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Twelfth Meeting of the Civil Aviation Authorities of the SAM Region (RAAC/12)
(Lima, Peru, 3 to 6 October 2011)

Agenda Item 6: Analysis on Environmental Protection and Sustainable Development of Air Transport

b) Fuel savings and reduction of CO_2 emissions

IMPLEMENTATION OF PERFORMANCE BASED NAVIGATION IN BRAZIL

(Presented by Brazil)

SUMMARY

This Working Paper presents the PBN implementation project in Brazil, which is the main tool available for fuel savings and the consequent reduction of CO2 emissions, contributing to the sustainable development of national and international air transport.

References:

- Resolution A37-11, of the 37th ICAO Assembly;
- Doc 9613 - PBN Manual; and
- Doc 9883 - Manual on Global Performance of the Air Navigation System.

ICAO Strategic Objectives:	*A - Safety* *C - Environmental Protection and Sustainable Development of Air Transport*

1. Introduction

1.1 The 11th Air Navigation Conference recommended that ICAO address and move forward with urgent issues related to the introduction of Area Navigation (RNAV) and Required Navigation Performance (RNP).

1.2 The Global Air Navigation Plan has identified Global Plan Initiatives (GPIs) to concentrate on the incorporation of advanced aircraft navigation capabilities into the infrastructure of air navigation systems and the optimization of terminal control areas through improved design and management techniques, the implementation of SID and STAR with RNP and RNAV and to offer more efficient aircraft operations in terms of fuel savings, through arrival procedures based on FMS.

1.3 Resolution A36/23 of the 36th Assembly, ratified by resolution A37/11 of the 37th Assembly urged all States to implement RNAV and RNP air traffic services (ATS) route and approach procedures in accordance with ICAO's PBN concept defined in the PBN Manual.

1.4 The meetings of the SAM Implementation Group (SAM/IG), in accordance with the aforementioned resolutions of the ICAO Assemblies, have developed a PBN implementation process, with guidance material and implementation project models, among others, with a view to ensuring the harmonization of PBN implementation in South America.

1.5 Following the ICAO guidelines, Brazil has implemented PBN in the Brasília and Recife TMAs, in order to optimize the airspace structure and gain enough experience for such a deployment to be possible in more complex airspaces, such as, for example, the Rio de Janeiro and São Paulo TMAs.

2. Implementation of PBN in São Paulo and Rio de Janeiro TMAs

2.1 Airspace Concept

2.1.1 An Airspace Concept provides the outline and intended framework of operations within an airspace. Airspace concepts are developed to satisfy explicit strategic objectives such as improved safety, increased air traffic capacity and mitigation of environmental impact etc. Airspace Concepts should include details of the practical organization of the airspace based on the characteristics of their users, as well as CNS/ATM infrastructure available or to be implemented.

2.1.2 The PBN implementation in Rio de Janeiro and São Paulo TMAs will address the following Strategic Objectives:

a) Safety
b) Capacity
c) Efficiency
d) Environment protection
e) Access

2.2 Analysis of air traffic flows

2.2.1 In the context of PBN Implementation Project, the main traffic flows in the Rio de Janeiro and São Paulo Terminal Control Areas (TMAs) were identified, both in historical terms and considering their future growth by the year 2015.

2.2.2 The main traffic flows should be considered in planning the airspace structure in order prioritize them in terms of defining the routes between airports and air navigation procedures, IAC, STAR and SID.

