International Civil Aviation Organization
CAR/SAM Regional Planning and Implementation Group (GREPECAS)
Seventeenth Meeting of the CAR/SAM Regional Planning and Implementation Group (GREPECAS/17)
(Cochabamba, Bolivia (Plurinational State of), 21 to 25 July 2014)

Agenda Item 4: Regional air navigation planning and implementation performance framework: Review of programmes and projects

4.1 Projects of the PBN programme

Follow-up to the activities under Project A1 (PBN implementation) and Project A2 (Air navigation system in support of PBN)

(Presented by the Secretariat)

SUMMARY

This working paper presents a report on the evolution of implementation activities related to the projects "*PBN implementation"* and *"Air navigation system in support of PBN*" under the PBN Programme, approved by the GREPECAS/16 for the CAR and SAM Regions, since the Second Meeting of the Programmes and Projects Review Committee (PPRC/2) (Lima, Peru, 16 to 18 July 2013).

References:

- Doc 9750, Global Air Navigation Plan
- Doc 9613, ICAO PBN Manual, 4th Edition
- GREPECAS/16 meeting report
- Report of the First Meeting of the Programmes and Projects Review Committee (PPRC/1) (Mexico City, Mexico, 25 to 27 April 2012)
- Report of the Second Meeting of the Programmes and Projects Review Committee (PPRC/2) (Lima, Peru, 16 to 18 July 2013)

ICAO Strategic Objectives	*A - Safety* *C - Environmental protection and sustainable development of air transport*

1. Introduction

1.1 Pursuant to GREPECAS Decisions 16/45 to 16/47, the Programme entitled *"Performance-Based Navigation (PBN)"* was structured with the following associated projects:

a) Operational implementation of PBN; and
b) Air navigation systems in support of PBN

2. **Discussion**

2.1 The activities carried out since the Second Meeting of the Programmes and Projects Review Committee (PPRC/2) in relation to the projects under Programme A: *Performance-based navigation (PBN)* are as follows:

2.2 ***CAR Region***

Project A1 "PBN Implementation"

2.2.1 At the PPRC/2 meeting, Projects A1 and A2 of the CAR Region were merged into one project entitled "PBN Implementation". The States/Territories agreed to update the regional performance objectives (RPO) in the NAM/CAR RPBANIP, as approved by the Fifth Meeting of Civil Aviation Directors of North America, Central America and the Caribbean (NACC/DCA/5).

2.2.2 PBN implementation provides significant benefits to the ATM community in terms of enhancing safety, increasing airspace capacity and access to aerodromes, and reducing environmental impact. PBN is not a concept in itself; it is one of the elements that support the strategic objectives of an airspace concept, together with communications, surveillance, and air traffic management (ATM).

2.2.3 The approach to the implementation of a PBN airspace concept requires a multidisciplinary team that coordinates the analysis of airspace organisation and management (AOM). The implementation of a PBN airspace concept requires that States implement RNAV 5/2 routes in continental upper airspace, publish continuous descent operations (CDO) and continuous climb operations (CCO) in terminal areas using standard instrument departures (SIDs) and standard instrument arrivals (STARs). Furthermore, in accordance with Assembly Resolution A37-11, it also requires publication of RNP approach procedures.

2.2.4 The last aspects of PBN implementation in the CAR Region include:

- RNP 10 in the New York Oceanic West FIR, RNP 10 and RNAV random routes in the oceanic airspace of the Gulf of Mexico and the Houston and Miami Oceanic FIRs.
- Random RNAV routes in the Piarco FIR.
- Review of RNAV 5 routes in continental upper airspace.
- Costa Rica, Honduras, Jamaica, Mexico, Trinidad and Tobago, and COCESNA have submitted reports on the implementation of PBN airspace redesign projects.
- SBAS and WAAS aspects continue to be analysed.

2.2.5 **Appendix A** shows the status and results of PBN implementation reported to ICAO Headquarters in Montreal for the dashboards. Based on the status of implementation and taking into account that several tasks have been completed, NAM/CAR States have established new goals as shown below:

- 80% of runways using instrument approaches, approach procedures with vertical guidance (APV), barometric vertical navigation (VNAV), implemented by service providers and users by December 2016;
- 80% of international aerodromes using PBN STARs implemented by December 2016;
- 60% of international aerodromes using PBN SIDs implemented by December 2016;
- 50% of international aerodromes using CDO implemented by December 2016;
- 60% of international aerodromes using CCO implemented by December 2016;

- ICAO will provide training and assistance for PBN airspace design and operational approval upon request by CAR States.

2.2.6 Significant progress has been made in PBN implementation. Nevertheless, key implementation requirements include increasing the number of qualified personnel, improving training programmes, and PBN operational approval/certification. Therefore, the States must review and enhance their own PBN programmes and achievements in coordination with the ICAO Regional Office.

