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

D47 – Transition Plan for the Evolution of Standards

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1 INTRODUCTION

1.1 Background

The civil avionics market is in the early stages of major revolution, which is being driven by the growth of civil air traffic (5% in time of recession, 8% in 1998). This growth is pushing present Air Traffic Management (ATM) systems to breaking point. Within Europe the situation can be characterised by long delays for passengers, inefficient routing for operators and unacceptable stress for controllers.

The More Autonomous Aircraft in the Future ATM System (MA-AFAS) programme aims to transform European research results into practical operational ATM procedures with the potential to radically improve the European ATM scenario in the near term (from 2005). By selecting and validating key airborne elements of Communications, Navigation and Surveillance (CNS) and defining their economic benefits and certification requirements, the research will enable more autonomous aircraft operation in the European ATM system.

The improvements must be capable of being applied to existing aircraft, so the project focuses on the ATM solution required for aircraft retrofit. The project is divided into four main Work Packages (WPs). WP1 defines the future ATM and ground requirements, ground infrastructure and operational scenarios, which will be used as a baseline. WP2 designs and develops the retrofit avionics solution to meet this baseline, which will be validated in WP3 within representative future ATM environments. Finally, WP4 identifies the steps required to transition from the trials demonstration of the avionics package to in-service pre-operational validation, by providing cost benefit analysis, operational procedures, new and modified standards and implementation and certification plans.

Annex 1 (ref.1) to the More Autonomous-Aircraft in the Future ATM System (MA-AFAS) contract shows that the aim of WP4 of the program is to identify the steps required to transition from the trials demonstration of an avionics package to pre-operational validation. Development of appropriate standardisation/regulatory material for new equipment, including both technical and operational aspects, is essential for this transition to occur, and foster user buy-in.

This document has been produced as deliverable D47, intended to identify a transition plan for the evolution of standards based on the earlier identification of standards activities relevant to MA-AFAS. It is the second deliverable (of two) from work package 4.2.2, the objective of which is to progress technical standards development (including spectrum allocation), and to define a plan for longer-term work towards new standards. This latter work will help to enable the transition from the current Air Traffic Control (ATC) system to that envisaged in the MA-AFAS operational concept.

This document is the deliverable for the second phase of work. It identifies the issues constraining the development of MA-AFAS systems (e.g. lack of standards, spectrum issues and transition Issues) and makes recommendations on the future way forward, giving suggested future work items required to solve issues arising.

This work will thus allow a Transition Plan to be prepared which will identify the strategy required to implement the new CNS / ATM requirements as addressed by MA-AFAS. This plan will then be available for review by ICAO with the aim of gaining their endorsement of it.

This work towards a Transition Plan must be in-line with other projects and predicted ATM environment.0

Milestones and criteria

Definable, achievable milestones will be developed as part of a phased approach, giving suitable cost benefit and/or cost incentives at each stage. This will allow the production of standards that will allow integration of the MA-AFAS avionics packages into the CNS / ATM environment together with their initial acceptance by the appropriate standards bodies and endorsement of the proposed transition by ICAO.

1.2 Scope

This document has been produced as Deliverable D47 to satisfy the requirements of Work Package 4.2.2. The objective of WP 4.2.2 is to generate a plan for the evolution of standards.

The More Autonomous Aircraft in the Future Air Traffic Management (ATM) System (MA-AFAS) project encompasses a number of themes, all of which require standardisation work. Although some support has been received on other aspects from other partners, this document has been produced from the air traffic service provider's (ATSP's) viewpoint. Due to the vast amount of work underway on ATM standards, the scope has been restricted, and thus does not address all aspects of MA-AFAS. Of the MA-AFAS themes, Precision Approach (PA) is addressed in the most depth.

Using the status of the spectrum issues for each theme given in D46, this report will state the actions that need to be done to permit transition to the MA-AFAS environment. This work will be done from an ATSP's perspective, but will include airborne equipage issues where possible.

This document serves as an input to the Transition Plan, which points out the specific standards, (i.e. additional standards or those derived from current international standards) necessary for MA-AFAS operational use. It also proposes a strategy in order to implement the new CNS/ATM requirements addressed by MA-AFAS.

Based on the previous identification of standards, this document identifies committees and working groups within standards bodies relevant to MA-AFAS, in which new/modified standards are required.

Neither legislative nor cost-benefit issues will be included.

Output of the ETSI standards body has not been considered.

From D15 Airworthiness Plan, for transition to MA-AFAS, aircraft systems will need to be certified. A plan for certification (D..) has been produced as part of Work Package. That document lists the certification standards applicable to MA-AFAS. Certification and Airworthiness Approval (regulatory authorities) are not considered by this report.

1.3 Document Overview

1.3.1 Objectives

Changes and new standards required to support the introduction of MA-AFAS-like avionics packages into operational use within the future ATM environment will be suggested. These standards shall be developed, with reference to standards bodies (such as ARINC, RTCA, ICAO), under this work package and proposed to the appropriate authorities (e.g. JAA, EUROCONTROL) for adoption.

This document aims to meet the MA-AFAS milestone intended to develop user buy-in. This is part of the establishment of a safe strategy implementation, based on economic benefit, standards, and world-wide agreement.

It aims to consider the further requirements for standards for both services and technologies.

1.3.2 How the Report is Organised

Firstly, there is a description of the MA-AFAS package, breaking it down into services and technologies per Theme.

Further to the review of selected Working Group activities included in D46 Identification (and Modifications to Existing) Standards, this document develops the transition plan for the evolution of standards by assessing recent activities of selected WGs, and makes suggestions for further work. This is done in the context of the services and technologies per Theme, with the emphasis on Precision Approach and Communications.

1.4 Description of Work

This document is the second deliverable of work package 4.2.2, the aim of which is to propose a transition plan for the evolution standards.

It is envisaged that the standards to be proposed will be:

- ICAO Standards and Recommended Practises (SARPs) and Procedures for Air Navigation Services (PANS)
- EUROCAE/RTCA Minimum Operational Performance Standards (MOPS)
- RTCA Minimum Aviation System Performance Standards (MASPS)
- ARINC equipment standards
- Airworthiness requirements and standards
- Other certification requirements
- International Telecommunications Union (ITU) decisions on spectrum allocation and management

The transition plan for the evolution of standards was done primarily for navigation, and addressed from an ATSP's perspective, and those communications and surveillance standards bodies attended by the partners involved.

This work may be used to form part of any overall Transition Plan detailing how adoption of MA-AFAS autonomous operation concepts will take place. Such an overall Transition Plan (which may involve safety, training, procedures etc.) is outside the scope of this work package.

2 MA-AFAS SYSTEM DESCRIPTION

2.1 System Description

The MA-AFAS programme is focused on the ATM solution required for aircraft retrofit with the system design being based on a core ARINC 702A standard Flight Management System (FMS). 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 Global Navigation Satellite Systems (GNSS) with ground and space based augmentation for enhancing approach procedures under 4D flight-path control.
- Automatic Dependent Surveillance – Broadcast (ADS-B) (using VDL Mode 4) with Cockpit Display of Traffic Information (CDTI) and Airborne Separation Assurance System (ASAS).
- Integration of an on-board taxiway map and data linked clearances.
- Support for the Airline Operational Centres (AOC) 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 AOC and ATC communications using ODIAC defined standards.

In order to meet these enhanced capabilities, it is expected that the following aircraft equipment will be affected:

- Flight Management System (FMS).
- Communication Management Unit (CMU).

The MA-AFAS Ground System (here also referred to as MA-AFAS Ground Platform) is the ATM ground counterpart of the airborne system designed and implemented by MA-AFAS. It should enable the testing and validation of the new avionic functions providing the peer functions on the ground.

The analysis of the requirements has led to the inclusion of the following high-level functions (or functional areas according to the FARADEX terminology) in the MA-AFAS Ground Platform:

- Capacity and Flow Management.

On the basis of airspace demand and capacity planning, this functional area develops the Daily Operational Plan (DOP). It is updated for any event that can change the demand or capacity and is presented to the ATS providers and other users the day before operations. In part, this corresponds to the function presently performed by the CFMU for the ECAC airspace.

- Air Traffic Services (ATS).

This includes ATC services in all phases of flight (en-route, approach, departure, landing, surface movement), Flight Information Services (FIS) and Traffic Information Service (TIS). In the MA-AFAS scope, these services are provided without interacting with the operational ATS (shadow mode).

- CNS infrastructure.

This function includes the Communication, Navigation and Surveillance capabilities that transport information throughout the whole system. The MA-AFAS CNS infrastructure is widely based on the use of digital communications, satellite-based navigation and ADS-B based surveillance. Nevertheless, traditional infrastructures (radar, voice communications) are also exploited.

