PBN AIRSPACE CONCEPT FOR THE CAR REGION

INTRODUCTION

1. The CAR Region airspace will be organized and managed in a manner that will accommodate all current and envisioned users of the airspace, *inter alia*, civil and military aircraft, unmanned aircraft systems and transiting spacecraft.

2. The implementation of the PBN Airspace Concept is supported by the ICAO Global ATM Operational Concept (Doc 9854), PBN Manual (Doc 9613), and the Regional Performance-based Air Navigation Implementation Plan (RPB ANIP) for NAM/CAR Regions.

3. PBN airspace concept will allow direct improvements to the airspace organization and management (AOM) and on other implementation activities such as improvements in ATM situational awareness, airspace and airport demand and capacity balancing (DCB), airport operations (AO), provision of meteorological information and publication of information in the AIP, etc.

4. Efficient airspace management will enhance the capacity of the air navigation service provider (ANSP) and will increase ATM system safety, capacity and efficiency in benefit to the ATM community. Environmental protection benefits will be periodically measured against implementation achievements.

5. Implementation of a PBN Airspace Concept in the CAR Region is consistent with the following strategic objectives:

   **Safety:**

   Implementation of a PBN Airspace Concept will facilitate the harmonization and interoperability of procedures and air operations among the ATS airspace.

   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).

   **Capacity**

   Implementation of a PBN Airspace Concept will allow the reduction of spacing between aircraft and the use of ATC vector guidance in departure and arrival routes, which will result in a reduction of airspace complexity and of ATC workload. The final goal effect will be an increment in ATS airspace capacity.
**Efficiency**

Implementation of a PBN Airspace Concept will allow aircraft operations on optimum tracks from the en-route phase to final approach and from departure to the selected route. Efficiency will also be reflected in the publication of better climb and descent profiles in gate-to-gate operations with more flexible tracks to increase operational efficiency, while reducing fuel consumption.

**The Global Air Traffic Management (ATM) Operational Concept**

6 The global ATM operational concept presents the ICAO vision for an integrated, harmonized and globally interoperable, ATM system. The planning horizon is up to and beyond the year 2025.

<table>
<thead>
<tr>
<th>Vision Statement</th>
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</thead>
<tbody>
<tr>
<td>To achieve an interoperable global air traffic management system, for all users during all phases of flight, that meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable and meets national security requirements.</td>
</tr>
</tbody>
</table>

**Homogeneous ATM Area**

7 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.

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

**Major Traffic Flow**

9 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.

10 A routing area may include groupings of routes, or area navigation (RNAV) areas, wherein is a specific detailed plan for the implementation of an ATM system; the objective is to attain a seamless system.

11 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 are required for high-level planning. Forecasts of aircraft movements in peak periods, such as during a particularly busy hour, are needed for detailed planning.

13 The CAR Region is a homogeneous ATM area with routes extending into the adjacent NAM and SAM Regions. Transition air operations between areas and regions will be transparent to users.

Implementation of PBN Airspace Concept

14 Having a very strategic geographical location at the confluence of ATS routes connecting the major destinations, Caribbean airspace has become a vital link to the flow of traffic between NAM and SAM Regions.

15 Traditionally, air navigation depended mostly on ground-based nav aids with inherent limitations that prevent the seamlessness and flexibility required for efficient air operations, specifically in the vicinity of airports with complex topography.

16 Performance-based navigation, comprising area navigation (RNAV) and required navigation performance (RNP), solves these limitations using existing aircraft navigation capabilities.

17 PBN specifies the navigation performance requirements necessary to operate on an ATS route, an instrument approach procedure or in a particular airspace.

18 Based on the evaluation of the navigation infrastructure it has been identified that the oceanic area of the Gulf of Mexico and the oceanic area of the Curaçao, Jamaica and Dominican Republic FIR requires an automatic dependent surveillance (ADS) or controller-pilot data link communications (CPDLC) for the implementation of the RNP. The coverage of the radionavigation aids networks, based on ground and satellite as well as the radar coverage and the communication coverage allows implementing specifications on navigation RNAV 5, RNAV 2, RNAV 1 in the remaining CAR airspace, as required. For the implementation of the RNP procedures in the lower airspace, the States, Territories, International Organizations should analyze the coverage of radionavigation aids based on ground and satellite.