2.3 ***SAM Region***

Project A1 "PBN Implementation"

2.3.1 Regarding GREPECAS Project A1, the SAM/IG/12 meeting (14-18 October 2013) planned a series of deliverables to extend the scope of the Project in accordance with SAM/IG/11 requirements, with a view to supporting States in the development of their PBN terminal area designs. These deliverables are shown in **Appendix B.**

2.3.2 The SAM/IG/12 meeting concluded that it would be necessary to conduct a broader assessment of the project with a view to including RNP 2 (continental airspace) and RNP 4 (oceanic airspace) implementation phases.

PBN Implementation Strategy in the SAM Region

2.3.3 Appendix B describes in detail the PBN implementation strategy in the SAM Region, which may be summarised in the following three phases:

- distance training;
- participation in Workshop I on PBN airspace design, with preliminary designs of the Asunción and Bogota terminal areas;
- participation in Workshop II on PBN airspace design, covering:
  - basic preliminary design of a selected TMA
  - integration of the entry and exit points of these TMAs

2.3.4 Subsequently, a draft Version 03 of the SAM route network will be prepared based on the entry and exit points of the main South American TMAs in order to continue optimising the SAM ATS route network and planning implementation for the years 2015 and 2016.

SAM Route Network Optimisation Programme

2.3.5 The SAM Route Network Optimisation programme and the planning conducted by SAM/IG meetings and implemented by the SAM ATS Route Network Optimisation (ATSRO) Meetings have resulted in significant emission reductions, as shown in the following table (see also Appendix B):

Period selected	Reduction of CO_2 emissions in tonnes
2001 to 2012	**134.460**
2013	**39.468**
1st semester 2014	**14.295**

2.3.6 The status of implementation of RNAV, SID, and STAR routes and PBN-based approach procedures are shown in Appendix B. In summary, 38% of SAM routes are RNAV-5, and 48% of SIDs/STARs and 61% of approach procedures in the SAM Region are based on PBN.

PBN Implementation in SAM States

2.3.7 Appendix B contains information on the main PBN implementation projects in the SAM Region, namely:

- The en-route and TMA airspace restructuring project conducted in Brazil, which incorporated the PBN concept for optimising air traffic flow between the main terminal control areas (TMAs) of Brazil. The project was implemented in two phases: restructuring of routes (first phase) and restructuring of the RJ and SP TMAs (second phase).

- PAMPA Project - Route optimisation in Chile, mainly aimed at connecting the busiest pairs of cities in the country through more direct routes, laterally separated from other routes and which permit the establishment of TMA entry/exit flows and climbs and descents with minimum restrictions.

- The **PROESA** programme, conducted by the DGCA of Peru, will offer a new structure of more efficient routes, with less climb/descent restrictions, both en-route and in TMAs, reducing pilot and controller workload, seeking to reduce the need for vector guidance by virtue of RNAV paths, decongesting frequencies and giving pilots and controllers more time to perform their respective activities, increasing situational awareness, upon transferring navigation to database coding of optimum flight paths.

Project A2 "Air Navigation System in Support of PBN"

Follow-up to RAIM availability prediction service implementation in the SAM Region

2.3.8 In 2010, as a follow-up to PBN implementation requirements set forth in Doc 9613 *Performance-Based Navigation Manual (PBN)* and to advisory circulars that establish the criteria for the approval of aircraft and operators for RNP/RNAV operations in the SAM Region, the SAM Region considered initiating a process for studying, drafting technical specifications, and calling for bids for the implementation of a RAIM availability prediction service to ensure en-route PBN procedures, as well as non-precision approaches, approaches with vertical guidance (APV) and terminal area for SAM States.

2.3.9 On 30 May 2014, ICAO, through the Technical Cooperation section, and on behalf of eleven SAM States, members of Regional Technical Cooperation Project RLA/06/901 *Assistance in the implementation of a regional ATM system, taking into account the ATM operational concept and the corresponding communication, navigation, and surveillance (CNS) technological support*, signed the contract for starting the implementation of the web-based RAIM availability prediction service to be called SRRPAS (from its acronym in English: *SAM Regional Receiver Autonomous Integrity Monitoring (RAIM) Prediction Availability Service*).

2.3.10 It is expected that the web-based RAIM availability prediction service will be commissioned at the beginning of the fourth quarter of 2014. The implementation of this service will initially require coordination amongst SAM States, the Secretariat, and the service provider in order to define the web page format, mode of access through the assignment of a password, and verification of information accuracy. This will be an on-going activity through web-based teleconferences. Once available and operating, the service shall be used by the States, encouraging its efficient use by all stakeholders.

3. Conclusion

3.1 Although significant progress has been made in PBN implementation, the need has been identified to increase the number of qualified personnel, enhance training programmes, and improve PBN operational approval programmes. Accordingly, the States need to review and improve their own PBN implementation programmes with the assistance of the ICAO CAR and SAM Regional Offices.

3.2 Based on the aforementioned progress, Appendices A and B to this working paper show the status of implementation of Projects A1 and A2 for the CAR and SAM Regions, respectively, based on the PBN programme (RNAV/RNP) approved by GREPECAS.