- Data Management.

The main aspect of this functional area is the process of retrieving and combining data in order to produce, in real-time, the current and the future Air Traffic Situation (Surveillance Data Processing and Flight Data Processing). Archiving capabilities also support off-line data analysis.

- Airline Operations Centre.

This refers to the aircraft operator participation in co-ordinating the initial flight planning and in-flight re-planning with the ATS. In the MA-AFAS scope, AOC functions are closely linked to ATS due to the involvement of the airline in the 4-D flight plan negotiation.

- Support Functions.

This area includes the functions that are required to enable the whole platform to be used as a validation platform for the objectives of the project (simulation functions, playback functions, platform management functions, evaluation functions, and so on).

Although the following functional areas exchange information with the system, they fall outside the scope of the MA-AFAS ground platform:

a) Airspace Management.

ATM is concerned with the definition of the Airspace and the Route Network structure (including areas of Free Routing / Free Flight).

b) Weather Service Provider.

This is the source of aviation weather information for all parties dealing with flight planning and flight operations. The Weather Service Provider will provide various weather forecasts, but may also use weather data down linked from a/c to produce ‘nowcasts’ which can then be provided to the ground platform.

2.2 Interface Descriptions

The external interfaces are assumed to include interfaces between aircraft equipment and ground equipment, and also aircraft to aircraft communications links.

2.2.1 ATN Communications

- The ATN communications interface shall be compliant with ATN SARPS ICAO 9705/2.

2.2.2 VDL Mode 2

- The aircraft equipment shall support the reception and transmission of ATN messages through VDL Mode 2 link.

2.2.3 VDL Mode 4

- The aircraft equipment shall support the reception and transmission of ATN messages through VDL Mode 4 link.

2.2.4 Ground Communications Infrastructure

- The ground equipment shall support the reception and transmission of ATN messages through either a VDL4 or a VDL2 link.

2.2.5 SATCOM

- The aircraft equipment shall support the reception and transmission of ATN messages through a satellite communications link.

- The ground equipment shall support the reception and transmission of ATN messages through a satellite communications link.

2.2.6 ATN Services

- The Generic ATN Communication Service (GACS) allows a user of this service to transfer data transparently across the ATN to one or more other users.

- It is assumed that the AOC will interface with the ATN upper layer (GACS API) in order to communicate information to the aircraft equipment or receive information from the aircraft.

2.2.7 CPDLC

- Controller Pilot Data Link Communications (CPDLC) is a means of communication between Controller and pilot using data link for ATC communication.

- The CPDLC capabilities of the ground and aircraft equipment shall be compliant with ODIAC AGC-ORD-01.

- CPDLC shall implement extensions of ATN SARPS ICAO 9705/2 CPDLC services where required to support FLIPCY, DYNAV and Taxi management operational functions.

- The CPDLC capability shall implement a subset of ATN SARPS ICAO 9705/2 CPDLC services sufficient to meet the MA-AFAS requirements.

2.2.8 FIS

- The Flight Information Service (FIS) provides a means of supplying advice and flight information (e.g. ATIS and meteorological information) to the pilot.

- The Data Link Flight Information Services (FIS) shall be compliant with ODIAC AGD-ORD-01

- FIS shall implement a subset of ATN SARPS ICAO 9705/2 FIS services sufficient to perform the scenarios defined for MA-AFAS.

2.2.9 ADS-C

- ADS-C supports a surveillance technique for use by air traffic services in which aircraft automatically transmit information derived from the on-board aircraft systems about he aircraft position, speed and heading to the ATC.

- The aircraft equipment shall implement all ATN SARPS ICAO 9705/2 ADS-C services.

- The ground equipment shall implement all ATN SARPS ICAO 9705/2 ADS-C services.

2.2.10 URCO

- The Urgent Communication Service (URCO) provides a mechanism for exchanging urgent messages with aircraft that are not yet under ATSU control.

- The aircraft equipment aircraft shall be capable of receiving urgent communications from ATC through a VDL mode 4 link.

- The ground equipment aircraft shall be capable of transmitting urgent communications from ATC through a VDL mode 4 link to the aircraft.

2.3 MA-AFAS Services and Technologies per Theme

2.3.1 Introduction

This section identifies from the above the MA-AFAS Systems and technologies for which a transition plan needs to be developed.

2.3.2 Precision Approach

This section only considers the technology, as the service to be provided by SBAS/GBAS has already been standardised.

2.3.2.1 SBAS

Standardisation efforts will be required to enable the proposed MA-AFAS applications for both

- Airborne
- Ground

2.3.2.2 GBAS

Standardisation efforts will be required to enable the proposed MA-AFAS applications for both

- Airborne
- Ground

2.3.2.3 Procedure Design

Standards are required to be developed in order to fully exploit the satellite technologies.

2.3.3 4D

Evaluation of airborne 4D trajectory generation and guidance, including negotiation of the flight path with the Air Traffic Control (ATC), requires a data link. Thus standardisation of the datalink, and the parameters to download, is required.

2.3.4 ASAS

2.3.4.1 Introduction

This section discusses the technology and applications for CDTI/ASAS that may require standards development. This project chose to adopt the VDL4 datalink for ADS-B.

2.3.4.2 Datalink for ADS-B

2.3.4.2.1 Airborne and Ground

The VDL-4 airborne and ground technology is mature, with a number of manufacturers able to make equipment to a common standard.

2.3.4.3 CDTI

Efforts to standardise CDTI are required.

2.3.5 Taxi Management

Taxi Management Theme is intended to validate taxi maps, and thus standards are required for the mapping database and presentation of the map. It also aims to validate datalinked clearances, and so requires a standardised datalink.

2.3.6 AOC

The AOC Theme aims to validate the support available for maintenance and fleet management. It is likely that the data to be transmitted will depend upon the requirements of each operator, and thus not require standardisation. However, a datalink will be required. This may need to be standardised.

2.3.7 Communications

2.3.7.1 ATN Technology

Standardisation development work has been performed for the ATN technology and services. A common underlying theme for many of the MA-AFAS themes is the need for communications, i.e. a datalink. Due to the many aircraft operators and ground service providers, a great deal of effort is required in order that a datalink can be standardised, in order to gain the benefits of standardisation, especially global interoperability.

2.3.7.2 ATN Services

The services of interest are: GACS, CPDLC, FIS. ADS-C, URCO.

3 PRECISION APPROACH

3.1 Introduction

This section looks at the transition from the current existing precision approach systems and methods to those (SBAS and GBAS) that permitted the procedures that are intended to be validated by the MA-AFAS trials.

In particular, it details the current status of efforts made to introduce curved approaches, and in view of the operational requirements, the likely transition to them. In order to keep the MA-AFAS applications in context, the general transition to satellite navigation and area navigation (RNAV) is discussed.

In order to transition to SBAS/GBAS, a concept of operations is required. That proposed by EUROCONTROL is discussed.

In order to examine the transition to a future precision approach environment consisting of SBAS and GBAS, EUROCONTROL have set up a task force. The results of this task force are discussed in the context of the MA-AFAS program.

WAAS is expected to be available for aviation operations in mid-late 2003, but there still seems to be uncertainty in the way in which SBAS and GBAS operations will relate. SBAS could be used by some European operators in areas where lesser infrastructure is available. Greater precision and lower minima could prove beneficial, particularly when the alarm limits could be reduced to take account of current GPS capability and also the additional robustness when Galileo becomes available. Issues concerning common mode failures, and costs, remain to be resolved.

Databases are critical for SBAS/GBAS, and are also significant for APV. GBAS avoids some of the processing steps. Improving SBAS integrity does not necessarily ensure overall system integrity. When operating parallel approaches there may be a need to use independent systems.

Therefore, transition requires a number of new questions to be resolved, for instance regarding terms of operations and the handling of different capabilities.

3.2 Transition

3.2.1 Existing Systems

Precision approach (PA) is almost exclusively performed using the standardised Instrument Landing System (ILS). This system provides two guidance VHF beams, one to enable glideslope deviation to be calculated, and another to allow azimuth deviations to be calculated on board the aircraft. The glideslope is usually set at a 3 degree angle, and the beam is usually intercepted at around 10 nm from touchdown. This means that a procedure designed to use ILS usually has a 10 nautical mile straight leg before touchdown. PA procedures are divided into three classifications, with Category 1 permitting approaches with a decision height down to a minimum of 250 feet, whilst category 3c is complete autoland. Only those airports regularly affected by poor visibility have purchased and maintain category 3 systems.

In the 1970s the Microwave Landing System (MLS) was developed in order to overcome shortcomings with ILS. Development was halted with the advent of satellite systems. However, standards are in place to allow the design of ground and airborne components. Only a handful are currently in operation.