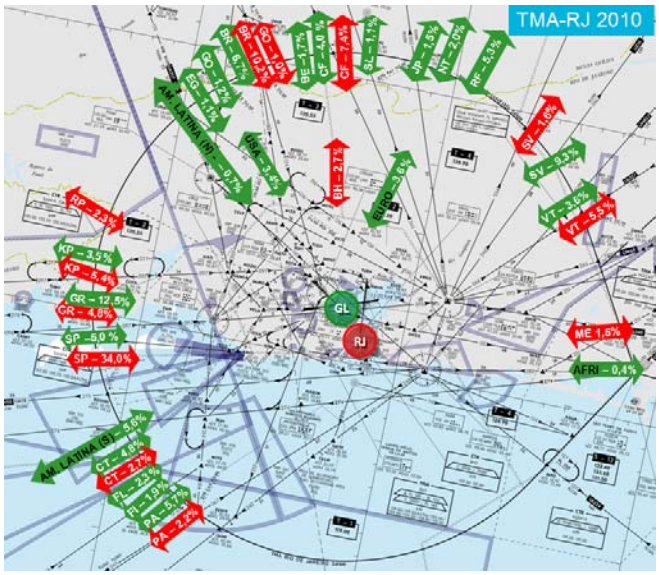

Figure 1: Major Traffic Flows of the RJ TMA

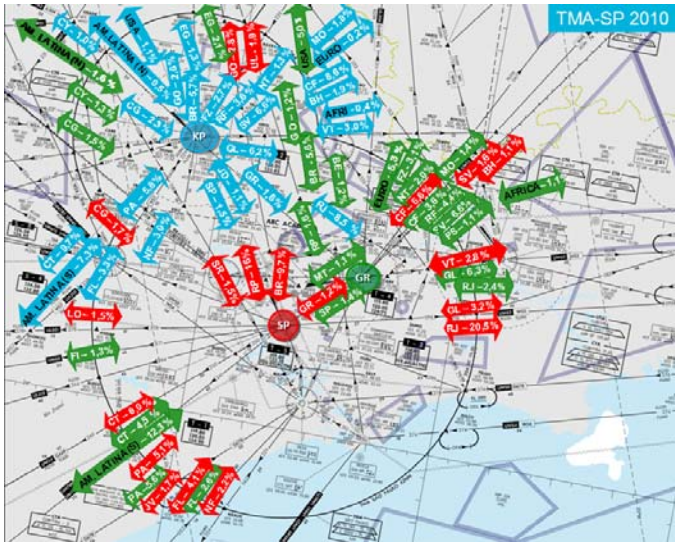

Figure 2: Major Traffic Flows of the SP TMA

2.3 Traffic projections for the airspace involved

2.3.1 Considering that PBN implementation in the RJ and SP TMAs is estimated for April 2013, it became necessary to analyze the projection of demand in the airspace involved, to ensure that the implementation in question meets the air traffic flows expected for the specified timeframe. Thus, air traffic flows between the major airports in the country and the RJ and SP TMAs were identified for the year 2015.

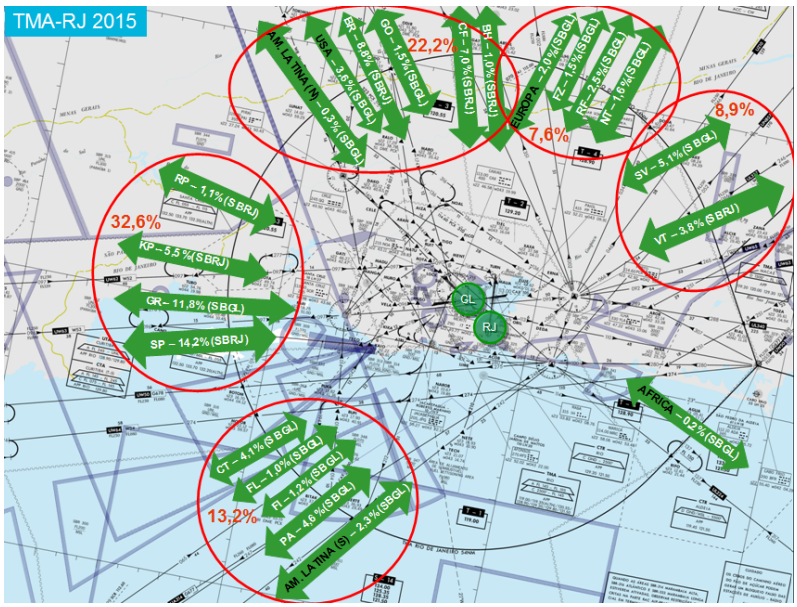

Figure 3: Rio de Janeiro ARC (2015)