3.3 The strategy of using PBN airspace training and preliminary design workshops has proven an excellent mechanism for the training of State experts and for PBN airspace harmonisation and optimisation.

4. Suggested action

4.1 The Meeting is invited to:

a) take note of the information contained in this working paper;

b) review project activities and status of implementation in Appendices A and B, and formulate other actions it may deem appropriate.

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APPENDIX A / APENDICE A

PROJECT IMPLEMENTATION OF PERFORMANCE BASED NAVIGATION (PBN)
PROYECTO IMPLANTACIÓN DE LA NAVEGACION BASADA EN LA PERFORMANCE (PBN)

CAR Region / Región CAR	**PROJECT DESCRIPTION / DESCRIPCION DEL PROYECTO (DP)**	**DP N° A1**	
Programme / Programa	**Project Title / Titulo del Proyecto**	**Start / Fecha inicio**	**End / Fecha término**
Performance Based Navigation /Navegación basada en la performance (PBN) Programme Coordinator / Coordinador del Programma: Victor Hernandez)	*Performance Based Navigation / Navegación Basada en la Performance (PBN)* Project Coordinator / Coordinador Proyecto: Alfredo Mondragón (COCESNA) Exoerts / Expertos contribuyentes: Carl Gayner (Jamaica) Jose Gil (México) Jose Perez (Dominican Republic) Randy Gomez (Trinidad and Tobago) Susan E. Pfingstler (IATA)	2008	2015
Objective /Objetivo	Support the implementation of the ATS route structure in terminal areas (SID/STAR RNAV) and en-route (RNAV) optimization Project, as well as the implementation of RNP approach procedures according to regional performance objectives of the Performance-based Implementation Plan for NAM/CAR (RPBANIP NAM/CAR) Regions. / Apoyar la implementación del proyecto de optimización de la estructura de rutas ATS en el espacio aéreo terminal (SID/STAR RNAV) y en ruta (RNAV), así como la implantación de aproximaciones RNP en base a los Objetivos regionales de performance del Plan de Implementación Basada en la Performance para las Regiones NAM/CAR (RPBANIP NAM/CAR)		
Scope /Alcance	Progressive implementation of PBN and use of GNSS according to the goals of Assembly Resolution A37-11 and the PBN Airspace Concept for the CAR Region. / Implantación progresiva de la PBN y uso del GNSS acorde a las metas de la Resolución de la Asamblea A37-11 y el Concepto de Espacio Aéreo PBN para la Región CAR.		

Metrics / Métricas	• Percentage of instrument runway ends with an approach procedure with vertical guidance (APV), (BARO-VNAV and/or augmented GNSS) either as the primary approach or as a back-up for precision approaches; • Percentage of international aerodromes with implanted SID/STAR RNAV, RNP and continuous descent and climb operations (CDO/CCO); • Estimated fuel saved with operational improvements. / • Porcentaje de final de pistas por instrumentos con un procedimiento de aproximación con guía vertical (APV), (BARO-VNAV y/o aumentación GNSS) sea como aproximación primaria o como apoyo para aproximaciones de precisión; • Porcentaje de aeropuertos internacionales con SID/STAR RNAV, RNP y operaciones de descenso y ascenso continuo (CDO/CCO) implantados; • Ahorros estimados de combustible por mejoras operacionales.
Strategy / Estrategia	The implementation of activities will be coordinated between Project members, the Project Coordinator and the Programme Coordinator. The Programme Coordinator will coordinate with the Project Coordinator requirements of other projects and NAM/CAR implementation working groups. States will develop their respective national programmes of implementation of routes and approach procedures according to PBN Airspace Concept in the CAR Region. Experts nominated by States, Territories and International Organizations will be incorporated to develop tasks as required. / La ejecución de las actividades será coordinada entre miembros del proyecto, el coordinador del proyecto y el Coordinador del Programa. El Coordinador del Programa coordinará con el Coordinador del Proyecto los requerimientos de otros proyectos y Grupos de Trabajo de implementación NAM/CAR. Los Estados elaborarán sus respectivos programas nacionales de implantación de rutas y procedimientos de aproximación acorde al Concepto de Espacio Aéreo PBN de la Región CAR. Se incorporarán expertos nominados por los Estados, Territorios y Organizaciones Internacionales para desarrollar las tareas, según se requiera.
Goals / Metas	• Implement RNAV/RNP routes and RNP approach procedures according to Assembly Resolution A37-11 in 2016: • Implement a PBN airspace concept (CDOs, CCOs, SIDs, STARs, RNAV/RNP route and RNP approach procedures) in 8 FIRs by end of 2014: • Analyze VOR. DME/DME infrastructure requirements for RNP approach procedures. / • Implementar rutas RNAV/RNP y procedimientos de aproximación RNP de acuerdo a la Resolución de la Asamblea A37-11, en 2016; • Implementar un concepto de espacio aéreo PBN (CDOs, CCOs, SIDs, STARs, rutas RNAV/RNP y procedimientos de aproximación RNP) en 8 FIRs a fines de 2014; • Analizar los requisitos de infraestructura VOR, DME/DME para procedimientos de aproximación RNP.

