



Agenda Item 2: Air Navigation Matters
2.3 Other Specific Air Navigation Developments
2.3.3 Air Traffic Management (ATM)

PBN AIRSPACE CONCEPT FOR THE CAR REGION

(Presented by the Secretariat)

SUMMARY	
This working paper presents a draft proposal of PBN airspace concept in line with PBN implementation tasks for the CAR Region.	
References:	
• Doc 9750- <i>Global Air Navigation Plan</i>; • Doc 9854 - ATM Operational Concept; • Doc 9613 - PBN Manual; • Report of the GREPECAS/15 meeting.	
<i>Strategic Objectives</i>	<i>This working paper is related to Strategic Objectives A and D.</i>

1. Background

1.1 GREPECAS/15, upon examining the work programme and terms of reference of GREPECAS and its contributory bodies and, particularly, those related with PBN implementation, approved that the ATM/CNS/SG work programme align itself with the following performance objectives:

- a) optimization of the ATS routes structure in the en-route airspace;
- b) optimization of the ATS routes structure in the terminal airspace; and
- c) implementation of RNP approaches.

1.2 It should be recalled that GREPECAS noted the convenience that the planning of PBN tasks be harmoniously developed between the CAR and SAM Regions, recognizing at the same time that the implementation should be carried out in accordance with the operational needs of each Region.

2. Analysis

Optimization of the ATS routes structure in the en-route airspace

2.1 As a result of the RNAV routes implementation process in the upper airspace many benefits have been achieved by operators, users and air navigation services providers (ANSPs). The implementation programme has generated great operational and economical advantages. Nevertheless, the possibility of implementing new RNAV routes has been identified.

2.2 In addition, the traffic increase forecast for the next years, the great demand of direct trajectories outside the air route and the possible implementation of additional routes could lead to a saturation in the various airspaces, which would complicate the airspace management.

2.3 Therefore, it would be convenient to conduct an overall review to the upper airspace, considering the possible implementation of new RNAV routes and the elimination of those conventional routes of low use, whose trajectory coincides or is similar to the fixed RNAV or random routes.

Optimization of the ATS routes structure in the terminal airspace

2.4 GREPECAS recommended the implementation of trunk routes that might link the upper airspace RNAV routes with the arrival and exit routes implemented in the terminal areas. To improve the ATS routes network in the terminal areas, focus has been on the need of implementing and improving the SIDs and STARs.

2.5 With this approach in mind, SIDs and STARs have been implemented in many terminal areas and international airports in the CAR States. Nevertheless, considering the current aircraft navigation capacity, it becomes necessary to evaluate other alternatives that permit linking the upper airspace routes structure with the terminal area routes; one of these alternatives is the implementation of continuous descent operations (CDO) also known as stabilized approach tracks.

2.6 The CDO can include the arrival route of an optimum trajectory calculated by the aircraft flight management computer (FMC) from the initial top of descent point (TOD), or another operationally defined point, up to a point where the approach procedure to the airport is started.

2.7 The CDO concept permits adjusting an aircraft's arrival trajectories and speed required to maintain traffic separation and the order that the air traffic control (ATC) provides and can provide a substantial improvement in operational forecasting. The CDO also maximizes the advantages for each flight in terms of reduction of pilots and controller's workload, less fuel consumption, less gas emissions and less noise, as well as better forecasting possibilities for the flight crew and the aircraft user.

2.8 The implementation of CDOs entails a review to the organization of the lower airspace and improving air traffic management, where operational advantages can be obtained. The implementation tasks and advantages of CDO also have impact on other air navigation areas, such as the need of improving ATM automation, airspace and airport demand and capacity (ATFM), meteorological information provision and publication of information in the AIP, etc.

Implementation of RNP approaches

2.9 In conformity with ICAO Assembly Resolution A36-23, CAR/SAM States have completed a PBN implementation plan that includes implementation during 2010 of vertical guide approach procedures (APV) (BARO-VNAV and/or augmented GNSS), as primary approach or as support for precision approaches.