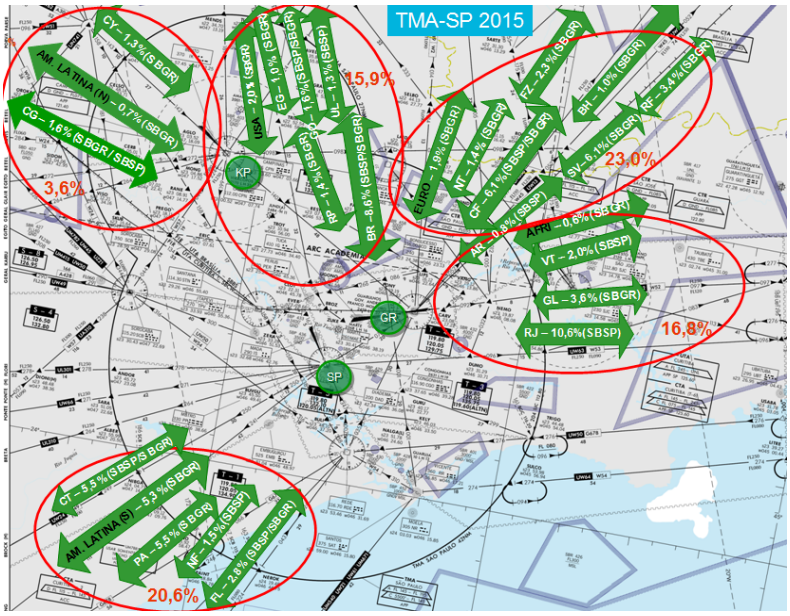

Figure 4: São Paulo ARC (2015)

2.4 Analysis of the navigation capability of the aircraft fleet that operates in the TMAs

2.4.1 Based on statistical data and the characteristics of the fleet, the navigation capability of the aircraft fleet operating in the RJ TMA and SP TMA was assessed and the percentage of operations to be benefited by the PBN project was estimated, as summarized below:

	RNAV Capability	
	GNSS	GNSS/DME/DME/INERTIAL
SBGL	81%	89%
SBRJ	60%	69%
TMA-RJ	69%	79%
SBGR	83%	96%
SBSP	72%	72%
SBKP	87%	88%
TMA-SP	76%	85%

Table 1: Summary of the percentage of operations to be benefited by the PBN project in the TMAs

2.5 Development of the new route structure

2.5.1 Based on the statistical data of the PBN project, air traffic flows between the major airports in the country and the RJ and SP TMAs were identified for the year 2015.

2.5.2 Thus, considering the PBN concept in Terminal area, ideal entry and exit flows were observed, not only between the SP and RJ TMAs, but also in the main surrounding TMAs: Curitiba, Brasília, Belo Horizonte (Figure 5). The ideal scenario of the route structure will serve as the basis for the development of the airspace concept (STAR and SID) of these TMAs.

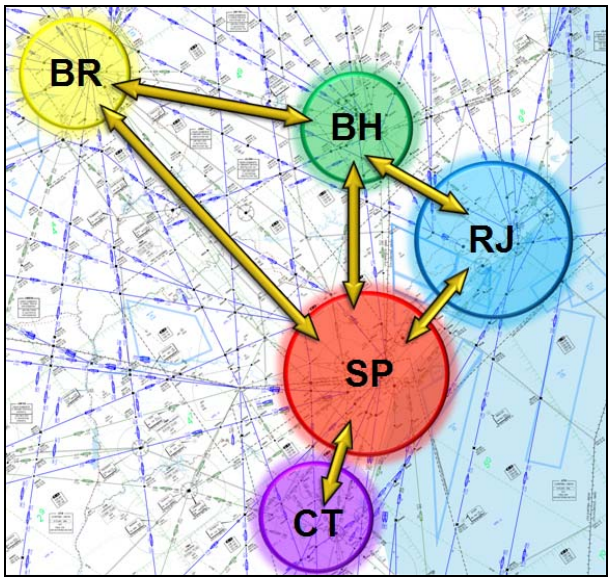

Figure 5: Major Traffic Flows between the SP and RJ TMAs

2.5.3 **Restructuring the network of routes**

2.5.3.1 Considering all the results presented, the study aimed at restructuring the routes network located inside the polygon comprising the SP, RJ, BR, BH and VT TMAs (Figure 6).

