APPENDIX C

CAR/SAM STRATEGY FOR THE EVOLUTION OF AIR NAVIGATION SYSTEMS

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INTRODUCTION

1.1 Acronyms

ABAS	Aircraft Based Augmentation System
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
ANSP	Air Navigation System Provider
APV	Approach with Vertical Guidance
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
BARO-VNAV	Barometric Vertical Navigation
CAR/SAM	Caribbean and South American Regions
CAT-I	Category I Precision Approach
CAT-II	Category II Precision Approach
CAT-III	Category III precision Approach
CFIT	Controlled Flight Into Terrain
CNS/ATM	Communications, Navigation and Surveillance/Air Traffic Management
DME	Distance-Measuring Equipment
EGNOS	European Geostationary Navigation Overlay Service
FAA	Federal Aviation Administration - USA
GAGAN	GPS and Geostationary Earth Orbit Augmented Navigation - India
GALILEO	Europe's own global navigation satellite system
GBAS	Ground Based Augmentation System
GLONASS	Global Navigation Satellite System – Russia
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GREPECAS	Caribbean and South American (CAR/SAM) Regional Planning and Implementation Group
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IRS	Inertial Reference System
LAAS	Local Area Augmentation System (USA)
MSAS	Multi-functional Satellite Augmentation System - Japan
NAVAID	Navigation Aid
NSP	Navigation Systems Panel
NDB	Non-Directional Radio Beacon
PBN	Performance-Based Navigation
RAIM	Receiver Autonomous Integrity Monitoring
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP APCH	Approach RNP
RNP AR	Approach RNP, with Authorization Required
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
STAR	Standard Instrument Arrival
TMA	Terminal Control Area
VFR	Visual Flight Rules
VOR	VHF Omnidirectional Radio Range
WAAS	Wide Area Augmentation System
WGS-84	World Geodetic System -1984

1.2 Objective and general considerations

Pursuant to its terms of reference and work programme, as revised and approved by the CNS/COMM/6 meeting, the GNSS Task Force (GNSS/TF) of the CNS Committee of the GREPECAS ATM/CNS Subgroup was assigned, *inter alia*, the task of developing a draft document describing the evolution of the air navigation infrastructure required to support CAR/SAM PBN requirements.

This proposal has its origin in the initiatives of the "Global Air Navigation Plan" (Doc. 9750) and the "CAR/SAM Regional Air Navigation Plan" (Doc. 8733), based on the fact that technology is not a goal in itself, and that it must be based on operational requirements in order to attain the global ATM operational concept.

Accordingly, this proposal has been developed taking into account the following guidance and reference documents:

a) Annex 10, Volume I;

b) Strategies for the introduction and use of non-visual radio aids for approach, landing, and departure procedures in the CAR/SAM Regions (Appendix I to the CAR/SAM Air Navigation Plan, Doc 8733);

c) Guidance for the transition to satellite-based navigation systems in the CAR/SAM Regions (Appendix H to the CAR/SAM Air Navigation Plan, Doc 8733);

d) CAR/SAM PBN Roadmap, version 1.4 / July 2009;

e) GNSS Manual, Doc 9849 AN/457; and

f) Analysis of the navigation infrastructure in support of PBN.

The main objective of this strategy is to define a gradual implementation of the navigation infrastructure that will help to promote the safety, inter-functionality, and cost-effectiveness of the infrastructure needed to meet future ATM requirements, propose the activities and actions required so that the air navigation infrastructure will support the short- and medium-term PBN requirements established in the CAR/SAM PBN roadmap, and develop a long-term projection of activities and actions for air navigation infrastructure.

The CAR/SAM Strategy for the Evolution of Air Navigation Systems, hereinafter called "the Strategy", shall be considered a guiding document for all parties involved. This document does not contain regulatory or mandatory requirements. Air navigation authorities shall publish the corresponding regulations for the introduction and use of PBN.