In addition there are many non-precision approach (NPA) procedures in use. With these, the supporting landing systems do not provide any glideslope information, and so the procedure steps down in height until the minimum descent height is reached, at which the aircraft is permitted to land if the airfield is in site, or else go around. It is widely acknowledged that NPA procedures carry more risk than PA procedures.

3.2.2 Future Systems

Whilst some NPA procedures are permitted using unaugmented GPS, it is acknowledged that PA procedures must be supported by an augmented GPS (or other satellite systems as they become available). Of the two proposed, SBAS provides wide area augmentation and thus provides a limited precision approach capability. It is envisaged that SBAS will provide a capability almost equivalent to ILS Category 1.

GBAS has been specifically designed as an ILS replacement, and thus initial systems will be able to provide an equivalent service to a category 1 ILS, with future systems capable of providing category 3. Some development is required in order to achieve this more stringent requirement.

3.2.3 FAA’s Transition Strategy

The FAA’s new navigation and transition strategy road map is as follows:

Summer 2002: Department of Transport (DoT) Position/Navigation Task Force completes the multi-modal navigation capability assessment.

October/November 2002: GPS Outage en-route simulation (GOERS).

December 2002: DoT Pos/Nav task force recommendations on navigation mix to the Secretary.

December 2002: Secretary’s decision on LORAN continuance 2003/2008 Phase I LORAN upgrade.

Summer 2003: GPS Outage Terminal Simulation (GOTS)

December 2003: Commissioning of WAAS with LNAV?VNAV approaches

March 2004: GPS/WAAS LPV approaches

March 2005: GPS/LAAS first production unit commissioned

2005: Block IIF and IIR launches begin with L5 (no increased power) – IOC (18 satellites) by 2013 (includes GPS III)

2005: Notice of proposed rulemaking for redundancy and backup of Class A airspace

2005: Third WAAS Communications Satellite

2007: Final Rule on Class A airspace

2007: Begin replacing VORs that are to be retained as part of the minimum operating network – continues through 2012

2008: First GPS III satellite launch – continues through 2019 – carries higher power L5 – IOC (18 satellites) by 2013 to 2016

2010: begin phase II of LORAN modernisation – continues through 2015

2010: begin reduction of ILS Cat I infrastructure – retaining at least one ILS at airports supporting the backup strategy

2010: Begin removing VORs not part of the minimum operating network

2014: Victor Airways and Jet Routes phased out

2015: ILS Cat II/III at end of service life

3.2.4 EUROCONTROL's Transition Strategy

Two separate EUROCONTROL entities consider satellite navigation, the GNSS group at the Experimental Centre, and Airspace Management and Navigation (AMN) at HQ.

For the GNSS group, research is under way into GNSS Sole Means, with a study having recently been completed. The GNSS group has also developed a GBAS Roadmap (ref. 18), which has been presented to the ICAO GNSSP.

AMN has stated its plans for transition to GNSS in its Navigation Strategy (ref. 12), and TPINS (ref. 13). The Strategy foresees the gradual implementation of SBAS and GBAS. AMN also runs the Navigation Sub Group (NSG), Terminal Airspace Applications (TARA). The E Precision Approach and Landing (EPAL) task force has also recently been formed.

3.3 Capabilities of Future Systems

3.3.1 Introduction

SBAS and GBAS are both RNAV systems that provide height information, and thus potentially able to support the capability of interest to this project, curved approaches.

3.3.2 Curved Approaches

The main aim of the PA Theme was to validate curved approaches and departures. It is believed that curved approaches and departures may

In order to enable their use, there will need to be a transition from current straight-line to curved approaches and departures. Ref. 17 shows what is possible with curved approaches.

The EUROCONTROL Navigation domain was asked by AWOG to investigate curved approaches and to consider potential requirements in relation to environment, terrain, conditions etc. This study considered how there the approach could be implemented, especially how the transition from the current systems to the future planned approaches could occur. MMRs are not configured for such approaches but RNAV could come close to Cat I.

Ref. 15 (as presented to 9th Meeting of the All Weather Operations Group (AWOG/09) Paris, September 2002) Reviews the current operational requirements and technical issues for curved and segmented approaches, and identifies work that needs to be done to establish whether there remains a potential for developing cost-effective curved and segmented approach capability in European airspace.

The operational requirements have been considered for many years, and they were among the operational requirements that identified the need of area coverage of MLS.

3.3.3 Operational Requirements

Ref. 15 gives the operational requirements for curved or segmented approaches. Most of the requirements have been considered for many years, and were among the requirements that led to definition of the need for area coverage for MLS. However, the implementation of MLS identified the difficulty in realising as cost –effective transition.

The operational drivers for curved and segmented approaches are:

- Environmental
- Terrain
- Capacity

3.3.3.1Environmental

Environmental issues are becoming increasingly important, with the main issue being noise. Curved approaches offer the benefit of noise preferential approaches, with a further benefit being that a non-straight in approach may reduce the track miles to be flown and therefore emissions will be reduced.

Both of the above issues are specific to a particular airport and its arrival route structure, but there can be significant benefits

In some cases, the reduction in noise could allow airport capacity to be increased, where arrival rates, or hours of opening, can be constrained by noise limits.

The use of such approaches would, for maximum benefit, need to be combined with the application of continuous descent approaches. Through the planning of the descent profile, it is possible to reduce level flight segments and flight profile changes to a minimum to reduce noise and fuel burn.

3.3.3.2Terrain

Terrain in the vicinity of airports presents a constraint of providing straight in approaches. ILS installations can sometimes overcome this by using an offset approach, but the minimums allowed for such approaches could be reduced if the final segment was aligned with the runway.

However, the approach minima in terrain-rich environments are often constrained by terrain in the missed approach area rather than the approach. This is due to the fact that there is, for conventional approaches, less accurate lateral guidance in the missed approach area. The provision of back azimuth might therefore be an important consideration in the application of segmented or curved final approaches.

3.3.3.3Capacity

The present ILS approach forces all aircraft to fly a common track to the runway from 8-9 miles out from threshold. Due to the range in aircraft speeds, the minimum radar separation at the start of the approach could be a limiting factor where a slow aircraft is following a fast one. Thus there may be potential to minimise separation.

The ability to make use of the curved or segmented approach to maximise the capacity will depend on the minimum straight-in segment that can be accepted in order to ensure that the aircraft is stabilised sufficiently before decision altitude/height.

Regarding technology limitations, curved approaches require navigation systems that give very high performance in both lateral and vertical planes. The MA_AFAS flight trials have further shown that this high level of performance can be achieved by SBAS and GBAS.

The cost benefit case for curved approaches is particularly complex.

In order to ensure a clear road map for future approach systems and to ensure that the requisite frequencies were available for implementation (particularly spectrum support to WRC2003). The EPAL – European Transition Strategy and prepare a business case to support the approach. EPAL was to supplement and not duplicate the work of AWOG, and it identified 32 areas where work did not appear to have been addressed.

3.3.4 Transition to Curved Approaches

To enable transition, a number of issues will need to be resolved, including:

- Operational requirements
- Technology Limitations
- Cost/Benefit
- Other areas
- Safety

The operational requirements are discussed above.

Regarding technology limitations, it can be seen that both SBAS and GBAS can potentially support curved approaches, although some modifications to equipment (and therefore standards for the equipment) are required.

One reason why the technology limitations still exist is that there has yet to be a cost beneficial case put forward.

Other areas:

Safety: EUROCONTROL have performed a hazard identification to identify and prioritise potential hazards, and determine their significance and means of mitigation.

This safety work is expected to be complete by April 2003.

3.4 SBAS update

Much of the current work is associated with the EGNOS test bed, which incorporates a number of remote monitoring sites,

It was the ESTB that was used in the MA-AFAS flight trials. Curved and missed approach paths.

3.4.1 SBAS Concept of Operations

EUROCONTROL have recently completed a concept of operations document, which covered the use of EGNOS and how it could be certified, and the application of the capabilities provided by EGNOS.

A set of standards including DO208 and TSO c129a cover some operations and extended by DO229c and TSOs 145 and 146. Various categories of receivers have been specified, but manufacturers appear unwilling to commit to a product line before the market is assured.

Procedure design is being addressed through OCP, which is issuing criteria presently based on specific equipment fits. However, there needs to be a move to an RNP-based criteria.

Some of the GPS criteria (alarm levels etc.) currently applied to SBAS may be too conservative and this is being addressed in a new TSO. Design criteria for APV approaches need to be addressed and there is a need to identify SBAS advantages over other means of meeting LNAV/VNAV.