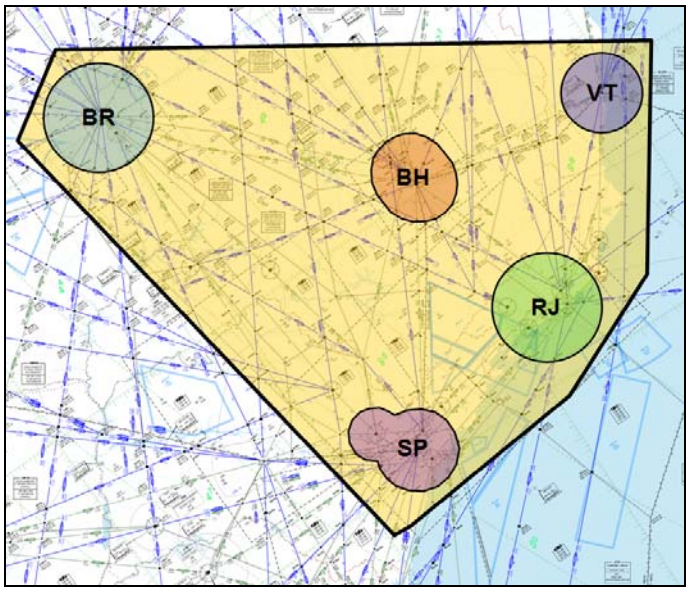

Figure 6 - Polygon comprising route changes

2.5.3.2 Thus, with the restructuring of the RNAV 5 routes, one can observe a decrease in the complexity of the en-route airspace, currently generated by the high number of crossings, as may be seen in the comparison between Figures 7 and 8.

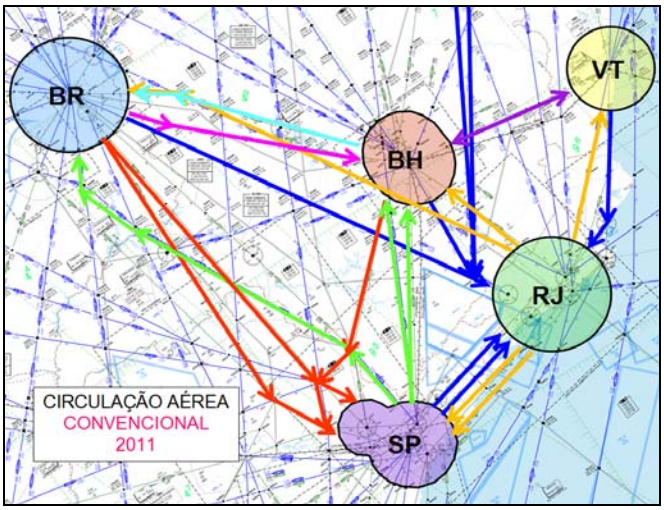

Figure 7 - Routes with origin/destination between TMAs before restructuring

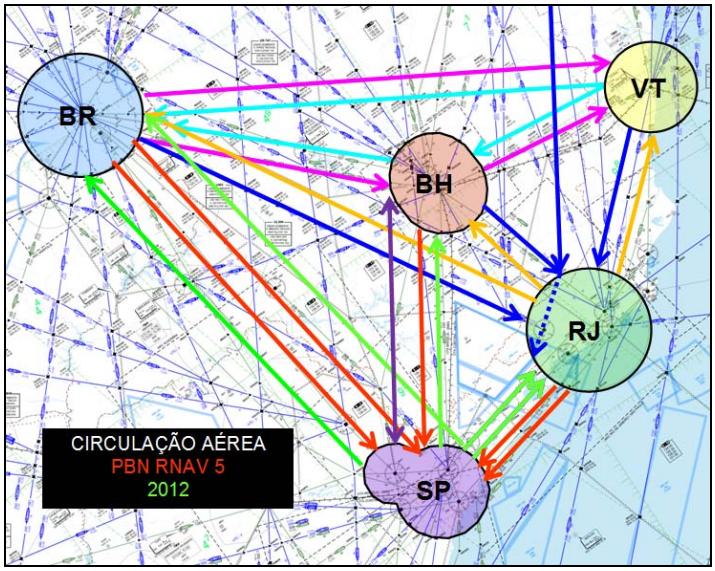

Figure 8 - Routes with origin/destination between TMAs after restructuring

2.5.3.3 The date of entry into force of this restructuring was set for March 2012 (Figure 8), or roughly one year before the application of the PBN airspace concept in the RJ and SP TMAs. This will allow better management of resources in terms of training and production of all needed aeronautical information, and it will enable a greater dilution of the whole volume of changes in the en-route procedures and in TMA.

2.6 Initial Version of the Rio de Janeiro TMA Airspace Concept

2.6.1 The design of the new air traffic flow in the RJ TMA, based on the Performance Based Navigation concept, was developed based on the strategic objectives of the project and on a few assumptions listed below:

a) Increased RNAV capability of the fleet;
b) Growth in air traffic in a horizon of 5 years;

c) Independent air traffic flow between the two main airports in the RJ TMA (SBGL and SBRJ); and
d) New gateway in the NE sector of the RJ TMA.