19 The comprehensive implementation of the PBN airspace concept will harmonize navigation specifications for all phases of flight on oceanic and continental en-route areas, terminal area and approach segments, and will harmonize ATS route network between NAM, CAR and SAM Regions with the objective of achieving a single airspace continuum. The application of navigation specification by flight phase is determined by the following table:
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<tbody>
<tr>
<td>RNAV/RNP 10</td>
<td>10</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>RNAV 5</td>
<td>5</td>
<td>5</td>
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<tr>
<td>RNAV 2</td>
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<td>RNAV 1</td>
<td>1</td>
<td>1</td>
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<td>RNP 4</td>
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<td></td>
<td></td>
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<tr>
<td>Basic RNP 1</td>
<td></td>
<td>1¹,2,3</td>
<td>1¹</td>
<td>1¹</td>
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<td></td>
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<tr>
<td>RNP APCH</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>0.3</td>
<td>1</td>
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<td></td>
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<tr>
<td>RNP AR APCH</td>
<td></td>
<td></td>
<td>1-0.1</td>
<td>1-0.1</td>
<td>0.3-0.1</td>
<td>1</td>
<td></td>
<td></td>
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</tbody>
</table>

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 the minimum sector altitude.
- ¹ The navigation application is limited to use on standard instrument arrivals (STARs) and standard instrument departures (SIDs) only.
- ² The area of application can only be used after the initial climb of a missed approach phase.
- ³ Beyond 30 NM from the airport reference point (ARP), the accuracy value for alerting becomes 2 NM.

20 The application of the PBN airspace concept is for the following 14 flight information regions (FIRs) of CAR Region:

Central American, Curacao, Habana, Houston Oceanic, Kingston, Mazatlan Oceanic, Mexico, Miami Oceanic, Nassau, New York Oceanic, Piarco, Port-au-Prince, San Juan, and Santo Domingo.

21 La implementación integral del concepto de espacio aéreo PBN comprende una optima revisión de rutas ATS en el espacio aéreo inferior y superior, la implementación de operaciones de descenso continuo (CDO) mediante el uso del sistema de gestión de vuelo (FMS) en las áreas terminales (TMAs), así como la implementación de procedimientos de aproximación RNAV/RNP, según sea necesario. La siguiente tabla presenta la relación entre el área de aplicación con la especificación de navegación, el nivel de precisión, así como con los requisitos de monitoreo y alerta y los sensores de radio-navegación a bordo de la aeronave.
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceanic /Remote</td>
<td>RNAV 10 / (RNP 10)</td>
<td>10</td>
<td>No</td>
<td>GNSS / INS-IRU</td>
</tr>
<tr>
<td></td>
<td>RNP 4</td>
<td>4</td>
<td>Yes</td>
<td>GNSS</td>
</tr>
<tr>
<td>En route Continental</td>
<td>RNAV 5</td>
<td>5</td>
<td>No</td>
<td>GNSS / INS-IRU / DME-DME / DME-DME-IRU / DME-VOR</td>
</tr>
<tr>
<td>En route Continental and Terminal</td>
<td>RNAV 2</td>
<td>2</td>
<td>No</td>
<td>GNSS / DME-DME / DME-DME-IRU</td>
</tr>
<tr>
<td></td>
<td>RNP 2 (TBD)</td>
<td>2</td>
<td>Yes</td>
<td>GNSS</td>
</tr>
<tr>
<td>Terminal</td>
<td>RNAV 1</td>
<td>1</td>
<td>No</td>
<td>GNSS / DME-DME / DME-DME-IRU</td>
</tr>
<tr>
<td></td>
<td>Basic RNP 1</td>
<td>1</td>
<td>Yes</td>
<td>GNSS</td>
</tr>
<tr>
<td>Approach</td>
<td>RNP APCH</td>
<td>0.3</td>
<td>Yes</td>
<td>GNSS</td>
</tr>
<tr>
<td></td>
<td>RNP AR</td>
<td>0.3-0.1</td>
<td>Yes</td>
<td>GNSS</td>
</tr>
</tbody>
</table>

**Airspace user operations**

Airspace user operations refer to the airspace-related aspects of flight operations, as follows:

a) the users’ needs and aircraft navigation capabilities will be identified in order to enhance safety and efficiency;

b) relevant ATM data will be made available for the airspace user’s tactical and strategic situational awareness and conflict management;

c) relevant airspace users operational information will be available to the ANSP to enhance tactical and strategic situational awareness and conflict management; and

e) collaborative decision-making will be encouraged to ensure that users expectations and aircraft capabilities will be taken into account when designing the airspace.
Air navigation service providers in charge of managing airspace will be able to make tactical modifications to specific parts of airspace to respond in real-time to changing situations in traffic patterns and/or runway(s) in use, according to operational needs.

The dynamic configurations on airspace will be established according to the transit flow forecasted in order to optimize dynamically the user-preferred path based on statistical data. The airspace management will consider the procedure application and dynamic sector division through flexible routes (parallel and perpendicular) according to the operational requirements in benefit of the air operations.