A further problem is the continuously moving standards. These have been called IPV, then APV with APV 1 and APV II introduced. The FAA proposed APV1.5 and now LPV, all of which are being defined to maximise the anticipated WAAS capability.

In the short term, SBAS is expected to be able to support a number of applications but nor to Cat I. Certain RNAV functionality is missing from the current SBAS standards, including FA legs, RNP holds, some alerts and fixed radius turns. In the medium term, APV is expected to bring some operational benefits.

With respect to service provision, TGL 10 assumes that ATS providers monitor the system, including GPS Notice to NAVSTAR Users (NANUs), and should there be an unexpected outage of Receiver Autonomous Integrity Monitoring (RAIM), fall back on conventional procedures. SBAS provides an independent monitor, although without a local monitor station it cannot warn of local effects such as multipath or interference.

The required actions are to agree an operational concept for SBAS, demonstrate its benefit to users, and to address the outstanding functional issues, design criteria, and support environment.

Standardisation efforts will be required to enable the proposed MA-AFAS applications for both

- Airborne
- Ground

3.5 GBAS update

Standardisation efforts will be required to enable the proposed MA-AFAS applications for both

- Airborne
- Ground

Implementation of ground stations in Europe is not likely to be funded centrally as per the US. Installation will be based on the cost benefit merits of each ground station. The EPAL can not do this for each individual airport, and so it will develop material to define the approach.

3.5.1 GBAS Concept of Operations

Work is currently ongoing in defining the GBAS concept of operations.

3.5.2 Transition to GBAS CAT I

3.5.2.1Introduction

Standards are agreed for GBAS for Cat I precision approach, based on the ILS look-alike approach.

3.5.2.2Ground Systems

A contract has been let to Honeywell by the FAA in the US to manufacture LAAS (GBAS) ground stations. These will then be installed at airports around the US.

EUROCONTROL has set up a Monitor Station and Analysis Research System

3.5.2.3Airborne Systems

Airbus is seeking to gain approval for 3 different MMRs, but it has no TGL against which to test them.

Airlines have suggested that Flight Technical Error (FTE) is the dominant factor in performance rather than the system itself. Airlines are particularly interested in Cat II/III operations, surface movement, and parallel approaches.

3.5.3 EUROCONTROL Transition Efforts

3.5.3.1 Operational Validation

The GNSS group is developing the MARS tool to support the operational validation of ground stations, and their certification.

3.5.3.2 EPAL

At its 27th Meeting, the EUROCONTROL Airspace and Navigation Team (ANT) noted the lack of a mature plan for the transition to a future All Weather Operations Landing System (ILS and/or MLS and/or GLS). It was agreed that this would make it difficult to defend the continued provision and protection of the necessary radio frequencies at the ITU and WRC meetings in 2003, and would lead to uncertainty on the part of service providers and airspace users on their future equipage requirements.

The ANT agreed that there was a need to identify a viable transition plan for Low Visibility Guidance Aids and that this task should be addressed by the Navigation Programme.

In order to meet this directive, the Navigation Programme established the All Weather Operations Task Force (AWOT). The Task Force was made up of Experts that could provide the necessary highly specialised inputs on these issues, and that would represent the interests and views of all the Stakeholders within the ECAC aviation community. The Task Force was directed to work in close co-operation with AOT and ICAO and to take full account, and avoid any duplication, of the work of the All Weather Operations Group (AWOG) of the EANPG.

The objectives of the Task Force were to:

- Identify the options available
- Identify the associated operational issues and financial implications
- Develop a detailed plan for the transition to a future infrastructure for Approach and Landing, in line with Implementation Project No.9 – Provision and Maintenance of All Weather Operation Capability (NPA and CAT I/II/III PA) at Airports, of the Transition Plan for the Implementation of the Navigation Strategy (TPINS).
- Make recommendations to the ANT on the action to be taken to protect Aviation requirements at the ITU and WRC meetings in 2003.

Cost benefit task amended to: Identify the potential for, and develop the specification, of a Business Case for the ILS/MLS/GLS transition"

3.5.3.3EPAL Work Program

The work program for the EPAL task force is divided into a number of work packages. Those most relevant to this project are discussed below:

WP12 Transition Plan For Precision Approach and Landing Aid

The objective of this work package is to propose a detailed planning for the most efficient and advantageous means of transitioning to the future ECAC Precision and Landing System. The output of this work package will be used to revise/update if necessary the ECAC Transition Plan for the Implementation of the Navigation Strategy (TPINS) (ref. 13) – Implementation Action N° 9 – Provision and Maintenance of AWO Capability.

It will provide the following deliverables:

- Business case for the precision approach and landing aids
- Feasibility studies for ILS, MLS, GLS and mix of infrastructures
- Recommendations for the ECAC Transition Plan for the Implementation of the Navigation Strategy (TPINS) – Implementation Action N° 9 – Provision and Maintenance of AWO Capability.

It will use the following as source material:

- EGNOS Multi-Modal Costs and benefits. A study of the aviation case in ECAC, Nov 1999.
- The Development of a Final Approach Transition Plan EUROCONTROL ANT/28 IP15
- ICAO EUR Region Air Navigation Plan, Vol II FASID (ICAO Doc7754), AOP-2 Table.
- ECAC Strategy
- Transition Plan for the Implementation of the Navigation Strategy in ECAC 2000-2015+
- ICAO Annex 10
- European Guidance Material on Aerodrome operations under limited visibility conditions - ICAO AWOG PT/LVP

Method:

The deliverables will result from the sub work packages defined below in addition to the results from work on going by ICAO AWOG and GNSSP.

The stakeholders involved are:

Civil and Military organisation from ECAC Member States

- User Organisations
- Aircraft Manufacturers
- Service Providers
- ICAO
- Internal:
- AMN
- GNSS
- AOP
- COM

The following Work Sub Packages will be of relevance to MA-AFAS:

WP 12.6 APV criteria covering the operational requirements

Identify those of the above (WP12.5) Runways where APV criteria cover the operational requirements

WP 12.17 Curved Approaches and Guided Missed Approaches with MLS

Study to identify the operational potential/impact/costs of the MLS capability to conduct Curved Approaches and Guided Missed Approaches.

WP 12.18 GBAS amended requirements for non ILS look alike concept

Study the impact upon GBAS systems requirements and certification in case alternative philosophy for GBAS is retained. This is of particular interest to MA-AFAS.

WP 12.22 Impact of omni-directional antennae on GLS frequency planning

If GBAS is to be used for RNAV, then the ground transmitter will need to use an omni-directional antenna. This WP will evaluate the extent to which the use of omni-directional antennae will impact the assignment exercise.

WP 12.25 GBAS antenna and station requirements

Study to determine:

- the Number of GBAS ground stations required (i) per airport and (ii) within the region.
- Number and Cost of antennas (i) per airport and (ii) within the region.

WP 12.29 GLS/GBAS benefits from additional applications

Study to determine/quantify the benefits, additional to the PA & Landing Capability), that could be attributable to the implementation of GLS/GBAS infrastructure. For example:

A-SMGCS Operations

Airport arrival and departure applications.

RNAV in the TMA

WP 12.30 GLS/GBAS benefits from additional applications

Study to determine benefits/additional costs of providing precision approach capability at airports and/or runways for which to date there is a lack of PA facilities e.g.:

- installing or upgrading runway lighting,
- provision of MET data,
- enhancement of the AIS service to include taxiway information.
- Estimate the number of NPA runways/Airports that could benefit from GBAS CAT I

3.5.4 Transition Issues

The basic issues remained largely unchanged from those that dictated the development of the ICAO AWO Strategy in 1995:

- For how long can ILS continue to provide the required AWO Capability?
- When will GLS provide the AWO Capability?
- To what extent will MLS be required to provide an interim, or in some cases - final, solution?

The use of a Space based navigation aid is comparatively new, as is the concept of it being a Sole Means of Navigation for all phases of flight - including Precision Approach and Landing. It is also the only landing system for which a failure can impact multiple runways and airports. It is not surprising therefore that the question of the need for System Redundancy and/or Backup in the event of a system outage (for any reason) is of great importance. The following studies seek to address this issue.

