only)

The flights defined below take into account the schedule changes, the time required for ground testing and functional verification, and the functionality contained in each build. The Boscombe flights have to be completed by 21 March, 2003 to allow the final assessment phase to take place in Rome during the last week in March. Financial and aircraft availability constraints prevent any slippage, resulting in a very demanding schedule for the Functional Checking and Assessment flights.

7.1 FUNCTIONAL CHECK FLIGHT 1

7.1.1 Introduction and Objectives

From previous experience with FMS flight trials, it is highly probable that the airborne environment will create problems not experienced during ground testing. The problems can arise from a variety of sources, including power supplies and earthing, interference, vibration, signal input/output characteristics and computer operating system/memory issues. These problems can be difficult to identify and time-consuming to rectify. It is therefore essential to fly the FMS as early as possible to give the maximum time for problem solving.
The objective of the first flight is to identify and record any problems with the basic operation (4D Trajectory Generation and Guidance) of the FMS + MCDU + Navigation Display, in an airborne environment.

7.1.2 Requirements & Support Equipment

Software Build C - 4D Trajectory Generation and Guidance (limited capability)
- Navigation Display with Lateral Arc and Rose Modes only
- Taxi Map

IHTP

7.1.3 Routing

The route will start as the full test route, with a SID from R/W 23 followed by a climb to Cruise FL. The pilot will edit the route to stay to the East of Airway A25, with left and right turns in the cruise followed by a descent to join the STAR for R/W 23. If the FMS is operating satisfactorily, the route will be repeated a second time.

7.1.4 Task Details

At the Gate - FMS Initialisation, Route selection, Trajectory Generation
During Taxiing - Taxi Map operation
After Take-off - Engage Autopilot and FMS Lateral at 500 feet in climb
- Engage FMS Vertical and Speed at 1000 feet in climb

Throughout Flight - Monitor 4D guidance relative to the trajectory
- Check MCDU operation
- Check Navigation Display (Lateral Arc and Rose Modes only)

At Cruise FL - modify route (through MCDU) and re-generate trajectory
During Descent - modify route and re-generate trajectory
ILS Established - insert original route and re-generate trajectory
During climb - modify route and re-generate trajectory
During Cruise - modify route and re-generate trajectory
During Descent - modify route and re-generate trajectory
After landing - Taxi Map operation

7.1.5 Flight Duration

Approximately 1hr 30 mins
7.2 FUNCTIONAL CHECK FLIGHT 2

7.2.1 Introduction and Objectives
This will be the first flight with a software build containing MA-AFAS functionality (Pass Behind) in addition to trajectory generation and guidance capability. Data Link communications will not be available.

7.2.2 Requirements & Support Equipment
Software Build D2
IHTP

7.2.3 Routing
A short route remaining to the East of Airway A25 will be used with Cruise at FL210. A Pass Behind manoeuvre will be executed during the descent phase using a simulated static target aircraft. If successful the route will be repeated a second time.

7.2.4 Task Details
Generate trajectory prior to take-off
Engage autopilot and stabilize speed, then engage FMS Lateral and Profile modes
Climb to FL210 for cruise at 260 knots
Select target and set up Pass Behind manoeuvre
During descent, generate Pass Behind at 5nm spacing. Execute manoeuvre, monitor spacing achieved and correct resumption of route at nominated waypoint.
Carry out manual GBAS approach at 3 degrees to R/W 23
Check Taxi Map on runway
Re-boot FMS for repeat of previous route, but this time with trajectory re-generation during the climb and a GBAS approach at 4.5 degrees

7.2.5 Flight Duration
Approximately 1 hour 20 mins
7.3 FUNCTIONAL CHECK FLIGHT 3

7.3.1 Introduction and Objectives
This will be the second flight with Software Build D2 (with rectification of faults found on the first flight, but the same MA-AFAS functionality). The VDL4 ground station will be available for communication checks (but CMU not connected to FMU).

7.3.2 Requirements & Support Equipment
Software Build D2
IHTP
VDL4 ground station
SBAS

7.3.3 Routing
Full initial assessment route with a sequence of Pass Behind manoeuvres using simulated dynamic target aircraft.