2.10 Currently, PBN procedures have been implemented in many Caribbean airports. Nevertheless, the general implementation results will be able to be obtained towards the end of 2010, as per the implementation horizon established in the aforementioned Resolution.

Conclusion

2.11 As can be noted, many tasks have been accomplished, plus there are other implementation tasks which are the responsibility of CAR States, Territories and International Organizations. Nevertheless, with the aim of optimizing the ATS routes network, it would be convenient to develop a PBN airspace concept through an overall evaluation of the upper and lower airspace, considering:

- a) the review and implementation of routes, or the elimination of others, as necessary;
- b) analyzing the ATS routes structure, on the basis of statistical traffic movement;
- c) optimizing the route network design and the ATS airspace on the basis of traffic flows;
- d) describing a new ATS routes network proposal, upon the analysis of:
 - the implementation of PBN requirements for en-route and terminal area flights;
 - one- or two-way routes;
 - random routes;
 - the development of a performance monitoring and measuring programme;
- e) analyzing the operational GNSS use;
- f) describing the routes interface between the CAR and SAM Regions;
- g) the application of continuous descent operations (CDO), where required; and
- h) ATS routes that should be realigned, removed or replaced by RNAV routes.

2.12 This vision originated the proposal of an airspace concept in accordance with Doc 9613 - *Performance-based Navigation (PBN) Manual*, included in the **Appendix** to this WP, which could be gradually implemented in the short- and medium-terms by CAR States/Territories/International Organizations to improve the airspace organization and management (AOM), including harmonized airspace classification in the lower airspace.

2.13 It should be noted that a workshop on a PBN airspace concept will be held in ICAO NACC Regional Office from 5 to 7 July 2010. The purpose of this workshop is to review and develop a PBN airspace concept for the CAR Region, which includes harmonized airspace organization and management (AOM) aspects related to the ICAO Global ATM Operational Concept (Doc 9854).

3. Suggested Action

3.1 The Meeting is invited to:

- a) Review and provide comments to the PBN airspace concept for the CAR Region, included in the Appendix to this Working Paper;
- b) urge States/Territories to review and propose improvements to the RNAV routes network and PBN procedures (RNAV/RNP) for airspace and international airports within the Piarco FIR;
- c) urge ECAR States and Territories to participate in the PBN airspace concept Workshop for the CAR Region to be held in ICAO NACC Regional Office from 5 to 7 July 2010; and
- d) propose other actions that the Meeting might deem pertinent.

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APPENDIX

PBN AIRSPACE CONCEPT FOR THE CAR REGION BASED ON ICAO PROVISIONS

INTRODUCTION

- 1 The airspace will be organized and managed in a manner that will accommodate all current and potential new uses of airspace, *inter alia*, unmanned aerial vehicles and transiting space-vehicles.
- 2 Airspace will be organized in CAR Region and gradually, PBN interface with adjacent NAM and SAM will be harmonized with the objective of achieving a single airspace continuum. Transition between areas and Regions will be transparent to users at all time.
- 3 The efficient airspace organization and management will enhance the ability of the ATM service provider and will also increase ATM system safety, capacity and efficiency.
- 4 The implementation of a PBN Airspace Concept in CAR Region is related with the following ICAO strategic objectives:

Safety:

The implementation of Continuous Descent Operations (CDO) and approach procedures with vertical guidance APV (Baro-VNAV) and/or RNP AR, through stabilized approaches, will reduce the risk of Controlled Flight into Terrain (CFIT).

PBN implementation will facilitate the harmonization and inter-operability of procedures and operations with low fuel consumption. This will have a direct impact on safety levels.

Capacity

PBN implementation will allow the reduction of spacing between aircrafts and the use of ATC vector guidance in departure and arrival routes, which will mean a reduction of the complexity of airspace and of ATC workload. The results will allow obtaining a higher airspace capacity.

Efficiency

PBN implementation will allow aircraft operations in optimum tracks from the en route phase to the final approach and from the departure to the selected route. Efficiency will also be reflected in the publication of better climbing and descent profiles in gate to gate operations with more flexible tracks to obtain higher operational efficiency.