Future Work Required

- Identify potential ATM impact of GLS failures
- Evaluate to which extent L5, and Galileo and potential combination of those reduce the susceptibility to jamming (robustness, increased power, diversity, etc.)
- Study and validate anti-jam and anti-spoofing techniques (receivers and antenna) that might be made available to the civil applications.
- Study and validate techniques to identify, locate and remove interference source(s);
- Investigate the need to supplement GPS with a backup system or operational procedures to cover the risk of disruption of GPS

3.5.5 Frequency Spectrum Issues

GBAS provides a VHF Data Broadcast (VDB) in the band 108 to 117.975 MHz. The lowest assigned frequency is 108.025 MHz and the highest assignable frequency is 117.950 MHz. The separation between assignable frequencies (channel spacing) is 25 kHz and a Time Division Multiple Access (TDMA) technique is used with a fixed frame structure. Because of the TDMA nature of the data link, channel re-assignment should be very efficient. Although results of capacity studies have shown that VDB needs cannot be fulfilled in the 112-117.950 MHz band without withdrawal of conventional Navaids in some parts of Europe, those studies have also shown that the use of the complete band (ILS+VOR bands) should solve the capacity problem in major parts of Europe subject to a validation of assumptions related to the compatibility criteria with ILS (ILS/GBAS geographical separation criteria are presently under development). In addition, if some VORs can be withdrawn, there would be a large increase in the number of available channels for GBAS since the intermediate 25 kHz channels would then be available. However since the use of the required “keyhole” coverage for approaches instead of omnidirectional is expected to significantly affect the results, potential issues related to the VDB needs beyond the ones considered for straight-in ILS look-alike operations, in particular frequency planning in some parts of Europe if GBAS is to support RNAV operations in TMA, will need to be investigated.

The task of managing the transition might be further exacerbated if the pressure for VDL Mode 4 to operate in the same band succeeds in them receiving an allocation in future WRCs.

Future work required will:

- Confirm, once ILS/GBAS geographical separation criteria are set, that the use of the complete band (ILS + VOR bands) can solve the capacity problem for GLS CAT-I (ILS look-alike) operations; (NAV)
- Evaluate the extent to which the use of omnidirectional antennae will impact the assignment exercise (NAV)
- Evaluate the need for conventional infrastructure withdrawal (NAV)
- Evaluate to which extent the use of GBAS (with up to 8 slots for CAT-III operations) will impact on frequency assignment (NAV)

3.5.6 Implementation

Implementation of GBAS for CAT-I could be achieved in ECAC as early as 2005. CAT-II/III GBAS-based operations are thought to be feasible and EUROCAE Working Group 28 (WG28) is working on the definition of requirements for GBAS to support Cat II and Cat III operations including directional take-off in low visibility. WG-28 will co-ordinate its activity with RTCA Sub-Committee (SC) 159 WG4 and the ICAO GNSS Panel. The target date for completion of the definition task is December 2003. Availability of signals validated and ready for GLS CAT-II/III operations is unknown at present but could be as late as 2010/2015. Thus no CAT II/III GLS implementation plans are currently available.

A full GLS implementation would require at least a 7 years notice after the decision is made to mandate GLS. Thus the earliest date for a full ILS replacement by GLS may not be possible before 2020 but partial implementation might be possible earlier. In addition, should there be any significant implementation of MLS, this could introduce some further delay in the final move to GLS.

Further Work Required will:

- Study to determine feasible Date(s) by which GLS/GBAS could be widely employed in ECAC for CAT I/II/III operations.

3.5.6.1 Airborne Equipment and Ground Infrastructure

GBAS is a completely new system, with its capability for CAT II/III operations still to be defined. It is therefore possible that the MMR specification may have to be changed to incorporate any changes of the GBAS system. Thus the equipment and infrastructure costs can only be rough estimates.

Study to asses the order of costs of the direct transition ILS to GLS This should take into account the provision and installation of GLS/GBAS Ground Stations (including ATC interface), Engineering, Certification & Avionics costs. Note: It may be possible to assess costs on a relative basis (compared to MLS) rather than to attempt an absolute approach.

3.5.6.2 Other Applications

Additional applications/benefits can be expected from the implementation of GLS/GBAS. These include:

- Guided Take Off and Go Around
- Guided Departure
- A-SMGCS application
- Airport/TMA coverage

For some of these applications, in particular A-SMGCS, the GBAS infrastructure would be a key enabler for major service improvements. GBAS alone however would not produce them since some of those applications may require the implementation of additional systems, tools and procedures.

The following studies do not lie within the existing remit of the EPAL Task Force, however the outcome may well influence the findings of the Members and consequently the studies are set out below.

- Study to determine/quantify the benefits, additional to the PA & Landing Capability), that could be attributable to the implementation of GLS/GBAS infrastructure. For example:
- A-SMGCS Operations
- Airport arrival and departure applications
- RNAV in the TMA

Transition to CAT I: For as long as GLS is only CAT I capable, the GLS infrastructure could only replace the existing ILS CAT I infrastructure or enhance the service at airports that presently can only provide Non Precision Approach (NPA) or APV. However operational benefits could be gained through the ability of GLS to provide lower minima in poor weather conditions at runways which lack precision approach facilities and accurate/integrated vertical guidance. It would, of course, be necessary to take into account the additional costs linked to the provision of CAT I capability, such as installing or upgrading runway lighting, providing MET data, enhancement of the AIS service to include taxiway information

In itself GLS CAT-I ILS look-alike precision approach capability would probably not be enough to promote the widespread introduction of GBAS. It is the more elaborate GBAS operations that are intended to offer additional significant benefits.

A major benefit of GLS/GBAS, compared to ILS and MLS is that multiple runways can be supported by one ground subsystem. (Note: a quite similar but more limited capability (CAT I only) has been demonstrated with MLS but this was not retained in the current standards).This might be a very attractive option at some airports. In this case, minimum service volume for each supported runway should be defined to support precision approach operations in Category I conditions. In addition, to support future application such as missed approaches, the data broadcast coverage and consequently the antenna pattern should be omnidirectional. Use of "keyhole" coverage antenna could be required only if a VDB frequency assignment is not possible with omnidirectional (see frequency-related discussions in 3.5.5).

Future Work Required

Study to determine benefits/additional costs of providing precision approach capability at airports and/or runways for which to date there is a lack of PA facilities e.g.:

- installing or upgrading runway lighting,
- provision of MET data,
- enhancement of the AIS service to include taxiway information.
- Estimate the number of NPA runways/Airports that could benefit from GBAS CAT I
- Mixed Mode Operations (Any combination of two of the three types of infrastructure)

Other applications outside the scope of MA-AFAS, which require further work, are issues such as the use of ILS and MLS and/or GLS at the same runway.

Frequency Issues

In order to overcome the ILS frequency limitation, MLS was developed on a basis of 200 channels. However in order to rationalise the existing infrastructure, and take into account the current airborne implementation for ILS using a DME as a range indicator, the “triple pairing” table (Annex 10 Vol. I Table A: DME/MLS angle, DME/VOR and DME/ILS/MLS channelling) establishes the ILS, MLS and DME channels.

This relationship between infrastructures induces some additional constraints and limits the frequency utilisation of each infrastructure, especially MLS. Thus the 200 channels may not be sufficient to support a widespread MLS implementation, and may require the use of the reserved MLS expansion band frequencies.

Should the ranging measurement be provided by DME, then similar constraints could apply to GBAS frequency planning.

Operational issues:

From an operational point of view , where an MLS is installed on a runway which is also equipped with ILS, it is essential that the ILS critical and sensitive areas are protected at all times against intrusion by persons, vehicles and aircraft on the ground. Therefore there will be no change to the existing CAT II/III holding positions during MLS operations.

Due to the different sizes of the ILS and MLS sensitive areas, the LVP spacing criteria can be different: 8 NMs could be required for landing after an ILS equipped aircraft, whereas only 5 NMs when landing after a MLS equipped aircraft. However in addition to this the wake vortex effect must be taken into account, leading to a much more complex estimation for the controller.

The impact of the end to ensure an appropriate guarding of the GBAS antenna from screening/multipath interference will need to be considered. Dependent upon the placement of the antenna there might be a need to define a sensitive area. How large this needs to be will need to be reviewed. The impact of a sensitive area will need to be assessed. In most situations it is expected that MLS and GLS will both be limited by the obstacle clearance Zone, wake vortex and runway occupancy issue rather than the sensitive area considerations. Therefore both MLS and GLS/GBAS should provide capacity benefits over ILS in low visibility conditions. Making effective use of these improvements in a mixed traffic environment will require a review of, inter alia:

ATC procedures for the mixed environment

Availability of information to controller of aids being used

Displays of Nav aids availability

Future Work Required:

Some of the following studies do not lie within the existing remit of the EPAL Task Force, however the outcome of the study may well influence the findings of the Members and consequently the studies are set out below.