This strategy is a living document that shall be reviewed and updated every two years or when major modifications to the base document are being considered.

1.3 Scope of the strategy

According to this proposal, the implementation of air navigation systems responds to a harmonised CAR/SAM strategy that takes into account operational requirements and the relevant cost-benefit analyses, based on which CAR/SAM States, Territories and International Organisations may draft their action plan for the implementation of the required navigation systems, in keeping with CAR/SAM implementation dates.

To better understand this air navigation strategy, the operational requirements, the required navigation infrastructure, the regional studies and trials proposed in this document are presented in chronological order. The timetable for this proposal is the same as that of the CAR/SAM PBN roadmap for the short (2006-2010), medium (2011-2015) and long term (2016+).

The dates indicated herein are tentative dates in which air navigation systems will be operational at regional level. However, some of the air navigation systems described in this strategy will be used for resolving local problems prior to the dates established in this document, so there will be a migration from these pioneering areas to broader regional areas.

The policy for the implementation of the new air navigation technologies in the CAR/SAM Regions should be based first on voluntary implementation in specific areas, using the existing certified equipment, followed by implementation in more extensive areas, supported by the respective regulations and updated equipment.

1.4 Structure of the document

This document is structured as follows:

- Section 1 (this section) lists the acronyms used, the purpose of the document, explains its scope and structure, and describes the target audience.

- Section 2 describes the evolution of the Air Navigation Operational Scenario, that is, the short- (2009-2010), medium- (2011-2015) and long-term (2016-2025) operational requirements for en route and terminal airspace, aerodrome operations, and on-board systems.

- Section 3 describes the evolution of the air navigation infrastructure required to support the envisaged operational scenario.

- Section 4 specifies a tentative action plan, whose timely implementation will promote the operational use of the new GNSS technologies.

1.5 Target audience

This strategy has been developed to assist States/Territories/International Organisations, as well as aviation community stakeholders, in the implementation of PBN, of the plan for the future transition, and of the corresponding investment strategies.

The main aviation community stakeholders in the CAR/SAM Regions that will benefit from this strategy are:

- Regulatory agencies, the national regulatory authorities of CAR/SAM States/Territories/International Organisations responsible for the verification of air navigation systems;

- Air navigation service providers (ANSPs). Civil and military air navigation service providers of CAR/SAM States/Territories/International Organisations responsible for the acquisition/design, acceptance, and maintenance of air navigation systems;

- Airport operators responsible for the acquisition/design, acceptance, and maintenance of navigation systems at the airports;

- Airspace users, who are the end users of air navigation systems; and

- International organisations.

2. EVOLUTION OF THE OPERATIONAL SCENARIO, ACCORDING TO THE CAR/SAM PBN ROADMAP

2.1 Oceanic airspace – En-route operations

a) Taking into account low air traffic density in oceanic airspaces, no significant short-term changes are expected in the existing airspace structure that would require changes in the applicable RNAV specifications. In airspaces where RNP-10 is applied (EUR/SAM corridor, Lima-Santiago de Chile and South Atlantic Random Route System), no changes are expected in the short term.

b) In oceanic airspace, it is expected that RNP 4 will be applied in the medium term, using ADS/CPDLC, to enable 30 NM lateral and longitudinal separations. This application will depend on the evolution of the aircraft fleet flying in the airspace.

2.2 Continental airspace – En-route operations

a) In the short term, RNAV-5 is envisaged in selected airspaces where operational benefits can be derived and where the available CNS infrastructure will support it.

b) In the medium term, RNP-2 is expected in selected high-density continental airspaces, using GNSS only, taking into account that the ground infrastructure will not support RNAV applications. The establishment of a backup system for GNSS will be required, as well as the development of contingency procedures in case of GNSS failure. The use of RNP-2 will facilitate the application of PBN in airspaces that lack surveillance. With the use of GNSS alone, it will be necessary to obtain more information from the GNSS signal through the use of GPS monitoring systems.