The Global Air Traffic Management (ATM) Operational Concept

5 The global air traffic management (ATM) operational concept, **(Doc 9854)**, presents the ICAO vision for an integrated, harmonized and globally interoperable, ATM system.

Vision Statement

To achieve an interoperable global air traffic management system for all users during all phases of flight that meets agreed to levels of safety, provides for optimum economic operations, is environmentally sustainable, and meets national security requirements.

6 The planning horizon is up to and beyond the year 2025. The baseline against which the significance of the changes proposed in the operational concept may be measured is the global ATM environment in the year 2000.

7 The implementation of the PBN Airspace Concept is supported by the Regional Performance Based Air Navigation Implementation Plan (RPB ANIP) approved by the NACC/DCA/3 Meeting, and State national implementation plans, which also describe the progressive intermediate steps toward the PBN goal.

Homogeneous ATM Area

8 A homogeneous ATM area is defined as airspace with a common ATM interest based on similar characteristics of traffic density, complexity, air navigation infrastructure requirements or other specified considerations, wherein a common detailed plan fosters the implementation of interoperable air navigation systems. The essential elements to be considered when establishing a homogeneous ATM area should be the technical and operational requirements.

9 Homogeneous ATM areas may extend over States, specified portions of States or groupings of smaller States. They may also extend over large oceanic and continental en-route areas.

Major Traffic Flow

10 A *major traffic flow* is defined as a concentration of significant volumes of air traffic on the same or proximate flight trajectories. Major traffic flows may cross several homogeneous ATM areas with different characteristics. A *routing area* is a defined area encompassing one or more major traffic flows.

11 A routing area may include groupings of routes, or area navigation (RNAV) areas, wherein it is logical to specify a detailed plan for the implementation of ATM system, where the objective is to attain a seamless system throughout the area concerned. Major traffic flows and routing areas are defined by origin and destination geographic areas, which could be States, specific portions of States or groupings of smaller States. This may include oceanic and continental en-route areas.

Planning Based on Homogeneous ATM Areas and Major Traffic Flows

12 The basic planning parameter in establishing a homogeneous ATM area or major traffic flow is the number of aircraft movements that must be provided with ATM services in an area or along a flow. Estimates and forecasts of annual aircraft movements over the planning period are therefore required for high-level planning. Forecasts of aircraft movements in peak periods, such as during a particularly busy hour, are needed for detailed planning. Additionally, appropriate civil/military coordination is required for the flexible use airspace (FUA).

PBN Implementation

13 Nowadays air navigation depends mostly of ground nav aids which inherent limitations prevent seamlessness and flexibility required by air operations, specifically in airports with complex topography.

14 Performance-based navigation (PBN), considering area navigation (RNAV) and required navigation performance (RNP), solves these limitations using current aircraft navigation capabilities.

15 Performance-based navigation specifies the RNAV system performance requirements operating on an ATS route, an instruments approach procedures or on an airspace.

16 The objective of a PBN is to harmonize implementation of navigation specifications in oceanic and continental areas for flights en-route, terminal and approach, as the following table specifies:

Navigation Specification	Flight Phase							
	En Route Oceanic / Remote	En Route Continental	ARR	APPROACH				DEP
				Initial	Interm.	Final	Missed	
RNAV 10	10							
RNAV 5		5	5					
RNAV 2		2	2					2
RNAV 1		1	1	1	1		1 ^b	1
RNP 4	4							
Basic RNP 1			1 ^{a,c}	1 ^a	1 ^a		1 ^{ab}	1 ^{a,c}
RNP APCH				1	1	0.3	1	
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1	

Notes: - The numbers given in the table refer to the 95 per cent accuracy requirements (NM).
 - RNAV 5 is an en-route specification which may be used for the initial part of the STAR outside 30 NM and above MSA.
 - 1^a means that the navigation application is limited to use on STARs and SIDs only.
 - 1^b means that the area of application can only be used after the initial climb of a missed approach phase.
 - 1^c means that beyond 30 MN from the airport reference point (ARP), the accuracy value for alerting becomes 2 MN.