Justification/ Justificación	The Assembly Resolution A37-11, performance-based navigation (PBN) global goals, urged States to implement RNAV and RNP ATS routes and approach procedures in accordance with the ICAO Performance-based Navigation (PBN) Manual, Doc 9613, and requested the PIRGs to include in their work programme the review of status of implementation of PBN by States according to the defined implementation plans and report annually to ICAO any deficiencies that may occur. In addition, NAM/CAR States adopted a regional performance framework on the basis of the regional performance objectives (RPO) of the performance based air navigation implementation plan (RPB-ANIP) for NAM/CAR Regions and the Global ATM Operational Concept. The performance framework includes the implementation of a set of performance common metrics to facilitate comparative analysis of overall regional development, such as operational and economic cost-effectiveness of gate-to-gate flight operations, and the protection of the environment in the planning, implementation and operation processes of the global ATM system. / La Resolución A37-11 de la Asamblea, metas mundiales de navegación basada en performance (PBN), instó a los Estados a implantar rutas ATS RNAV y RNP, así como procedimientos de aproximación de acuerdo al Manual de la OACI sobre Navegación Basada en la Performance (PBN), Doc 9613, solicitando a los PIRGs incluir en sus programas de trabajo la revisión del estado de implantación de PBN por los Estados, de acuerdo a los planes de implantación definidos e informar anualmente a la OACI sobre cualquier deficiencia que pudiera ocurrir. Adicionalmente, los Estados NAM/CAR adoptaron un marco regional de performance en base a los objetivos regionales de performance (RPO) del plan de implantación de navegación basada en performance (RPB-ANIP) para las Regiones NAM/CAR y el Concepto Global de Operación ATM. El marco de performance incluye la implantación de un conjunto de métricas de performance comunes para facilitar el análisis comparativo del desarrollo regional en general, tales como el costo-efectividad operacional y económico de operaciones aéreas puerta a puerta y la protección del medio ambiente en los procesos de planificación, implantación y operación del sistema ATM global.
Related Projects / Proyectos relacionados	• Enhance demand and capacity balancing; • Flexible use of airspace; • Improve ATM Situational awareness; • Implement the New ICAO Flight Plan Form. • Mejorar el equilibrio entre la demanda y capacidad; • Uso flexible del espacio aéreo; • Mejorar la Conciencia Situacional ATM; • Implementación del Nuevo Formato de Plan de Vuelo de la OACI.

Entregables del Proyecto	Relación con el RPB-ANIP NAM/CAR	Responsable	Estado de Implantación*	Fecha entrega	Comentarios
PBN Airspace Concept / Concepto de Espacio Aéreo PBN	RPOs 1, 2, 3	Alfredo Mondragón		Completed / Finalizada	Developed a comprehensive PBN Airspace Concept, in order to implement a trunk route network to/from city pairs in the upper and lower airspace. / Se elaboró un concepto del espacio aéreo PBN integral para implantar una red de rutas troncales desde-hacia pares de ciudades en el espacio aéreo superior e inferior
Optimize the ATS route structure based on RNAV-5 implementation in the upper continental airspace . / Optimizar la estructura de rutas ATS en base a la implementación de RNAV 5 en el espacio aéreo superior continental	RPOs 1.1	States, Territories, International Organizations / Estados, Territorios, Organizaciones Internacionales		Completed / Finalizada	RNAV 5 Routes implemented in the upper airspace. / Rutas RNAV 5 implantadas en el espacio aéreo superior.
Implement SIDs/STARS, CDO and CCO in terminal areas based on RNAV/1-2 and RNP1 navigation specifications. / Implementar SIDs/STARS, CDO y CCO en áreas terminales en base a especificaciones de navegación RNAV/1-2 y RNP1	RPOs 1.2	States, Territories, International Organizations / Estados, Territorios, Organizaciones Internacionales		Completed / Finalizada	-211 SIDs implemented /implementadas -145 STARs implemented /implementadas -Implemented STARs /SIDs meet CDO/CCO criteria. / Las STARs / SIDs implementadas cumplen con criterios CDO/CCO.