7.3.4 Task Details
Generate trajectory prior to take-off
Engage autopilot and stabilize speed, then engage FMS Lateral and Profile modes
Climb to FL240 for cruise at 260 knots
On each of the four designated legs, Select target and set up Pass Behind manoeuvre
Execute manoeuvre, monitor spacing achieved and correct resumption of route at nominated waypoint.
Carry out manual GBAS approach at 3 degrees to R/W 23
Check Taxi Map on runway
Throughout flight monitor VDL4 operation to establish whether two-way communication is available over the entire trials area.

7.3.5 Flight Duration
Approximately 2 hr 15 mins
7.4 FUNCTIONAL CHECK FLIGHT 4

7.4.1 Introduction and Objectives
This will be the first flight with Software Build D3, containing additional MA-AFAS functionality (Merge Behind).

7.4.2 Requirements & Support Equipment
Software Build D3
VDL4 ground station
IHTP
SBAS

7.4.3 Routing
Revised assessment route (maximum range = 135 nm)

7.4.4 Task Details
Generate trajectory prior to take-off (including SID for R/W 23)
Engage autopilot and stabilize speed, then engage FMS Lateral and Profile modes
Climb to FL240 for cruise at 260 knots
On each of the four designated legs, Select target and set up Pass Behind manoeuvre
Execute manoeuvre, monitor spacing achieved and correct resumption of route at nominated waypoint.
On both of the designated legs, Select target and set up Merge Behind manoeuvre
Execute manoeuvre, monitor spacing achieved at the Merge Point.
Carry out manual GBAS approach at 3 degrees to R/W 23
Check Taxi Map on runway
Throughout flight monitor VDL4 operation to establish whether two-way communication is available over the entire trials area.

7.4.5 Flight Duration
Approximately 2 hr 15 mins
7.5 FUNCTIONAL CHECK FLIGHT 5

7.5.1 Introduction and Objectives
This will be the second flight with Software Build D3 (with rectification of faults found on the first flight of D3, but the same MA-AFAS functionality). A new VDL4 airborne Transponder will be fitted (to provide increased range).

7.5.2 Requirements & Support Equipment
Software Build D3
VDL4 ground station
IHTP
SBAS

7.5.3 Routing
Revised assessment route

7.5.4 Task Details
Generate trajectory prior to take-off (including SID for R/W 23)
Engage autopilot and stabilize speed, then engage FMS Lateral and Profile modes
Climb to FL240 for cruise at 260 knots
On each of the four designated legs, Select target and set up Pass Behind manoeuvre
Execute manoeuvre, monitor spacing achieved and correct resumption of route at nominated waypoint.
On both of the designated legs, Select target and set up Merge Behind manoeuvre
Execute manoeuvre, monitor spacing achieved at the Merge Point.
Carry out manual GBAS approach at 3 degrees to R/W 23
Check Taxi Map on runway
Throughout flight monitor VDL4 operation to establish performance of the new transponder.

7.5.5 Flight Duration
Approximately 2 hours 30 mins
7.6 FUNCTIONAL CHECK FLIGHT 6

7.6.1 Introduction and Objectives
This will be the first flight with Software Build E1 with additional MA-AFAS functionality (Precision Approach and Departure, Change Spacing). The aircraft will be linked via Data Link to the ATC Simulator at Bretigny for ASAS Partial Delegation function testing.

7.6.2 Requirements & Support Equipment
Software Build E1
The VDL4 ground station
IHTP
AOC ground station
Taxi ground station
NATS GBAS ground system
SBAS
Escape ATC Simulator

7.6.3 Routing
Revised assessment route + Precision Approach and Departure routing

7.6.4 Task Details
Will be defined in accordance with the results of the previous flight

7.6.5 Flight Duration
Approximately 2 hours 30 mins
### 7.7 FUNCTIONAL CHECK FLIGHT 7

#### 7.7.1 Introduction and Objectives
This will be the first flight with Software Build E2 (with rectification of faults found on the first flight of E1, but the same MA-AFAS functionality).

#### 7.7.2 Requirements & Support Equipment
- Software Build E2
- The VDL4 ground station
- IHTP
- AOC ground station
- Taxi ground station
- NATS GBAS ground system
- SBAS
- Escape ATC Simulator

#### 7.7.3 Routing
- Revised assessment route + Precision Approach and Departure routing

#### 7.7.4 Task Details
- Will be defined in accordance with the results of the previous flight.

#### 7.7.5 Flight Duration
- Approximately 2 hours 20 mins
7.8 ASAS, 4D NAVIGATION, AOC AND TAXI ASSESSMENT FLIGHTS 1 TO 6

7.8.1 Introduction and Objectives
The assessment flight trials will demonstrate the system functioning in an operational mode for each theme. Each flight test will focus on the interaction between the themes and their performance in the intended environment.