17 The area of application of a PBN airspace concept is the 13 FIRs in the CAR Region: Central American, Curacao, Havana, Houston Oceanic, Kingston, Mazatlan Oceanic, Mexico, Miami Oceanic, Nassau, Piarco, Port-au-Price, San Juan, and Santo Domingo.

Airspace user operations

18 Airspace user operations are referred to the airspace related aspects of flight operations, as follows:

- a) the users needs and accommodation of aircraft capabilities should be addressed to enhance safety and efficiency;
- b) relevant ATM data will be fused for an airspace user's tactical and strategic situational awareness and conflict management;
- c) availability of relevant airspace user operational information will improve; and
- e) collaborative decision making will be encouraged to ensure that aircraft capabilities and user expectations will be taken into account for the airspace design.

Airspace organization and management

19 The CAR Region is considered as a homogeneous ATM area with particular routing routes with adjacent regions NAM and SAM. Transition between areas and Regions will be transparent to users at all time.

20 All airspace will be a usable resource. The organization, flexible allocation and use of airspace will be based on the principles of access and equity. ATM Service providers in charge of managing this airspace should make the tactical modifications to specific parts of airspace, according to their own operational needs.

21 It is foreseen that efficient airspace organization and management will provide the first layer for airspace users of conflict management, will enhance the ability of the ATM service provider and will also increase ATM system safety, capacity and efficiency.

Airspace organization

22 The airspace organization function will provide the strategies, rules and procedures by which the airspace will be structured to accommodate the different types of air activity, volume of traffic, and differing levels of service and rules of conduct. The airspace organization should be in accordance with the ICAO airspace classification. The principles of organization will be applicable from high and low traffic flow, en-route, oceanic and domestic, terminal and approach airspace. The organizational principles include the following:

- a) airspace should be organized to be easily learned, understood and used by the ATM community.
- b) Airspace organizational boundaries and divisions will be adjusted to particular traffic flows and changing situations so as to allow actual operations to dictate a more optimum configuration, and should not be constrained by national or facility boundaries;
- c) airspace should be organized to facilitate the seamless operations of flights and the ability to conduct flights along optimum flight trajectories from gate to gate eliminating if possible all restriction or delay; and

- d) airspace organization should establish ATS route system and dynamic trajectories so as to enable aircraft to operate along, or as near as practicable to, the preferred flight paths . Airspace management should be dynamic, flexible and based on services demanded.

23 Airspace organization will be based on the principle that all airspace is managed to meet the needs of the ATM community. “Managed” means that a strategic or tactical decision at the level of service to be provided will be taken by the appropriate authority and/or air navigation service providers (ANSP).

24 There should not be permanent/fixed constrained airspace, airspace should be subjected to service limitations, including access over an extended period, motivated by national interests or safety issues and appropriately considered in coordination with the ATM community.

25 Priority for the use of specific airspace will not be constrained by the primary usage or equipage on a routine basis. While it is recognized that airspace designation is useful, it should not be organized in a manner that permanently precludes the possibility of mixed usage/mixed equipage operations.

Optimization of the ATS routes structure in the en-route airspace

26 As of 2000, when the ATS routes implementation process started, the implementation of many RNAV routes in the CAR/SAM upper airspace was achieved, as per GREPECAS recommendations, plus many other new ones which had not been foreseen. These implementations have been carried out by identifying the particular needs of the users, operators and ATS services providers. The implementation programme has generated important operational and economical benefits.

27 Upon evaluating the operational results of the most direct flight trajectories, as well as the savings in flight distances and time obtained through the implementation of RNAV routes, it can be concluded that the air operators requirements to obtain operational and economical advantages has been satisfied in great measure. Nevertheless the benefits obtained, the possibility of implementing new RNAV routes has been identified.

28 In addition, the NDB equipment removal, the traffic increase forecast for the next years, the great demand of direct trajectories outside the airway and the possible implementation of additional routes could lead to saturation in the various airspaces, which would complicate the airspace management.

29 Therefore, it should carry out an overall review to the upper airspace, considering the possible implementation of new RNAV routes and the removal of those low use conventional routes, whose trajectory coincides or is similar to the fixed RNAV or random routes.