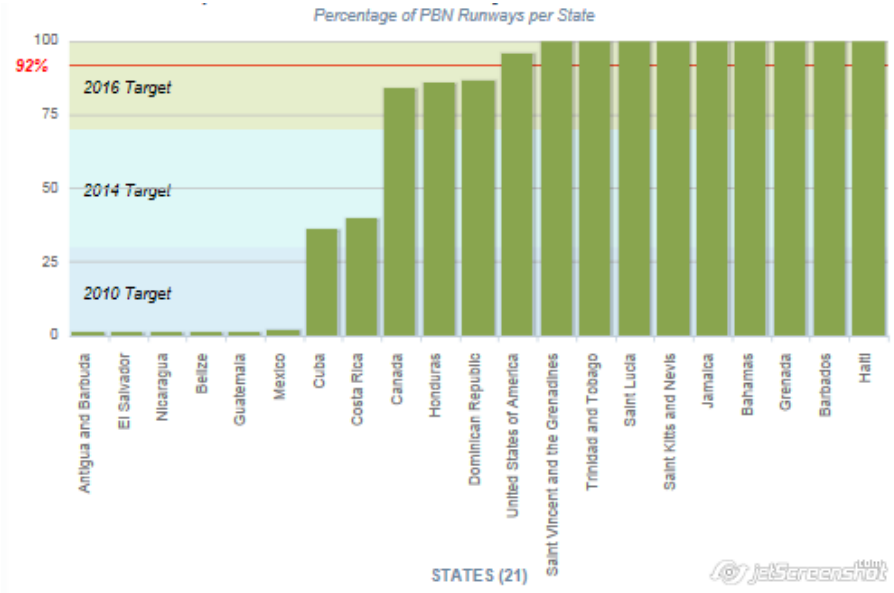
Design and implement PBN APV approach procedures in accordance with Assembly Resolution A37-11 (BARO-VNAV), / Diseñar e implementar procedimientos de aproximación PBN APV (BARO-VNAV) según la Resolución de la Asamblea A37-11	RPOs 1.3	States, Territories, International Organizations / Estados, Territorios, Organizaciones Internacionales		2014	152 RNP approach procedures implemented. / 152 procedimientos de aproximación RNP implementados.
Analysis to implement a comprehensive PBN airspace concept for the lower and upper airspace in the Central American FIR. / Estudio para implementar un concepto de espacio aéreo PBN integral para el espacio aéreo inferior y superior en la FIR Centro América	RPOs 1, 2, 3	Alfredo Mondragón		Completed / Finalizada	COCESNA coordinated the implementation of PBN airspace concept with 6 Central American States. / COCESNA coordinó la implementación de un concepto de espacio aéreo PBN con 6 Estados Centroamericanos
PBN training programme for Pilots, ATCOs, operators and regulators. / Programa de Capacitación PBN para Pilotos, ATCOs, operadores y reguladores	RPOs 1	States, Territories, International Organizations / Estados, Territorios, Organizaciones Internacionales		Completed / Finalizada	States conduct their training programme according to the ICAO PBN Manual, Doc 9613. / Los Estados llevan a cabo su programa de capacitación acorde al Manual PBN, Doc 9613, de la OACI
Evaluate and implement PBN requirements for ATC Automated Systems, according to the new ICAO Flight Plan Form requirements. / Evaluar e implementar los requisitos de los sistemas automatizados ATC acorde a los requisitos del nuevo formulario de plan de vuelo de la OACI	RPOs 1, 3, 4, 5	States, Territories, International Organizations / Estados, Territorios, Organizaciones Internacionales		Completed / Finalizada	States have completed their action plan for the implementation of the New ICAO flight plan form. / Los Estados han completado su plan de acción para el procesamiento del nuevo formulario del plan de vuelo de la OACI

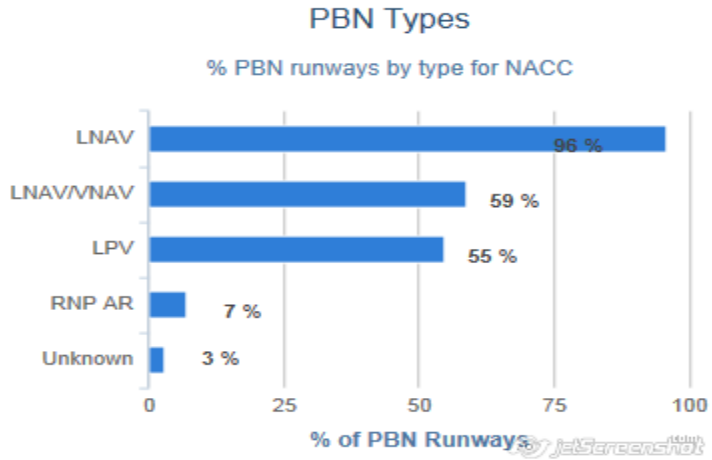
Development of a proposal for amendment of the ATS routes network for the implementation of RNP 10 in the Gulf of Mexico Oceanic area and RNAV 5 for the continental areas. / Elaboración de propuesta de enmienda a la red de rutas ATS para la implementación de RNP 10 en el área oceánica del Golfo de México y RNAV 5 para las áreas continentales	RPOs 1.1	Alfredo Mondragón, Roy Grimes		Completed / Finalizada	The proposal for amendment has been approved and implemented 11 new RNAV Routes. / La propuesta de enmienda ha sido aprobada e implementó 11 nuevas Rutas RNAV
Develop PBN Safety Assessment Programme based on SMS methodology. / Desarrollar un Programa de Evaluación de Seguridad Operacional PBN en base a la metodología del SMS	RPOs 1			Completed / Finalizada	States conduct safety assessment to implement changes in the airspace of their jurisdiction. / Los Estados efectúan una evaluación de la seguridad operacional para los cambios en el espacio aéreo de su jurisdicción
Implementation of random Routes in defined oceanic airspace. / Implantación de rutas aleatorias en espacio aéreo oceánico definido	RPOs 1.1, 3	Trinidad and Tobago		Completed / Finalizada	RNP 10 and Random Routes implemented in the Oceanic area of the WATRS airspace, the Gulf of Mexico, Houston and Miami Oceanic and Piarco FIRs / RNP 10 y Rutas RNAV aleatorias implementadas en el espacio aéreo oceánico WATRS, el Golfo de México y las FIR Houston y Miami Oceanic y Piarco.