2.6.2 Because of the proximity between the two main airports in the RJ TMA (about 5 NM) and the existence of natural obstacles in the operating environment, the air traffic flow is of significant complexity, requiring the establishment of several operational standards that create dependencies between the types of operations in both airports, which are basically determined by the prevailing weather conditions.

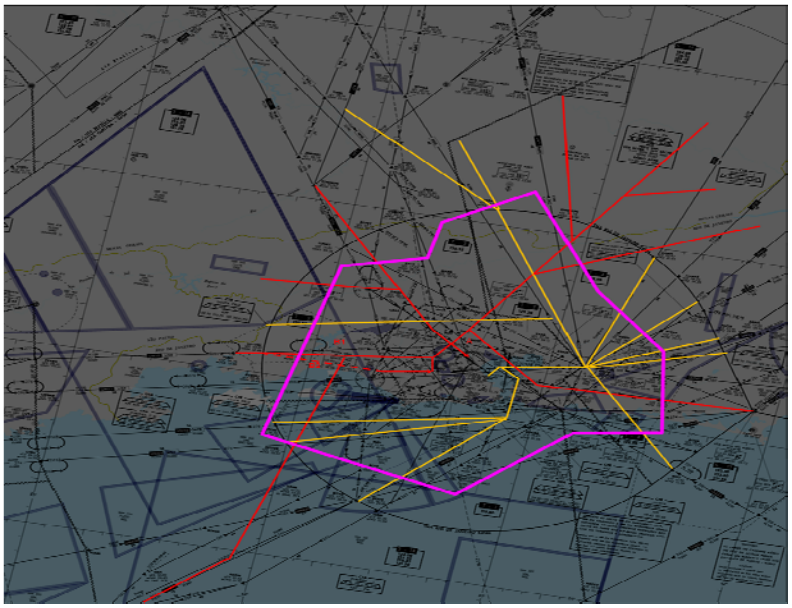

Figure 9 – Initial Version of the Rio de Janeiro TMA Airspace Concept

2.7 Initial Version of the São Paulo TMA Airspace Concept

2.7.1 The design of the new air traffic flow in the SP TMA, based on the Performance Based Navigation concept, was developed based on the strategic objectives of the project and on a few assumptions listed below:

a) Increased air traffic movement at the Campinas Viracopos Airport;
b) Increased RNAV capability of the fleet;
c) Growth in air traffic in a horizon of 5 years;
d) Independent air traffic flow between the three main airports in the SP TMA (SBGR, SBSP, and SBKP);
e) New gateway in the NE sector of the SP TMA; and
f) Absorption of the SJ APP by the SP APP.

2.7.2 Thus, the study for the busiest TMA in the country adds a high degree of complexity, depending on the following variables:

a) Three major airports with movements and flows between pairs of cities and pairs of airports that are quite different from each other, which hinders the formation of departure and arrival sectors;

b) Proximity between the major airports, which renders it difficult to develop procedures in optimum flight profiles;
c) Rugged topography that affects the planning of arrivals and departures as well as frequency coverage, and ground-based stations;
d) Very heterogeneous mix of aircraft operating at these airports, creating the need for the development of procedures with different profiles.

2.7.3 Considering the three major airports in the TMA (Guarulhos, Congonhas and Viracopos), one can clearly note an even division between Guarulhos and Congonhas; however, in the last five years, Viracopos increased its share and there was a slight decrease in the other two airports.

2.7.4 Thus, the air traffic concept for the SP TMA has considered such growth, as well as the flows of major movements between these airports and major airports in the country, in addition to the main international connections.

2.7.5 Based on this data, the air traffic was planned to meet more direct routes to these airports, minimizing the possible crossings, so that the departure and arrival routes are different for each airport.