2.3 Continental airspace – Terminal control area (TMA)

a) In the short term, the implementation of RNAV-1 is expected in TMAs selected by the States, under radar coverage, and with the appropriate ground navigation infrastructure that allows for DME/DME and DME/DME/INS operations. During this phase, both equipped and non-equipped aircraft will be allowed to operate, and RNAV-1 operations shall begin once the appropriate percentage of approved air operations has been achieved.

b) In non-radar environments and/or where there is no appropriate ground navigation infrastructure, the implementation of RNP-1 in the short term is expected in TMAs selected by the States, using GNSS alone, provided there is an appropriate percentage of approved air operations. Both approved and non-approved aircraft will also be allowed to operate in these TMAs.

c) PBN approach procedures shall be implemented in the short term as approach procedures with vertical guidance (APV) using baro-VNAV for runways, be it as primary approach or as backup for all final approaches to the runway, based on RNP APCH or RNP AR APCH navigation specifications.

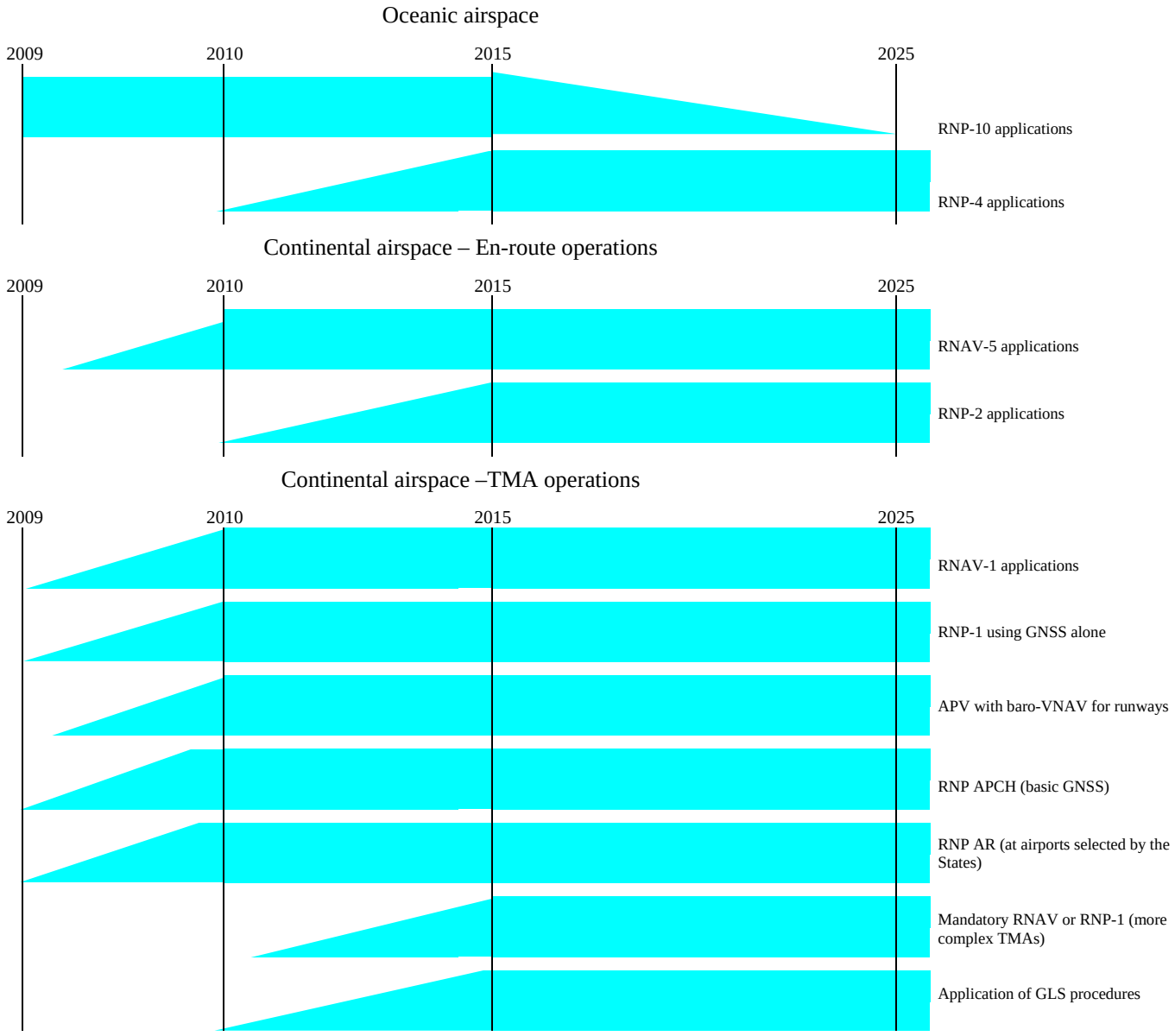
d) Use of RNP APCH (basic GNSS) approach procedures is expected in the short term in most international airports selected by the State, maintaining conventional approach procedures for conventional non-equipped aircraft.