Analyse the DME/DME and GNSS infrastructure and coverage supporting PBN implementation. / Analizar la infraestructura y cobertura DME / DME y GNSS requerida para dar soporte a la implantación de la PBN	RPOs 1	States, Territories, International Organizations / Estados, Territorios, Organizaciones Internacionales		Completed / Finalizada	Current DME infrastructure supports the PBN approach procedures requirements. Regionally was not detected the necessity of more DME infrastructure. States will review their own DME radioaids requirements. / La infraestructura DME actual apoya los requisitos de los procedimientos de aproximación PBN. Regionalmente no se detectó la necesidad de más infraestructura DME. Los Estados analizarán sus propias necesidades de radioayudas DME
Analysis of regional feasibility for SBAS (WAAS/SACSA) implementation. / Estudio de factibilidad regional de la implantación del SBAS (WAAS / SACCSA)	RPOs 1	Alfredo Mondragón assisted by / asistido por SACCSA and/y WAAS		2016	Mexico is testing 5 WAAS stations for domestic use. WAAS requirements will be regionally reviewed in the medium term. Feasibility of regional application, technical aspects, operational benefits, associated costs, for an SBAS (WAAS/SACSA) implementation. Implications for airborne equipment (factory delivered and retrofits) and other relevant aspects. / México tiene a prueba 5 estaciones WAAS para uso nacional. Los requisitos WAAS serán regionalmente revisados en el mediano plazo. Factibilidad de la aplicación regional, los aspectos técnicos, los beneficios operacionales, los costos asociados, de la implantación del SBAS (WAAS / SACCSA), así como las implicaciones para los equipos de a bordo (nuevas o actualización de aviónicas) y otros aspectos pertinentes
Practical guidance for the implementation of GBAS Systems/ Guía práctica para la implementación de sistemas GBAS.	RPOs 1	Alfredo Mondragón assisted by / asistido por SACCSA and/y WAAS		2018	

Develop a performance measurement programme. / Desarrollar un programa de medidas de la performance	RPOs 1, 3	ICAO / OACI		Completed / Finalizada	Implementation achievements are presented to the NACC/DCA Meetings. / Los resultados de implementación se presentan a las Reuniones NACC/DCA
Monitor System Performance. / Monitorear la performance del sistema	RPOs 1	ICAO		2015	ICAO NACC Regional Office conducts this activity. / La Oficina Regional NACC de la OACI lleva a cabo esta actividad
Required Resources / Recursos necesarios	CAR Regional Project with the participation of States to support PBN training programme / Proyecto regional CAR con la participación de los Estados para apoyar el programa de capacitación PBN				

Gris	Tarea no iniciada;
Verde	Actividad en progreso de acuerdo con el cronograma;
Amarillo	Actividad iniciada con cierto retardo pero estaría llegando a tiempo en su implantación;
Rojo	No se ha logrado la implantación de la actividad en el lapso de tiempo estimado se requiere adoptar medidas mitigatorias.


Percentage of PBN Runways per State
100
92%
75
50
25
0
2016 Target
2014 Target
2010 Target
Antigua and Barbuda
El Salvador
Nicaragua
Belize
Guatemala
Mexico
Cuba
Costa Rica
Canada
Honduras
Dominican Republic
United States of America
Saint Vincent and the Grenadines
Trinidad and Tobago
Saint Lucia
Saint Kitts and Nevis
Jamaica
Bahamas
Grenada
Barbados
Haiti
STATES (21)


PBN Types
% PBN runways by type for NACC
LNAV
96 %
LNAV/VNAV
59 %
LPV
55 %
RNP AR
7 %
Unknown
3 %
0
25
50
75
100
% of PBN Runways

END - FIN

APPENDIX B

PBN Implementation in the South American Region

Project A1 "PBN Implementation"

1.1 Regarding GREPECAS Project A1, the SAM/IG/12 meeting (14-18 October 2013) planned a series of deliverables to extend the scope of the Project in accordance with the requirements of SAM/IG/11, with a view to supporting States in the development of their terminal area PBN designs. These proposed deliverables were as follows:

- Prepare and give a course/workshop on terminal area design using PBN.
- Develop the planning strategy for terminal area optimisation, based on harmonisation workshops and use of lessons learned.
- Develop guides for the design, evaluation, and selection of navigation specifications to be applied in TMAs as necessary.
- Develop procedures for verifying and validating the concept and procedures using risk analysis.
- Identify implementation restrictions and develop guides for pre-implementation training.
- Action plan for Version 03 of the SAM ATS Route Optimisation Programme.
- Design the tasks required for the implementation of Version 03 of the SAM ATS Route Optimisation Programme.
- Regional strategy and work programmes for the implementation of the flexible use of airspace through a phased approach, starting with more dynamic sharing of reserved airspace.