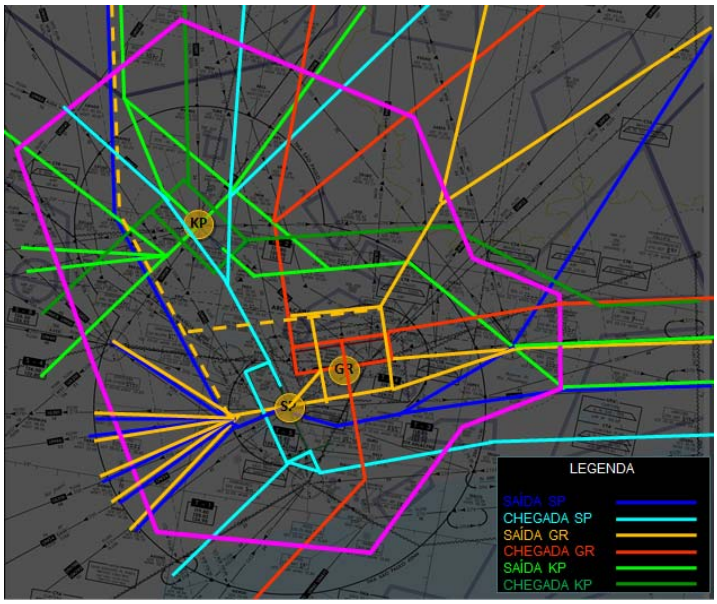

Figure 10 – Initial Version of the São Paulo TMA Airspace Concept

2.8 Perform ATC Simulation (Accelerated Time and Real Time) and Use of Flight Simulators

2.8.1 The next development stage of the airspace concept of the RJ and SP TMAs involves carrying out the simulations required to optimize the chances of project success.

2.8.2 Fast Time ATC Simulation has the main objective of verifying the metrics related to the sustainability of air transport, notably with regard to flight time reduction, fuel savings and reduction of greenhouse gas emissions in the atmosphere. In addition, this simulation also will aim at reconciling the ATC capacity with the existing and projected air traffic demand, by verifying the adequacy of the proposed sectorization.

2.8.3 The real-time simulation will be mainly done to verify the workload assigned to the air traffic controller, according to the new operating model in order to also check the adequacy of the proposed sectorization.

2.8.4 The use of flight simulators will aim at verifying the appropriateness of level restrictions in SID and STAR, considering the performance of most users of the RJ TMA and SP TMA, to enable the use of Continuous Descent Operations and minimize aircraft climb constraints.

2.9 Collaborative Decision Making (CDM)

2.9.1 To ensure the effectiveness of collaborative decision-making related to implementing PBN in the RJ and SP TMAs, two forums have been created specifically for the presentation, discussion and approval of the various project deliverables.

2.9.2 The internal forum is made up of organizations of the Department of Airspace Control (DECEA) and involves those responsible for the provision of air navigation services.

2.9.3 The external forum is made up of ANSP plus representatives of airlines, general aviation, military aviation and industry in general.

2.9.4 To date, three internal forum and two external forum meetings were held, in which the several stakeholders involved had the opportunity to discuss the proposals submitted, contributing to their improvement, and approve them with modifications deemed necessary, which resulted in the products presented in this Working Paper.

3. Conclusion

3.1 The restructuring of routes in the vicinity of the SP and RJ TMAs will enable more direct routes between pairs of airports as well as the reduction of conflicts in the sectors of the BS and CW ACC. These gains can be obtained through parallel RNAV 5 routes across the upper space.

3.2 Such restructuring will cause less impact on the restructuring phase of the SP and RJ TMA procedures, as the volume of information and changes will be divided into distinct stages, with time for users and controllers to adapt to the new scenario beyond the TMA limits.

3.3 The Rio de Janeiro and São Paulo TMAs are highly complex in view of the particularities of traffic volume and proximity to major airports, combined with the local topography, and their restructuring needs to be deployed in order to absorb the traffic growth expected by 2015.

3.4 After restructuring the network of routes, it was possible to establish arrival/departure gateways through the development of SID/STAR for major airports. The guidelines for airspace planning in terminal areas were considered in the process, such as: use of the "four corner" concept, STAR grouping, SID dispersion, TMA limits and sectors in order to cover the necessary ATS procedures.

3.5 The structure of TMA procedures in the PBN concept followed the strategic objectives established for the project, including improvements in terms of safety, capacity, efficiency and environmental protection, and enabled conventional procedures to be designed to coexist with the RNAV/RNP procedures.

3.6 Therefore, the next phases of the Fast Time Simulation (STA) and Real-Time Simulation (STR) project can validate the planning described herein, or even enable the necessary adjustments to optimize their deployment.

3.7 Significant positive results are expected in terms of reduction of distance and time flown and, consequently, fuel consumption and emission of harmful gases in the atmosphere. These results will be estimated during the simulation phase and measured during post-implementation monitoring.

4. Suggested action

4.1.1.1 The Meeting is invited to:

a) Take note of the information contained in this Working Paper concerning the PBN Implementation Project in the Rio de Janeiro and São Paulo TMAs; and
b) Consider the planning presented in this Working Paper in the process of PBN implementation in the South American Region.

- END -