7.8.2 Requirements & Support Equipment
Software Build E1/E2
The VDL4 ground station
AOC Ground Station
Taxi Ground Station
Escape ATC Simulator

7.8.3 Routing
Revised assessment route

7.8.4 Task Details
The following list details the activities, including data link communications, planned to take place during all Gate-to-Gate assessment flights.
Note: Pilot has to action the underlined communication items.

Pre-startup

- VDL4 Register (AOC) (ATC)
- Company Flight Plan uplink (AOC)
- FMS Meteo uplink (AOC)
- Load Sheet uplink (AOC)
- Loadsheet acknowledge downlink (AOC)
- Slot Allocation uplink (AOC)
- Request EOBT change downlink (ATC)
- Revised EOBT uplink (ATC)
- Request Route Clearance downlink (ATC)
- Cleared Route Clearance uplink (ATC)
- Non-active Trajectory downlink (AOC)
- OOOI (Out) downlink (AOC)
- Request Start-up Clearance downlink (ATC)
- Cleared Start-up uplink (ATC)

Pre-taxi

Select Taxi Map
Request Pushback Clearance downlink (ATC)
Cleared Pushback uplink (ATC)
Request Taxi To downlink (ATC)
Cleared Taxi To uplink (ATC)

Taxi route shown on Map

During Taxi
  Constraints List uplink (AOC)
  Pilot accept (Constraints List) downlink (AOC)
  Non-active Trajectory downlink (AOC)

Approaching Runway - Alert on Map

Pre-takeoff

Select Normal Map
  Line-up Runway uplink (ATC)
  Wilco downlink (ATC)
  Cleared Take-off uplink (ATC)
  Wilco downlink (ATC)

After Take-off
  OOOI (Off) downlink (AOC)
  Active Trajectory downlink (ATC)
  Flight Progress downlink - at regular intervals (AOC)

Uplink requests and Downlink replies for Engine Status Report and APU Report - as demanded by AOC (AOC)
SNAG Report downlinks - as sent by IHTP operator (AOC)

After SID (ends at KATE at FL50)
  Continue climb to FL240, CAS 250 Kts
    Trajectory Request uplink (AOC)
    Active Trajectory downlink (AOC)

On Leg KATE to X
  Request SIGMET downlink (AOC)
  SIGMET uplink (AOC)
  Aircraft Meteo Request uplink (AOC)
  Aircraft Meteo Response downlink (AOC)

On Leg X to B
  Aircraft Meteo Report downlink (AOC)

On Leg B to Y
**In Cruise** (at FL 240, CAS 260 kts)

Free Text downlink (AOC)

**On Leg Y to D**

Free Text uplink (AOC)

**On Leg D to E**

Select Target uplink (ATC)
Target Identified downlink (ATC)
Pass Behind Target uplink (ATC)
Wilco downlink (ATC)

**On Leg E to F**

*Generate Pass Behind Trajectory*

*Execute Pass Behind*

Request TAF downlink (AOC)
TAF uplink (AOC)

At F

Delegation Ended Normally downlink (ATC)

**On Leg F to G**

*Airway crossing at FL240*

Select Target uplink (ATC)
Target Identified downlink (ATC)
Pass Behind Target uplink (ATC)
Wilco downlink (ATC)

**On Leg G to H**

*Generate Pass Behind Trajectory*

*Execute Pass Behind*

Aircraft Meteo Request uplink (AOC)
Aircraft Meteo Report downlink (AOC)
Free Text uplink (AOC)
Free Text downlink (AOC)

At H

Delegation Ended Normally downlink (ATC)

**On Leg H to M**

Trajectory Request uplink (AOC)
Active Trajectory downlink (AOC)
Select Target uplink (ATC)
Target Identified downlink (ATC)
Pass Behind Target uplink (ATC)
Wilco downlink (ATC)

On Leg M to J

Generate Pass Behind Trajectory
Execute Pass Behind
Aircraft Meteo Request uplink (AOC)
Aircraft Meteo Report downlink (AOC)

At J
Delegation Ended Normally downlink (ATC)

On leg J to Z

Select Target uplink (ATC)
Target Identified downlink (ATC)
Pass Behind Target uplink (ATC)
Wilco downlink (ATC)
Free Text uplink (AOC)
Free Text downlink (AOC)