Optimization of the ATS routes structure in the terminal airspace

30 GREPECAS recommended the implementation of trunk routes that might link the upper airspace RNAV routes with the arrival and exit routes implemented in the terminal areas. To improve the ATS routes network in the terminal areas standard instrument departure routes (SIDs) and standard terminal arrival routes (STARs) should be implemented for each instrument runway when air traffic justifies their application. Its purpose is to facilitate the description of the route and procedure in ATC clearances.

31 Several SIDs and STARs have been implemented and improved in the terminal areas and international airports of CAR States. Nevertheless, considering the current aircraft navigation capacity, it becomes necessary to evaluate other alternatives that permit linking the upper airspace routes structure with the terminal area routes; one of these alternatives is the implementation of continuous descent operations (CDO), known also as stabilized approaches.

32 The CDO allows an optimum profile descent and can include the arrival route of an optimum trajectory calculated by the aircraft flight management computer (FMC) from the initial top of descent point (TOD), or another operationally defined point, up to a point where the approach procedure to the airport is started.

33 The CDO concept permits adjusting an aircraft's arrival trajectories and designate the speed necessary to maintain the separation and the order that the air traffic control (ATC) provides and can provide a substantial improvement in operational forecasting, reducing workload of pilots and controllers. The CDO also maximizes the advantages for each flight in terms of less fuel consumption, less gas emissions and less noise, as well as better forecasting possibilities for the flight crew and the aircraft user.

34 The implementation of CDOs entails a review to the organization of the lower airspace and improving air traffic management, where operational advantages can be obtained. The implementation tasks and advantages of CDO also have impact on other air navigation areas, such as the need of improving ATM automation, airspace and airport demand and capacity, meteorological information provision and publication of information in the AIP, etc.

35 The following are international airports where CDO is able to be implemented:

BARBADOS

TBPB BRIDGETOWN /Grantley Adams Intl.

COSTA RICA

MROC ALAJUELA /Juan Santamaría Intl.

CUBA

MUHA HABANA /José Martí

EL SALVADOR

MSLP SAN SALVADOR / EL SALVADOR Intl.

GUATEMALA

MGGT GUATEMALA /La Aurora

HONDURAS

MHTG TEGUCIGALPA /Toncontin Intl.

JAMAICA

MKJP KINGSTON / Norman Manley Intl.

MEXICO*MMUN CANCUN /Cancún Intl.**MMGL GUADALAJARA /Miguel Hidalgo Costilla Intl.**MMM MEXICO /Lic. Benito Juárez Intl.**MMMY MONTERREY /Gral. Mariano Escobedo Intl.**MMPR PUERTO VALLARTA /Lic. Gustavo Díaz Ordaz Intl.**MMSD SAN JOSE DEL CABO /San José del Cabo Intl.**MMTO TOLUCA /Lic. Adolfo López Mateos Intl.***PUERTO RICO***TJSJ SAN JUAN /Luis Muñoz Marín Intl.***TRINIDAD Y TOBAGO***TTPP PORT OF SPAIN /Piarco Intl. Trinidad I.***Implementation of PBN Approach Procedures**

36 According to the ICAO Assembly Resolution A36/23 States should implement approach procedures with vertical guidance (APV) to all runway ends serving aircraft with a maximum certificated take-off mass of 5700 kg or more, according to the following timelines and intermediate milestones:

- i) Implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones; and
- ii) Implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS) for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014.