In order to achieve a dynamic management of air space the organization should be analyzed for the vertical strata on airspace through the strategic application of one or the combination of the following actions:
a) From the minimum en-route altitude (MEA) up to FL190 aircraft operations will be allowed using the route network RNAV published,

b) From FL200 to FL350, through the continental or oceanic airspace, the aircraft operations will be allowed:
   i) on RNAV random routes, or
   ii) on the fixed RNAV regional and/or national networks

c) The long-haul flights above FL360 should be allowed to operate on RNAV random routes based on foreseen transit flows as much as possible

30- The air transit management at the aerodromes should facilitate the route operation RNAV and/or RNP optimized in all meteorological conditions and it should as well, comply with the overcome of obstacles and protection to the environment. The proper authority and the ANSPs should make sure to spread at the appropriate time the norms and procedures applicable in the different classes of airspace.

31 There should be no permanent/fixed constrained airspace or during an extended period; airspace should only be subjected to service limitations, national interests or safety issues. All airspace constraints should be properly coordinated with the ATM community. Additionally, for a complete dynamic airspace management implementation of efficient civil/military coordination is required so as to achieve flexible use of airspace (FUA).

32 Airspace should not be organized in a manner that permanently precludes the possibility of mixed usage/mixed equipage operations. Priority for the use of specific airspace should not be constrained by equipage usage.

Optimization of the ATS route structure in en-route airspace

33 Up to date, many RNAV routes have been implemented in the upper CAR/SAM airspace, as per GREPECAS recommendations, plus many additional routes which had not been foreseen. These implementations have been carried out by identifying the needs of the users, operators and ANSPs. The implementation programmes have generated important operational and economical benefits.

34 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 operators’ requirements to obtain operational and economical advantages have been satisfied in great measure. Consistent with the benefits obtained, the need for additional RNAV routes has been identified.

35 The regionally agreed decommissioning of NDBs combined with forecast traffic growth, the increasing demand for direct trajectories outside conventional airways and the possible implementation of additional RNAV routes could lead to saturation in various airspaces, further complicating airspace management.
Therefore, an overall review of the upper airspace should be conducted considering the possible implementation of RNAV routes and the removal of those rarely used conventional routes whose trajectories coincide with or are similar to fixed RNAV or random routes.

**Optimization of the ATS route structure in terminal airspace**

GREPECAS recommended the implementation of trunk routes to link the upper airspace RNAV routes with the arrival and departure routes implemented in terminal areas. Standard instrument arrivals (STARs) and standard instrument departures (SIDs) should be designed to connect directly to the upper airspace ATS route network in order to enhance airspace management and provide more consistent flight paths and stabilized approach paths while reducing pilot and ATC workload, radio-frequency transmissions, fuel consumption and incidence of controlled flight into terrain (CFIT).

SIDs and STARs have been implemented and improved in the terminal areas of international airports of many CAR States. Nevertheless, considering the current aircraft navigation capability, it is appropriate to consider extending these procedures, linking the upper airspace route structure directly with the terminal area routes.

The soon-to-be-published *Continuous Descent Manual*, Doc 9931, urges States to consider implementation of continuous descent operations (CDO) on all STARs, starting from top of descent in the upper airspace. To this end, STARs should be designed such that they connect directly from the en-route RNAV or conventional routes to the instrument approach procedure.

A CDO allows an optimum profile descent on the published arrival route, calculated by the aircraft’s flight management computer (FMC) from the initial top-of-descent point (TOD), or other operationally defined point, to the point where the approach procedure to the runway is commenced.

The CDO concept permits ATC to adjust an aircraft’s arrival trajectory and speed if necessary to maintain separation and sequencing from other aircraft while providing a substantial operational improvement, and reducing workload of both pilots and controllers. The CDO also maximizes the advantages for each flight in terms of reduced fuel consumption, gaseous emissions and noise, as well as better forecasting possibilities for the flight crew and the aircraft operator.

Continuous descent operations are enabled by airspace design, procedure design and ATC facilitation, allows the aircraft to descend continuously employing minimum engine thrust in a low drag configuration. CDO is potentially usable by 85% of the aircraft, 85% of the flight time of descent.

The implementation of CDOs entails a review of the organization of upper and lower airspace and consequential improvements to air traffic management in order to determine where operational advantages can be obtained. The following are international airports where CDOs could be implemented:

**BARBADOS**
*TBPB BRIDGETOWN /Grantley Adams Intl.*

**COSTA RICA**
*MROC ALAJUELA /Juan SantamaríaIntl.*
GRAND CAYMAN
MWCG / Roberts International Airport

CUBA
MUHA HABANA /José Martí

DOMINICAN REPUBLIC
MDPC PUNTA CANA INTERNATIONAL AIRPORT

EL SALVADOR
MSLP SAN SALVADOR / EL SALVADOR Intl.

GUATEMALA
MGGT GUATEMALA /La Aurora

HONDURAS
MHTG TEGÚCIGALPA /Toncontín Intl.