At Z
Delegation Ended Normally downlink (ATC)

On Leg Z to P

Select Target uplink (ATC)
Target Identified downlink (ATC)
Merge Behind Target (distance) uplink (ATC)
Wilco downlink (ATC)

On Leg P to Q

Generate Merge Behind Trajectory
Execute Merge Behind (gives Go Direct to R)
Request SIGMET downlink (AOC)
SIGMET uplink (AOC)
Aircraft Meteo Request uplink (AOC)
Aircraft Meteo Response downlink (AOC)

At R
Merge Behind Target – maintain spacing

On Leg R to H
Aircraft Meteo Report downlink (AOC)

On Leg H to S
Select Target uplink (ATC)
Target Identified downlink (ATC)
Merge Behind Target (distance) uplink (ATC)
Wilco downlink (ATC)

**On leg S to T**

*Generate Merge Behind Trajectory*

*Execute Merge Behind (gives Go Direct to Z)*

Request TAF downlink (AOC)
TAF uplink (AOC)
Free Text uplink (AOC)
Free Text downlink (AOC)

**At Z**

*Merge Behind Target – maintain spacing*

**On Leg Z to K**

Request METAR downlink (AOC)
METAR uplink (AOC)

**On Leg K to C**

*Airway crossing at FL240*

Trajectory Request uplink (AOC)
Active Trajectory downlink (AOC)

**On Leg C to A**

*After Top of Descent*

Change Spacing (time) uplink (ATC)
Wilco downlink (ATC)

*Generate Change Spacing trajectory*

*Execute Change Spacing*

**On Leg A to AGIBS**

Cancel Delegation uplink (ATC)
Cancelling Delegation downlink (ATC)

*Cancel Spacing Delegation*

**After STAR**

*GBAS approach R/W 23*

Cleared Land uplink (ATC)
Roger downlink (ATC)

**After Landing**
Select Taxi Map

- OOOI (On) downlink (AOC)
- Cleared Taxi To uplink (ATC)
- Wilco downlink (ATC)

Taxi route shown on Map

On Stand

- OOOI (In) downlink (AOC)

7.8.5 Flight Duration

Approximately 2 hours
7.9 PRECISION APPROACH AND DEPARTURE ASSESSMENT
FLIGHTS 1 TO 3

7.9.1 Introduction and Objectives
These flights will be conducted to assess the accuracy of precision approach and departure capability using SBAS and GBAS, particularly concerning characteristics when switching between SBAS and GBAS guidance.

7.9.2 Requirements & Support Equipment
Software Build E1/E2
NATS GBAS ground system
SBAS

7.9.3 Routing
Precision Approach and Departure routing

7.9.4 Task Details
TBD

7.9.5 Flight Duration
Approximately 2 hours 15 mins
8 DATA RECORDING

Data will be logged in the MA-AFAS FMS and CMU during all testing. In addition, the ESCAPE platform recordings and aircraft DAT data recording systems will be used whenever the aircraft is conducting the airborne tests.

8.1 AIRCRAFT PARAMETERS

The following ARINC 429 parameters will be recorded at an update rate of 10Hz with the resolution as defined by ARINC 429, on the DAT recording system:

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<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTC</td>
<td>GNSS</td>
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<td>Latitude</td>
<td>GNSS</td>
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<tr>
<td>Longitude</td>
<td>GNSS</td>
</tr>
<tr>
<td>Barometric Altitude</td>
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<td>DADC</td>
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<td>DADC</td>
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<td>IRS</td>
</tr>
<tr>
<td>Magnetic Track</td>
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<tr>
<td>Magnetic Heading</td>
<td>IRS</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>IRS</td>
</tr>
<tr>
<td>Wind Angle</td>
<td>IRS</td>
</tr>
</tbody>
</table>

8.2 FMS PARAMETERS

The following parameters will be recorded at the start of each run or whenever they change:

Software configuration

8.3 NON ATN CMU PARAMETERS

The following parameters will be recorded at the start of each run or whenever they change:

Software configuration

The following parameters will be recorded and time stamped with UTC at a resolution of 0.1 seconds by the CMU:

Message content
Message number
Retry message number
8.4 ATN CMU PARAMETERS
The following parameters will be recorded at the start of each run or whenever they change:-
   Software configuration
   Timer settings
The following parameters will be recorded and time stamped with UTC at a resolution of 0.1 seconds by the CMU:-
   Message content
   Message number
   Retry message number