Study of the ATC Human Factors aspects of the use of the Mixed Mode Operations involving any mixing of the three types of infrastructure - in each type of control (en route, Approach or Tower control), and of the viability of the mixed landing mode with other mixed operation systems (e.g. B-RNAV/P-RNAV, ADS-B, ASAS)

Other studies:

- Study to develop specific mixed mode procedures to enable the benefit of the new infrastructures (landing clearance time/point, holding point for mixed operation) to be achieved
- Dynamic management of traffic mix to optimise the capacity.
- MLS and GLS mixed mode

3.5.6.3Business Case

The function of the EPAL task force has been redefined to be to:

Identify the potential for, and develop the specification of, a business case for the ILS/MLS/GLS.

Work is currently ongoing in the definition of this business case.

The following milestones will have an impact on transition:

- GLS Cat I availability date.
- NLA introduction date.
- GLS Cat III availability date
- Galileo availability date

3.6 Standards Groups Update

3.6.1 Overall

Amendment 76 to the SARPs gave the standards for Cat I, and Amendment 77 to the SARPs gave the standards for GDPS and GLONASS. PANS OPS (Doc. 8168) gave the procedures for Category I, and was agreed at OCP13, October 2002. The State Letter will be drafted by November 2003, and published in November 2004.

At the WRC-03, it is hoped that there will be agreement for the allocation for GBAS in the Aviation Navigation band 108-117.975 MHz. Discussion on this allocation has so far centred on whether GBAS should be considered a communication system, and therefore given an allocation in the communication band.

The RTCA MASPS (DO-245) was published in 1998, and the corresponding EUROCAE document (ED 99) was published in 1999.

The RTCA MOPS for the airborne side (DO-253A) was published in December 2002 (with the corresponding ED88 published in 2003). MOPS These will be the basis for standards that civil aviation authorities will impose to certify user equipment for primary use of GBAS/GPS as a navigation aid for precision approach operations

The RTCA MOPS for the ground side (ED-114) is currently being circulated for discussion.

The LAAS Interface Control Document (ICD) (DO-246) was published in 2001.

For EUROCONTROL, work is ongoing on the Operational Concept.

Regarding implementation, there are several experimental receivers in existence, and a multi-mode receiver (MMR) to comply with the SARPs is under development. Individual States are working on the technical and operational issues.

The FAA recently awarded the LAAS contract to Honeywell. The first phase consists of the design of the hardware and software. Phases two and three consist of production of station to enable Cat I operations. This will be a low rate if initial production, with the plan being to equip 6 airports by late 2006.

Regarding the airborne side, Airbus is committed to developing an onboard capability.

GBAS supports analog and ARINC-429 digital interfaces to aircraft avionics. Analog ILS-like outputs (per ARINC-578 [can be produced to drive a CDI display or autopilot. ARINC-429 Digital outputs (per ARINC-710 and ARINC-743A[]) can be produced to drive additional cockpit avionics requiring an ARINC-429 interface, such as an autopilot or Flight Management System. The problem arises for curved approaches using GBAS is that autopilots certified to permit curved approaches are not readily available.

3.6.2 ICAO

3.6.2.1GNSSP

The Global Navigation Satellite System Panel (GNSSP) Fourth Meeting was held in Montreal, 23rd April to 2nd May 2003.

Agenda Item 4 reviewed progress in the development of new GNSS elements, and considered the benefits and issues related to the combination of Galileo and GPS.

The GNSSP is developing material for the 11^{th} ANC on GNSS vulnerabilities, the need for terrestrial back-ups, and the concept of using combinations of independent systems, e.g. GPS and Galileo. Some analysis relevant to these tasks has been carried out within the Galileo project to support the standardisation of combined GPS/Galileo receivers within Eurocae WG-62. The analysis considers a number of combined GPS and Galileo scenarios and provides some preliminary analysis of the degraded modes due to the loss of a frequency, e.g. due to interference, or due to the loss of a complete constellation.

The information paper shows that all of the scenarios considered will support APV-II operations. This is of interest as there is a degree of overlap between GBAS and SBAS. GBAS is currently only capable of supporting Category I operations, with development required before it will support Cat II/III operations.

The meeting also discussed the feasibility of GNSS-based Category II/III approach and landing, and aerodrome surface operations.

As a result of discussions, changes will be made to the SARPs to permit new APV approach criteria.

3.6.3 EUROCAE

3.6.3.1WG-62

WG-62 is tasked with developing MOPS for Galileo receivers, and in conjunction with WG-28, to consider the existing standards related to precision approach and if appropriate update these standards to take account of GALILEO use (including joint GALILEO/GPS use).

3.6.4 RTCA

3.6.4.1SC-159

3.6.4.1.1WG-2: GPS/Wide Area Augmentation System (WAAS)

Standards to allow the use of SBAS for precision approach are largely complete. Standards will evolve as GPS is modernised, and Galileo introduced. It is unlikely that standards will be developed to allow curved approaches. Rather, curves sections will be performed in much the same way as at present, followed by a transition to a final straight in leg.

3.6.4.1.2WG-4: GPS/Local Area Augmentation System (LAAS)

Standards to allow the use of GBAS for category 1 precision approach are largely complete. Standards will evolve as GPS is modernised, and Galileo introduced. Development of message structures to permit complex approach procedures is unlikely, as in order to fly such procedures operators would need to be a change in autopilot design. No such autopilots currently exist.

Standards have been modified to permit the GBAS ground station to provide Position, Velocity and Time, and thus GBAS can now support RNAV. Thus the GBAS PVT output could support curved approaches (in the same way as the SBAS PVT), should the supporting data have sufficient integrity.

3.7 Procedure Design

Standards are required to be developed in order to fully exploit the satellite technologies.

3.8 Conclusion

Transitioning to new standards for precision approach has been discussed. GBAS has been discussed in the most depth, with reference to EUROCONTROL's GBAS Roadmap.

For Precision Approach, the SBAS signal in space will soon be operational in Europe. For some applications, SBAS and GBAS require no further standardisation. This will provide a precision approach capability over wide area. Issues affecting transition include:

- User Equippage,
- Cost Recovery,
- Procedure Design,
- Interface to ATC.

For GBAS, it will soon be possible to purchase ground stations. Some aircraft already fly with the MMR, which permits GBAS to be selected as the guidance source.

As yet, there is no specific point which is standardised as the changeover point between SBAS and GBAS. This point is now not likely to be formally standardised.

For curved procedures using GBAS, new words in the GBAS message need to be defined. This should not be difficult, but does not feature in the work program as yet, due to lack of interest.

For curved and straight procedures using SBAS, the main transition issue concerns integrity of the database on board the aircraft. Whilst standards and procedures for data manipulation are in place, the data does not yet meet the integrity standard, and there will undoubtedly be a cost in ensuring that it does.

Autopilot standards are currently concerned only with deviations about a straight-in approach. For curved procedures using any navigation source, new autopilot standards are required and thus re-certification.

Procedure design standardisation efforts continue, in order to harness the evolving satellite navigation technologies.

Considerable effort is being undertaken by international organisations (ICAO, EUROCONTROL) to examine the transition for future PA systems. However, EUROCONTROL have concluded that curved approaches are not a short term priority, and plan to undertake no further work on this unless States make requests.

4 COMMUNICATIONS

4.1 Introduction

4.1.1 ATN Technology

Standardisation development work has been performed for the ATN technology and services. A common underlying theme for many of the MA-AFAS themes is the need for communications, i.e. a datalink. Due to the many aircraft operators and ground service providers, a great deal of effort is required in order that a datalink can be standardised, in order to gain the benefits of standardisation, especially global interoperability.

4.1.2 ATN Services

The services of interest are: GACS, CPDLC, FIS, ADS-C, and URCO.

Whilst not a MA-AFAS Theme, datalink implementation underpins future plans for ATM development, and thus is considered separately here.

4.2 Feasibility and Options for the Introduction of Datalink Services

NATS have looked at implementing a CPDLC capability to support the delivery of routine data, and the delivery of routing/re-routing data. These functions are seen to help reduce the workload of domestic controllers and pilots. An additional objective is to enhance safety.

For routine ATC, datalink will aid issue of domestic VHF R/T contact frequencies, SSR codes, and HF frequencies to aircraft.

Datalink relieves domestic controllers of having to pass this data by VHF voice. It offers possibility that such data can be correctly and unambiguously sent, displayed on a/c or input into FMS without need to repeat it.

Regarding upgrade to ATN, it is unlikely to be feasible if not in design of equipment from the outset. However, if COTS chosen, then upgrade more feasible.

4.3 ATN stack progress

The ATN stack and its mapping to the OSI 7 layer module was discussed. It was stated that layer 4 follows the ISO 8073 specification and layer 7 upper layer message formats will be written to ASN.1.