1.2 More details about Project A1 for the SAM Region may be found in **Attachment A** to this Appendix.

1.3 The SAM/IG/12 meeting concluded that a broader assessment of the project would be required in order to include RNP 2 (continental airspace) and RNP 4 (oceanic airspace) implementation phases.

PBN Implementation Strategy in the SAM Region

1.4 Taking into account Conclusion SAM/IG/11-1 (*Support to SAM States in the redesign of their TMAs*), it was felt convenient to plan the activities of Project RLA/06/901 for 2014 in order to determine the needs and expand the training of ATM experts of the SAM Region, in order to support and facilitate the regional PBN implementation plan, thus allowing participants to gain more knowledge on PBN application.

1.5 The SAM/IG/12 meeting (Lima, Peru, 14-18 October 2013) agreed that it would be better to conduct the required training in three consecutive phases.

1.6 The first phase consisted of distance training, consisting of basic PBN fundamentals shared through the ICAO website (*http://www.icao.int/safety/pbn/SitePages/PBN%20ikit.aspx*) and the study by each participant of the following PBN-related manuals: PBN Manual (Doc 9613), Manual on the Use of Performance-Based Navigation in Airspace Design (Doc 9992), Continuous Descent Operations Manual (Doc 9931), and Continuous Climb Operations Manual (Doc 9993).

1.7 The second phase consisted of participation in Workshop I on PBN airspace design, which lasted 2 weeks, the purpose of which was to provide theoretical/practical training in PBN terminal area design. For the practical exercise, 1 highly complex TMA (Bogota) and 1 less complex TMA (Asuncion) were selected. In this regard, the First workshop on PBN airspace design in the SAM Region was conducted in Bogota, Colombia, on 12-23 May 2014, sponsored by the Aeronautical Authority of Colombia and with the support of Regional Project RLA/06/901.

1.8 The result of this workshop was the preliminary design of the terminal areas of Asuncion and Bogota, which will serve as reference material for planning, design, and implementation of PBN in their respective States.

1.9 A final exam was taken on the last day of the PBN Workshop 1 in order to identify the level of knowledge gained by the participants during the event. In summary, the results were as follows:

- Average score of the group: 89
- All the participants obtained a good score (70 - 84) or very good score (more than 84).
- None of the participants obtained a final score of less than 72.
- The group average increased 13.5 points (from 75.5 to 89), comparing the first and the final assessments.

1.10 Likewise, a survey was completed to measure the degree of satisfaction of the participants with respect to the workshop and the instructors. The summarised results were as follows:

- 87% of the participants considered that the workshop had been excellent, while 13% considered it had been good.
- 91% of the participants considered that the instructors had been excellent, and 9% considered that they had been good.

1.11 The third phase will consist of Workshop II on PBN airspace design, lasting 1 week, where the participants from the first workshop will present the preliminary basic design of a TMA selected from each State, so that the proposed designs may be harmonised and optimised during the workshop using the techniques learned during the first workshop. The participants will also seek to integrate the entry/exit points of these TMAs with a view to producing Version 03 of the SAM route network. The second workshop on PBN airspace design in the SAM Region will be conducted on 8-12 September 2014 at the ICAO SAM Regional Office.

1.12 Once the aforementioned 3 phases of the Training Programme have been completed, Regional Project RLA/06/901 will hire three experts for a period of 3 weeks to develop a draft Version 03 of the SAM route network based on the entry/exit points of the main South American TMAs as defined at the PBN Workshop 2.

1.13 Based on the draft Version 03 of the SAM route network, the sixth SAM ATS Route Network Optimisation meeting (ATSRO/6) will be held on 20-24 October 2014, whose main objectives will be to assess the status of Version 03 of the SAM route network and continue with the ATS route implementation, realignment, and elimination programme.

1.14 The SAM/IG/14 meeting, scheduled for 3-7 November 2014, will assess the progress made by the PBN Programme and will plan the implementation for 2014-2016, based on the preliminary PBN designs for the main TMAs produced during the PBN Workshops 1 and 2, and of Version 03 of the SAM route network. It is expected that implementation will be based on the PBN airspace design workshops and bilateral and multilateral meetings aimed at defining the necessary details for TMA and en-route implementation.