8.5 ESCAPE PLATFORM DATA
The following parameters will be recorded at the start of each run or whenever they change:-
   Software configuration
The following data will be recorded and time stamped with UTC at a resolution of 0.1 seconds by the ESCAPE ground platform:-
   Received message content
   Received message number
   Received LACK message number
   Transmitted message content
   Transmitted message number
   Transmitted LACK message number

8.6 DATA LINK DATA
The following parameters will be recorded at the start of each run or whenever they change:-
   Software configuration

8.7 SBAS/GBAS DATA
SBAS and GBAS Position, Velocity and Time data will be logged throughout the time the aircraft is flying a SID, STAR and Precision Approach.
9 TIMESCALES

9.1 SOFTWARE DELIVERY

Before delivery to Boscombe each software build will be thoroughly tested in the laboratory to prove that each MA-AFAS function is operating correctly as far as can be established on the ground. The following timescales are based on estimates of the time needed for the lab testing.

**BUILD C**
- Delivery to Boscombe: 9 Dec, 02
- Ground tests with BAC 1-11: 9 Dec, 02 - 10 Jan, 03 (4 weeks)

**BUILD D1**
- Delivery to Boscombe: 17 Jan, 03
- Ground tests with BAC 1-11: 20 - 31 Jan, 03 (10 working days)

**BUILD D2**
- Delivery to Boscombe: 3 Feb, 03
- Ground tests with BAC 1-11: 3 - 14 Feb, 03 (10 working days)

**BUILD D3**
- Delivery to Boscombe: 17 Feb, 03
- Ground tests with BAC 1-11: 17 - 24 Feb, 03 (6 working days)

**BUILD E1**
- Delivery to Boscombe: 3 March, 03
- Ground tests with BAC 1-11: 3 – 6 March, 03 (4 working days)

**BUILD E2**
- Delivery to Boscombe: 17 March, 03
- Ground tests with BAC 1-11: 17/18 March, 03 (fault corrections only)

9.2 TEST FLIGHTS

<table>
<thead>
<tr>
<th>1st</th>
<th>Build C</th>
<th>14th Jan, 03</th>
<th>Completed</th>
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</thead>
<tbody>
<tr>
<td>2nd</td>
<td>Build D2</td>
<td>7th Feb, 03</td>
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<tr>
<td>3rd</td>
<td>Build D2</td>
<td>19th Feb, 03</td>
<td>Completed</td>
</tr>
<tr>
<td>4th</td>
<td>Build D3</td>
<td>27th Feb, 03</td>
<td>Completed</td>
</tr>
<tr>
<td>5th</td>
<td>Build D3</td>
<td>28 Feb – 6 Mar, 03</td>
<td>(5 working days)</td>
</tr>
</tbody>
</table>
9.3 ASSESSMENT FLIGHTS

Precision Approach and Departure

1\textsuperscript{st} to 3\textsuperscript{rd} Build E1/E2 10 - 21 Mar, 03 \}

Gate-to-Gate \}

4\textsuperscript{th} to 9\textsuperscript{th} Build E1/E2 10 - 21 Mar, 03 \}

9.4 BOSCOMBE FLIGHT TIME ALLOCATION

Test Flights \ - 7 \ = \ 13:15 \ hours

Gate-to-Gate Assessment Flights \ - 6 \ @ \ 2:00 \ = \ 12:00 \ hours

Precision Approach Flights \ - 3 \ @ \ 2:15 \ = \ 6:45 \ hours

\hline

TOTAL Boscombe Flight Time \ = \ 32:00 \ hours

The above allocation of dates, number of flights and flight times are the best that can be made at this time, based on planned software delivery times and estimated times for ground testing and fault correction. Obviously, it is impossible to forecast the quantity and nature of problems that may be experienced with each software Build, or the amount of time required to identify and fix each problem. Therefore it will be essential to continuously review the planned schedule with respect to available functionality, calendar time remaining and flight hours remaining.

Total flight time at Boscombe Down is planned to be 32 hours, and therefore any increase in the amount of Test flying required will result in an equal reduction in Assessment flying. However, should more than 32 hours be required to get sufficient functions operational for the Rome trials, then the amount of flying in Rome will have to be reduced accordingly. (Total BAC 1-11 flight time for MA-AFAS Project = 50 hours, including transit to/from Rome).