e) Use of RNP AR approach procedures is expected in the short term at airports selected by the State, where operational benefits to be obtained are evident, based on the existence of significant obstacles.

f) In the medium term, it is expected that RNAV or RNP 1 applications will be extended to TMAs selected by the States, depending on ground infrastructure and aircraft navigation capabilities. At more complex TMAs, the use of RNAV or RNP 1 (exclusionary airspace) equipment will be mandatory. At less complex TMAs, both equipped and non-equipped aircraft will be allowed to operate.

g) In the medium term, it is expected that RNP APCH and RNP AR procedures will be extended to selected airports. Initial implementation of GLS procedures is also envisaged, thus ensuring a smooth TMA-to-approach transition, basically using GNSS for the two phases.

2.4 Timetable for operational requirements



3. EVOLUTION OF AIR NAVIGATION INFRASTRUCTURE

3.1 Short term (up to 2010)

a) Initial deactivation of NDBs.

b) Definition of the GNSS backup infrastructure.

c) Changes to DME infrastructure to meet ICAO RNAV (DME/DME) requirements at selected TMAs.

d) Initial implementation of ABAS for en-route, TMA, and NPA operations.

3.2 Medium term (2011-2015)

a) The implementation of GBAS CAT I stations at airports with sufficient operational demand will improve en-route and TMA operations (SIDs and STARs) on paths similar to those of the ILS.

b) At some airports, ILS systems will be maintained as GNSS/GBAS backup.

c) Initial deactivation of VOR for en-route operations.