JAMAICA
MKJP KINGSTON / Norman Manley Intl.

MEXICO
MMUN CANCUN / Cancún Intl.
MMGL GUADALAJARA / Miguel Hidalgo Costilla Intl.
MMMX 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 AND TOBAGO
TTTP PORT OF SPAIN / Piarco Intl. Trinidad I.

The Continuous Climb Operations (CCO) also provide States and other stakeholders with pragmatic guidance on how to implement CCOs for departing aircraft climbing continuously, ideally to cruise level.

PBN Implementation

According to ICAO Assembly Resolution A37/11, States should complete and implement PBN action plan as follows:

1) implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones;

2) implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV only minima 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; and

3) implementation of straight-in LNAV only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting available and where
there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5 700 kg or more;

46 The ICAO NACC Regional Office has elaborated an action plan that is presented in the attachment to provide assistance to the States in a harmonized implementation of the PBN with a methodology.

**Implementation Phases**

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

<table>
<thead>
<tr>
<th>Stage</th>
<th>Operational improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage I</strong></td>
<td>Review of ATS route network in the CAR Region</td>
</tr>
<tr>
<td>(2010 - 2011)</td>
<td>• Gathering data on aircraft PBN capacity</td>
</tr>
<tr>
<td></td>
<td>• Review of CNS infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Realignment and implementation of new RNAV routes in the upper airspace based on RNAV 5</td>
</tr>
<tr>
<td></td>
<td>• Implementation of RNAV routes in the lower airspace based on RNAV 1, RNAV 2 and RNP 1, as required</td>
</tr>
<tr>
<td></td>
<td>• Implementation of approach procedures PBN APV (BARO-VNAV in accordance with Assembly Resolution A36-23)</td>
</tr>
<tr>
<td><strong>Stage II</strong></td>
<td>Review and interface of the ATS routes network in the CAR/SAM Regions</td>
</tr>
<tr>
<td>(2011 - 2012)</td>
<td>• Realignment and implementation of new RNAV routes in the interface of the upper airspace between the CAR and SAM Regions, based on RNAV 5 or RNAV 2, as applicable</td>
</tr>
<tr>
<td></td>
<td>• Implementation of CDO in international airports, as required</td>
</tr>
<tr>
<td><strong>Stage III</strong></td>
<td>• Elimination of conventional ATS routes in the upper and lower airspace, as required</td>
</tr>
<tr>
<td>(2012 - 2014)</td>
<td>• Implementation of random routes, by airspace altitude stratum</td>
</tr>
<tr>
<td></td>
<td>• Review of the upper airspace configuration</td>
</tr>
<tr>
<td></td>
<td>• Review of the lower airspace configuration</td>
</tr>
<tr>
<td></td>
<td>• Implementation of flexible use of airspace (FUA)</td>
</tr>
<tr>
<td></td>
<td>• Implementation of dynamic ATS route management</td>
</tr>
</tbody>
</table>

48 In each phase, the air traffic management procedures and Letters of Agreement between ATS units will be reviewed accordingly, as applicable.

49 States, Territories and ANSPs concerned should develop their action plans including development and implementation of PBN airspace concept, with progressive tasks according to the PBN regional goals.
### Safety assessment

50 Previous to the implementation of a new route or procedure, or changes to the same, an evaluation of the risks should take place in order to guarantee the safety according to ICAO SMS provisions. The safety evaluation could be qualitative or quantitative under the responsibility of the ANSPs in coordination with the aeronautical authority of the States. The references to evaluate the safety previous to the PBN implementation are according to the following table:

<table>
<thead>
<tr>
<th>Navigation specification</th>
<th>Safety assessment references</th>
</tr>
</thead>
</table>
| RNAV/RNP 10              | 1) Regional Supplementary Procedures (Doc 7030)  
2) Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689)  
3) Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM) (Doc 4444) |
| RNAV 5                   | EUROCONTROL B-RNAV route spacing study European Region Area Navigation (RNAV) Guidance Material (ICAO EUR Doc 001, RNAV/5) |
| RNAV – RNP 2             | TBD                         |
| RNAV 1                   | EUROCONTROL safety assessment of PRNAV route spacing and aircraft separation |
| RNP 4                    | 1) Regional Supplementary Procedures (Doc 7030)  
2) Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689)  
3) Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM) (Doc 4444) |
| BASIC RNP 1              | Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS) (Doc 8168), Volume II |
| Advanced-RNP 1           | TBD                         |
| RNP APCH                 | Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS) (Doc 8168), Volume II |

51 A monitoring programme should be established to evaluate the safety after the PBN implementation through the analysis and measurement of performance data according to the established on ICAO’s Air Traffic Management Manual (Doc 4444) and the Safety Management Manual (Doc 9859)