It was identified that various ICAO panels are addressing standardisation of the ATN stack. The Aeronautical Mobile Communications Panel (AMCP) is responsible for defining and maintaining the standards for Layers 1 and 2. Layers 3 to 7 are covered by the Aeronautical Telecommunication Network Panel (ATNP). Above Layer 7, panels have been set up per application, such as the Automatic Dependent Surveillance (ADSP).

The AMCP has approved subnets for the following:-

- Satellite
- VDL
- HFDL
- Mode S

For transition, the following issues will need to be considered:

- Airframe evolution and retrofit
- Avionics development
- Airspace carriage requirementt
- Fleet operations
- Training, infrastructure, safety

Supporting platforms will also need to be developed, i.e.:

- FMS/CMU
- Software upgrade
- Hardware upgrade
- I/Os

4.4 Development of MOPS/ standards for equipment

No further details of standards development have been made available.

4.5 ICAO OPLINKP Update

Below is a report of the meetings held on 19-28 February 2003.

The meetings were attended by approximately 26 representatives from Australia, Brazil, Canada, France, Germany, Japan, Saudi Arabia, Spain, UK, USA, Eurocontrol, IFALPA and IFATCA. France only attended WGB.

This was a Joint Meeting of OPLINKP Working Groups A (ADS-B) and B (Data Link applications (AIDC)). RCP issues also discussed.

<u>Agenda item 1 (ADS-B Concept of Use and operational requirements)</u>

The main WG discussions concerned the further development of the draft of an ADS-B Concept of Use document. The ICAO Secretariat believes that ADS-B will be a significant item for discussion at the forthcoming Air Navigation Conference in Sept/Oct 2003. Hence the aim was to have a mature version of the Concept of Use available for the Conference, which means that it needed to be sufficiently developed by the end of the Meeting so that it can be formally issued after Air Navigation Commission agreement. It was thought that the Concept of Use will not be further developed after this meeting. Instead, it will be used as a baseline for developing operational requirements for ADS-B, which will be the main target of future WGA work.

Germany submitted a WP giving results from a research project known as TAGA (Traffic Awareness for General Aviation) which used Traffic Information Service – Broadcast (TIS-B). This was intended to evaluate the usefulness of the TIS-B application itself and was specifically not intended to investigate the technology used. The pilots involved considered that TAGA assisted significantly in the tasks of detecting and identifying traffic and facilitated an awareness of the traffic situation. However, some pilots felt that the update rate used was problematic for the detection of fast moving targets and position errors for these could be as high as 1 nm. Further work was needed in this area.

It was agreed that the current draft of the Concept of Use reflected the state of the work completed and incorporated various differing views on the part ADS-B might play in the short to medium term. As such, it was agreed that, subject to Commission approval, it could be submitted to the Air Navigation Conference.

However, considerable work remains to define detailed operational requirements for ADS-B together with the capability of the respective airborne and ground systems. SARPs, procedures and Guidance Material for ADS-B also need to be developed as identified in the current OPLINKP work programme.

<u>Agenda item 2 (Required Communications Performance [RCP])</u>

A breakout group during two days of the meeting reviewed the current draft of the RCP Manual and a number of amendments were proposed together with identifying further work required. A new draft will be prepared and circulated for review by e-mail before the next meeting.

Agenda item 3 (AIDC Amendment proposal for PANS-ATM and guidance material)

Progress with PANS-ATM was made, but the priority was given to work on the ADS-B Concept of Use.

Two methods were proposed of co-ordinating assigned Mach numbers and the distance between two aircraft via AIDC. A need had been identified based on operational experience to date, and the meeting agreed there was an operational requirement for this type of co-ordination.

Agenda item 4 (Any Other Business)

A paper was presented giving statistical data on the use of preformatted free text messages used in the South Pacific. The aim is to identify potential additional messages that could be included in the existing CPDLC message set identified in the PANS-ATM and then to develop the amendment proposals for submission to OPLINKP/1. Seven messages had been used at least twenty times but, after discussion, it was agreed that three of these could use existing messages in the PANS-ATM. Amendment proposals for the remaining messages will be developed and submitted to WGB.

A number of members were experiencing difficulties in getting resources (time) and travel approval due to increased workload in their organisations and budgetary cuts. Similar problems were being experienced in other ICAO panels as well as in other organisations and industry groups. The Secretary will be discussing this issue further within ICAO and will keep members informed of any results or actions taken by ICAO HQ. The possibility of a letter from ICAO to States highlighting this issue was mentioned.

Next meeting

The next meeting for the OPLINKP Working Groups is scheduled for 27 October to 7 November 2003 at Annapolis, USA.

WG-B

A WP giving CPDLC uplink & downlink message pairings was discussed in detail & revised during the meeting. There were detailed discussions on the Document 4444 AIDC message set and a significant number of changes were made, which may lead to major revisions with the AIDC SARPs.

A paper proposing that aircraft should be capable of downlinking details of the CPDLC message set they can support (to ease interoperability problems) received little support.

EUROCONTROL presented a paper on the FLIPCY service with a view to getting this included in the Manual. It was stated that ADS did not have the full capability to support this because it only downlinked Latitudes and Longitudes for waypoints and not names.

A paper was submitted concerning the deletion of some messages as a result of inputs from the Human Factors strategy Group. It was stated that this issue would remain open until after the next Panel meeting and this would then be followed by the State Letter procedure.

Detailed reports were received of the progress of the three sub-groups. All had completed final change pages for Document 9705 Ed 3 arising from review and further validation activity. All had dedicated most of their time to the production of new Guidance Material for the new Security, System Management and Directory Services Sub-volumes that would be released as part of Document 9705 Ed 3. Most material was technically complete.

A Validation Report for the GACS (Generic ATN Communication Service) was presented. EUROCONTROL had had the service coded and successfully tested, and a flight trial is expected.

Items of Future Work were agreed:

- The development of Encryption functionality as part of the ATN Security provisions would be progressed to satisfy airline requirements.
- The inclusion of IP subnetworks into the ATN Ground Internetwork was endorsed. A meeting dedicated to resolving this quickly was called.

Relevant Possible Future Work Items:

- The development of a LDAP interface to the Directory Service should be considered.
- Management of Security Key Infrastructure
- Impact on Key Management on Avionics
- Consideration of an appropriate sunset date for the non-secure ATN internetwork needs serious consideration and is an Institutional Issue that requires expert communications and regulatory input.

WG-C

A revised version (v2.0) of the RCP Concept paper was developed for submission to ANC.

Significant comments had been received from both AMCP and RGCSP. These were discussed and taken into account where considered possible in the new draft. However, the WG seemed to feel that, while it could define a method of specifying RCP, actual figures were implementation-dependent and, particularly considering the human factors contribution, needed to be specified by States` airspace planners as part of any implementation. It seemed to be left to the Technical Panels to define what technical performance (RTCP) could be achieved by the various subnetworks.

All WGs – major input from, and co-operation with, other Panels (RGCSP, AMCP, SICASP, and ATMCP) required.

WG A – More work to be done by Chairman on the proposed Concept of Use required by ICAO. States need to review policy on air-to-air operations. Papers are required to finalise Figure of Merit implementation. Each State's ADS-B policy is to be reviewed and presented at the next meeting.

WG B – Remaining AIDC procedures approved for Document 4444. More solutions required for perceived operational interoperability problem. Air/ground CPDLC message set comparison methods to be detailed. Figure of Merit needs more work. CPDLC Message pairing needs UK input.

WG C –RCP concept document v 2.0 for submission to ANC, followed by circulation and State comment. WG in abeyance until State replies received, and review required.

4.6 Spectrum

An increasingly important part of any transition plan is consideration of the spectrum issues, especially obtaining an allocation, obtaining an assignment, planning criteria and susceptibility to interference.

MA-AFAS applications centred on the use of the VDL4 datalink. Operators of VDL-4 systems would like global common channels, to obtain maximum benefit from the system. Currently frequencies are co-ordinated on a State basis, subject to guidelines from the World Radio Commission. It is thus extremely difficult to obtain global common channels.

The proposed allocation for VDL-4 will be in the navigation band. Other uses in this band consist of fixed ground stations. However, VDL-4 applications will make use of mobile platforms, and so careful frequency assignment will be required.

5 OTHER THEMES

5.1 4 D

Evaluation of airborne 4D trajectory generation and guidance, including negotiation of the flight path with the Air Traffic Control (ATC), requires a data link. Thus standardisation of the datalink, and the parameters to download, is required.

The EUROCONTROL Navigation Strategy (ref. 12) recognises that 4D RNAV in an Air/Ground Integrated ATM Environment addresses the long-term requirements of 4D navigation which, with the production of 4D RNAV MASPS, may provide significant benefits to aircraft operations and airspace capacity when integrated with advanced ATC tools

5.2 ASAS

5.2.1.1Datalink for ADS-B

The VDL4 datalink is becoming standardised for ADS-B applications such as ASAS. Spectrum issues need to be worked through, as the airborne mobile nature of the aircraft will mean that careful frequency planning will be required.