3.3 Long term (2016-2025)

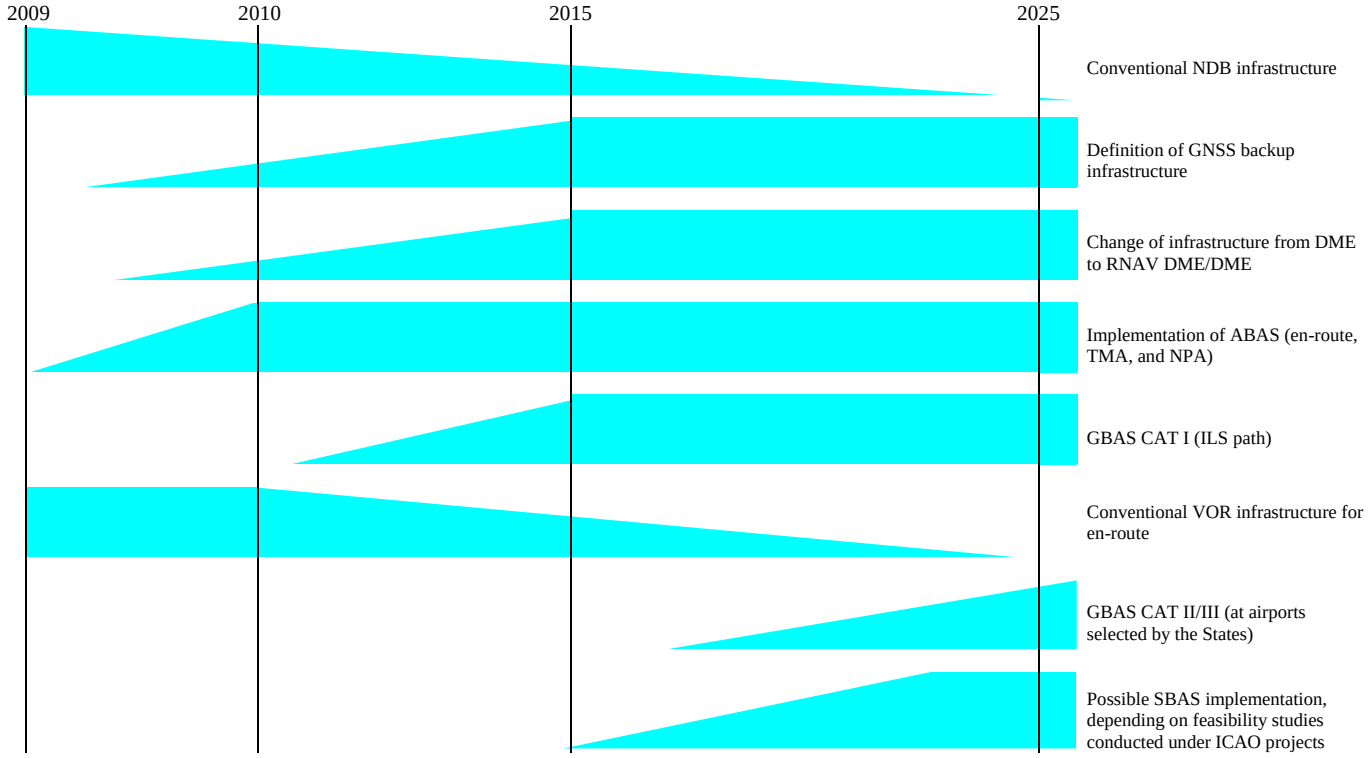
a) Continue deactivating conventional aids, maintaining the backup structure, if necessary.

b) Implementation of GBAS Cat II/III at selected airports.

c) Implementation of GBAS CAT I approach at other CAR/SAM airports with sufficient operational demand.

d) Possible implementation of SBAS, depending on feasibility studies already carried out and underway under ICAO projects, taking into account current mono-frequency systems and the evolution of ionosphere algorithms, as well as the future availability of a multi-frequency, multi-constellation satellite structure.

3.4 Timetable for air navigation infrastructure



4. TENTATIVE ACTION PLAN

4.1 Short term (up to 2010)

a) The implementation of an automatic tool for the development of procedures should be established in order to meet the new demand for procedures such as RNAV and RNP.

b) Analysis of DME/DME coverage and DME implementation to support operations, and introduction of improvements.

4.2 Medium term (2011-2015)

a) In order to determine which airports are suitable for the installation of GBAS CAT I stations, each State must make a cost-benefit analysis based on its own operational demand.

b) For each eligible airport, a GBAS ionosphere threat model will be required for certification and commissioning purposes.

c) Complete and conclude the SACCSA project to see the possibility of implementing an SBAS system in the CAR/SAM Regions.

d) Assess the technical, operational, and financial feasibility of SBAS systems, based on the development of new mono-frequency system models, the future implementation of GPS operations, and the commissioning of the GALILEO constellation.

4.3 Long term (2016-2025)

a) In order to determine which airports are suitable for the installation of GBAS CAT II/III stations, each State must conduct a cost-benefit analysis, based on its own operational demand.

b) SBAS operations with a self-owned or leased GEO satellite, which could enable SBAS operations independently from WAAS and/or EGNOS.

4.4 Action Plan timetable