Implementation Phases of PBN Airspace Concept

37 The implementation of PBN Airspace Concept should be in three phases as follows:

Stage	Operational improvement
Stage I (2010 2011)	<u>Review of ATS route network in the CAR Region</u> • Gathering data on aircraft PBN capacity • Review of CNS infrastructure • Realignment and implementation of new RNAV routes in the upper airspace based on RNAV5 • Implementation of RNAV routes in the lower airspace based on RNAV1, RNAV2 and RNP1 • Implementation of approach procedures PBN APV (BARO-VNAV in accordance with Assembly Resolution A36-23)
Stage II (2011 2012)	<u>Review and interface of the ATS routes network in the CAR/SAM Regions</u> • Realignment and Implementation of new RNAV routes in the interface of the upper airspace between the CAR and SAM Regions, based on RNAV5 or RNAV2, as applicable • Implementation of CDO in international airports, as required

Stage	Operational improvement
Stage III (2012 2014)	• Elimination of conventional ATS routes in the upper and lower airspace, as required • Implementation of random routes, by airspace altitude stratum • Review of the upper airspace configuration • Review of the lower airspace configuration • Implementation of the flexible use of airspace (FUA) • Implementation of the dynamic ATS route management

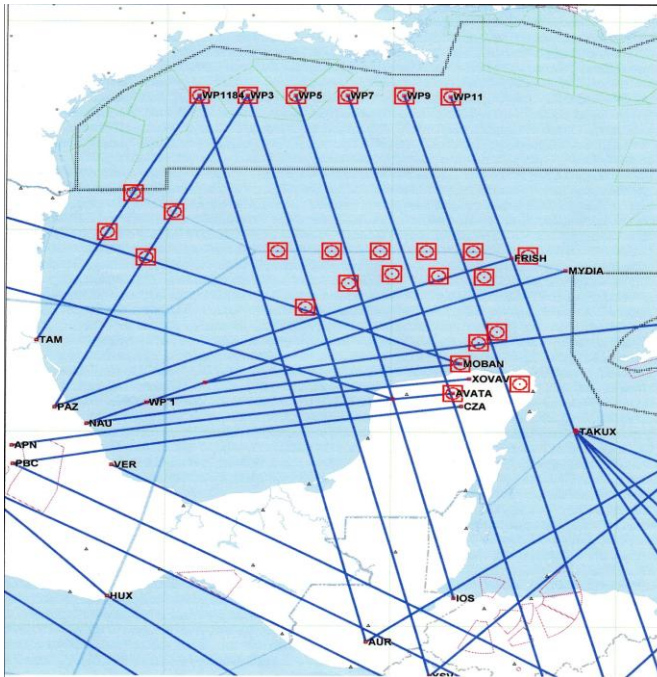
38 In any phase, the LOAs between ATS units will be reviewed, if applicable

39 The **Attachment** to this Appendix provides diagrams on:

- proposal of PBN routes for their implementation in the upper airspace of the CAR Region;
- proposal of PBN routes for their analysis and implementation on the CAR/SAM upper airspace;
- a model of a descent profile for CDO; and
- a model of a PBN approach procedures.

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Apéndice / Appendix
Concepto de Espacio Aéreo - PBN – Airspace Concept

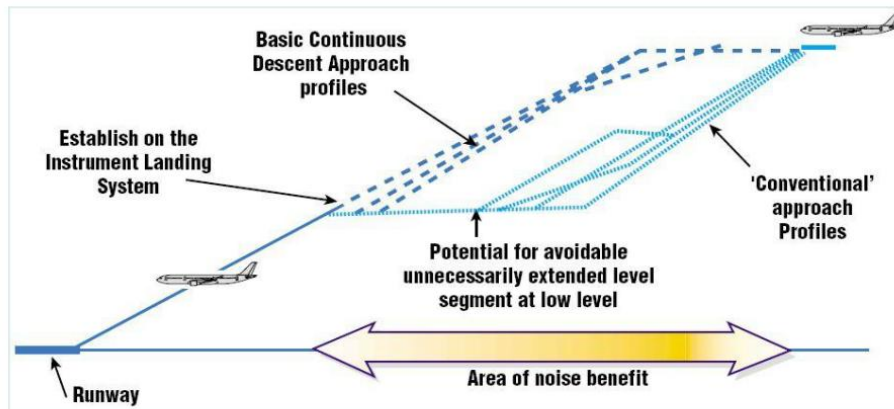


Extend
RNAV
Routes in
the CAR
Region



Extend
RNAV
Routes in
the
CAR/SAM
Regions

Continuous Descent Approach



ICAO-ANB

RNP Approach (RNP APCH) Procedure Design