5.2.1.2ASAS Services

The services to be provided (i.e. permissible manoeuvres), will need to be clearly defined and agreed. Also the ATC terminology to permit their use will need to be standardised.

5.2.1.3CDTI

Some basic standards have been developed for CDTI. However, further work is required.

5.3 Taxi Management

Taxi Management Theme is intended to validate taxi maps, and thus standards are required for the mapping database and presentation of the map. It also aims to validate datalinked clearances, and so requires a standardised datalink.

No information regarding standardisation of Taxi Management has been made available.

5.4 AOC

The AOC Theme aims to validate the support available for maintenance and fleet management. It is likely that the data to be transmitted will depend upon the requirements of each operator, and thus not require standardisation. However, a datalink will be required. This may need to be standardised.

No information regarding the standardisation of AOC has been made available.

5.5 Conclusion

Standardisation of a suitable datalink technology is essential for 4D and ASAS applications. That permits advancement with work on the standardisation of services.

A standards working group is required to investigate Taxi Management technology and services standardisation.

6 CONCLUSIONS AND FURTHER WORK

6.1 Introduction

The MA-AFAS system has been broken down in order to see where effort for standards development will be beneficial. Transition issues, and reports of selected standards body meetings, were then discussed, primarily for the Precision Approach Theme.

There are a large number of players involved in ATM, and transition to more autonomous flight requires a large co-ordinated effort. It is in fact very difficult to separate issues from their context.

6.2 Precision Approach

For Precision Approach, the SBAS signal in space will soon be operational in Europe. This will provide a precision approach capability over wide area. Issues affecting transition include:

- User Equippage,
- Cost Recovery,
- Procedure Design,
- Interface to ATC.

For GBAS, it will soon be possible to purchase ground stations. Some aircraft already fly with the MMR, which permits GBAS to be selected as the guidance source.

As yet, there is no specific point which is standardised as the changeover point between SBAS and GBAS. This point is now not likely to be formally standardised.

For curved procedures using GBAS, new words in the GBAS message need to be defined. This should not be difficult, but does not feature in the work program as yet, due to lack of interest.

For curved and straight procedures using SBAS, the main transition issue concerns integrity of the database on board the aircraft. Whilst standards and procedures for data manipulation are in place, the data does not yet meet the integrity standard, and there will undoubtedly be a cost in ensuring that it does.

Autopilot standards are currently concerned only with deviations about a straight-in approach. For curved procedures using any navigation source, new autopilot standards are required and thus re-certification.

Procedure design standardisation efforts continue, in order to harness the evolving satellite navigation technologies.

6.3 Communications

6.3.1 VDL4

VDL4 has been standardised for a number of applications, but work is still required on

For transition to using this technology, work will be required in order to co-ordinate the frequency planning of mobile platforms.

6.3.2 Status of ATN

ATN technology standardisation is now mature.

6.3.3 Data Link Services

Standardisation for limited datalink services is now mature.

6.4 Other Themes

6.4.1 4D

Little standardisation is in place so far.

6.4.2 ASAS

Little standardisation is in place so far, with the exception of basic standards for CDTI.

6.4.3 Taxi Management

Standardisation is required, especially in the area of taxi-way databases.

6.4.4 AOC

Little standardisation is in place so far.

7 ACRONYMS

ABAS	Aircraft Based Augmentation Systems
ACARS	Aircraft Communications Addressing and Reporting System
ADIRS	Air Data Inertial Reference System
ADS	Automatic Dependent Surveillance
ADS-B	ADS Broadcast
ADS-C	ADS Contract
ADSP	Automatic Dependent Surveillance Panel (ICAO)
AEEC	Airlines Electronic Engineering Committee
AFS	Aeronautical Fixed Service
a/g	Air-ground
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
AMCP	Aeronautical Mobile Communications Panel (ICAO)
AMSS	Aeronautical Mobile Satellite Service
ANC	Air Navigation Commission (ICAO)
APV	Approach with Vertical Guidance
AOC	Aeronautical Operational Communications
ASSAP	Airborne Surveillance and Separation Assurance Processing
A-SMGCS	Advanced SMGCS
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network

ATS	Air Traffic Service
ATS	Air Traffic System
ATSP	Air Traffic Service Provider
ATSU	Air Traffic Services Unit
CCB	Configuration Control Board (of ICAO ATNP)
CDTI	Cockpit Display of Traffic Information
CD&R	Conflict Detection and Resolution
CFMU	Central Flow Management Unit
CMU	Communications Management Unit
CNS	Communications, Navigation and Surveillance
CPDLC	Controller Pilot Data Link Communications
CPM	Conference Preparation Meeting
CRM	Crew Resource Management
CSMA	Carrier Sense Multiple Access
D-ATIS	Data-link Automatic Terminal Information Services
D-ATSU	Downstream ATS Unit
DCL	Departure Clearance service
DFW	Dallas Fort Worth
DITS	Digital Information Transfer System
DLASD	Data Link Application Systems Document
DLK	Data Link
DLL	Data Link Logon
D-RVR	Data Link – Runway Visual Range
D-SIGMET	Data Link – Significant Meteorology
DSC	Downstream Clearance

DYNAV	Dynamic Route Availability Service
EGNOS	European Geostationary Navigation Overlay System
EOBT	Estimated Off Block Time
ESA	European Space Agency
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAS	Final Approach Segment
FDPS	Flight Data Processing System
FEC	Forward Error Correction
FFAS	Free Flight Air Space
FIS	Flight Information System
FIS	Flight Information Services
FLIPCY	Flight Plan Consistency
FM	Frequency Modulation
FMBC	Frequency Modulation Broadcast
FMS	Flight Management System
FMU	Flight Management Unit
FTE	Flight Technical Error
GACS	Generic ATN Communications Service
GBAS	Ground Based Augmentation System
GLS	GPS Landing System
GNLU	GNSS Navigation and Landing Unit
GNSS	Global Navigation Satellite System
GNSSP	Global Navigation Satellite System Panel (ICAO)
GPS	Global Positioning System

GRAS	Ground Based Regional Augmentation System
HF	High Frequency
HF	Human Factors
HFDL	HF Data Link
HMI	Human Machine Interface
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICD	Interface Control Document
ICS	Internet Communications Service
IFR	Instrument Flight Rules
ISO	International Standards Organisation
ITU	International Telecommunications Union
ILS	Instrument Landing System
ITU	International Telecommunications Union
JAA	Joint Aviation Authorities
LAAS	Local Area Augmentation System
LDAP	Lightweight Directory Access Protocol
MA-AFAS	More Autonomous Aircraft in the Future ATM System
MAS	Managed Air Space
MASPS	Minimum Aviation System Performance Standards
MLS	Microwave Landing System
MOPS	Minimum Operational Performance Standards
MMR	Multi-Mode Receiver
NAS	National Airspace System
NASA	National Aeronautics and Space Administration

NATS	National Air Traffic Services
NDB	Navigation Data Base (ARINC)
NDB	Non-Directional Beacon
NPA	Non-Precision Approach
OCP	Obstacle Clearance Panel (ICAO)
OCL	Oceanic Clearance DataLink
PA	Precision Approach
PVT	Position Velocity Time
QoS	Quality of Service
RCP	Required Communications Performance
RFI	Radio Frequency Interference
RNAV	Area Navigation
RNP	Required Navigation Performance
RSP	Required Surveillance Performance
RTCP	Required Technical Communication Performance
SARPS	Standards and Recommended Practises
SBAS	Satellite Based Augmentation System
SC	Special Committee (RTCA)
SDLS	Satellite Data Link System
SG	Sub-Group
SID	Standard Instrumented Departure
SIS	Signal In Space
SMGCS	Surface Movement Guidance and Control System
STAR	Standard Arrival Route
TBD	To Be Defined

TCAS	Terrain Collision Avoidance System
TDMA	Time Division Multiple Access
TIS-B	Traffic Information Service – Broadcast
TMA	Terminal Manoeuvring Area
TSO	Technical Standard Order
UAT	Universal Access Transceiver
ULCS	Upper Layer Communications Service (ATN)
UMAS	Unmanaged Air Space
URCO	Urgent Communication
US	United States
UTC	Universal Time Co-ordinated
UWB	Ultra WideBand
VDB	VHF Data Broadcast
VDL	VHF Data Link
VDR	VHF Data Radio
VHF	Very High Frequency
VNAV	Vertical Navigation
WAAS	Wide Area Augmentation System
WG	Working Group