SAM Route Network Optimisation Programme

1.15 The SAM Route Network Optimisation Programme, as planned by the SAM/IG meetings and executed by the SAM ATS Route Network Optimisation (ATSRO) meetings, showed the following progress:

a) Route UM662 was finally implemented to optimise the Guayaquil-Madrid route that was pending since the beginning of the Programme. Based on 160 monthly operations along this route (60 B767 operations, 60 A340 operations, and 40 B777 operations), the IFSET tool has calculated initial annual savings of **730.800 kg of fuel** and an annual reduction of **2.307 tonnes of CO_2** since the date of its implementation on 17 October 2013.

b) During the 2001-2012 period, CO_2 emissions into the atmosphere were reduced by approximately 134.460 tonnes per year, a conservative estimate that does not consider the reduction in CO_2 emissions obtained from RVSM implementation in the SAM Region in 2005.

c) Regarding the first implementation stage of Version 02, two dates were defined for two different groups of routes. For the first date, 2 new RNAV routes were selected and 11 routes were realigned, some segments of which were eliminated to make them more direct and save a total of 123 NM in 1151 monthly operations, mainly with B 737, A 320, and B767 aircraft. Using the IFSET tool, a total of **11.760.000 kg of fuel per year** and a reduction of **37.161 tonnes of CO_2** per year were calculated as of the date of implementation.

d) With the early implementation of route UM662 and the implementation of the first stage of phase 3, Version 02 of the ATSRO Programme, **an annual reduction of 39.468 tonnes of CO_2** has been achieved.

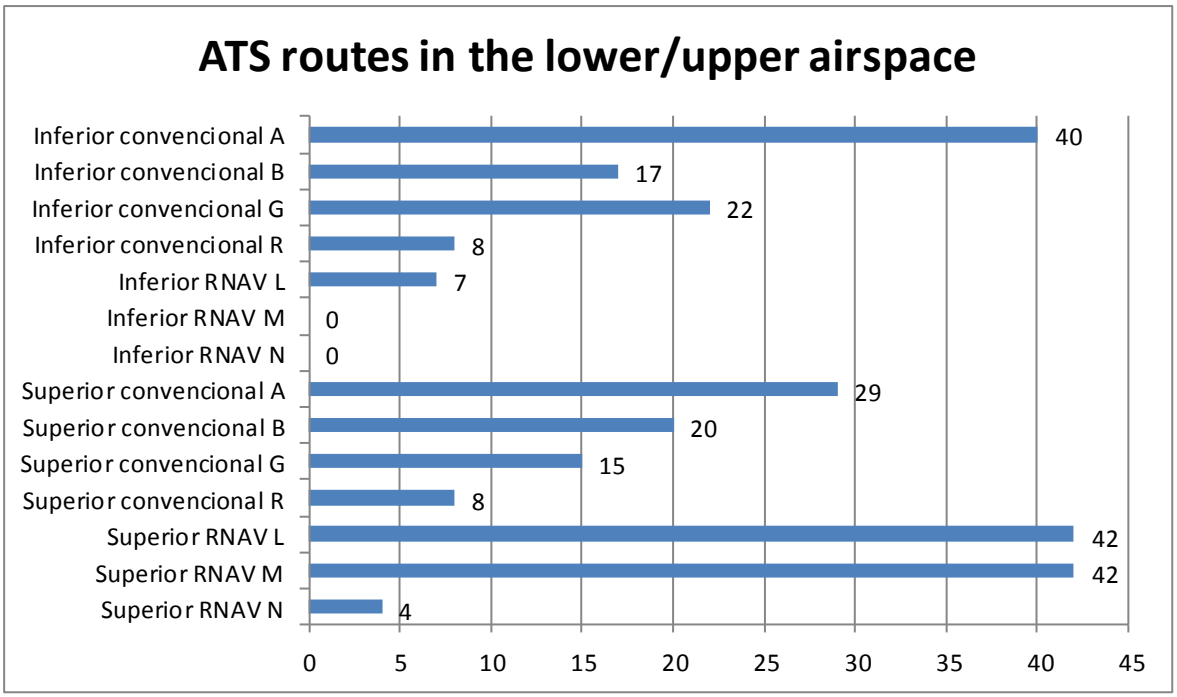
e) With the realignment of route UM 548 and the implementation of route UN775, **a reduction of 14,295 tonnes of CO_2** was achieved during the **first** semester of 2014.

Period selected	Reduction of CO_2 emissions in tonnes
2001 to 2012	**134,460**
2013	**39,468**
1st semester of 2014	**14,295**

1.16 The following table shows the optimisation achieved to date within the framework of the ATSRO Programme:

Route Optimisation in the South American Region			
Phase/Version	**Status of implementation**	**Date**	**Optimisation**
Phase 1 - RNAV-5	Implemented	October 2011	77 new RNAV routes 58 routes optimised 7 routes eliminated
Phase 2 - Version 01	Implemented	March 2011	15 new routes 19 routes optimised 18 routes eliminated
Phase 3 - Version 02	Stage 1	October 2013	1 RNAV route UM662
		December 2013	2 new routes 11 routes optimised 4 segments eliminated
		June 2014	2 routes optimised
	Stage 2	November 2014	18 candidate routes under study

1.17 The following graph shows the number of conventional ATS and PBN routes in the lower and upper airspace of the SAM Region:



1.18 In summary, out of the 254 routes that make up the regional ATS route network, 159 (62%) are conventional routes and 95 (38%) are PBN routes.

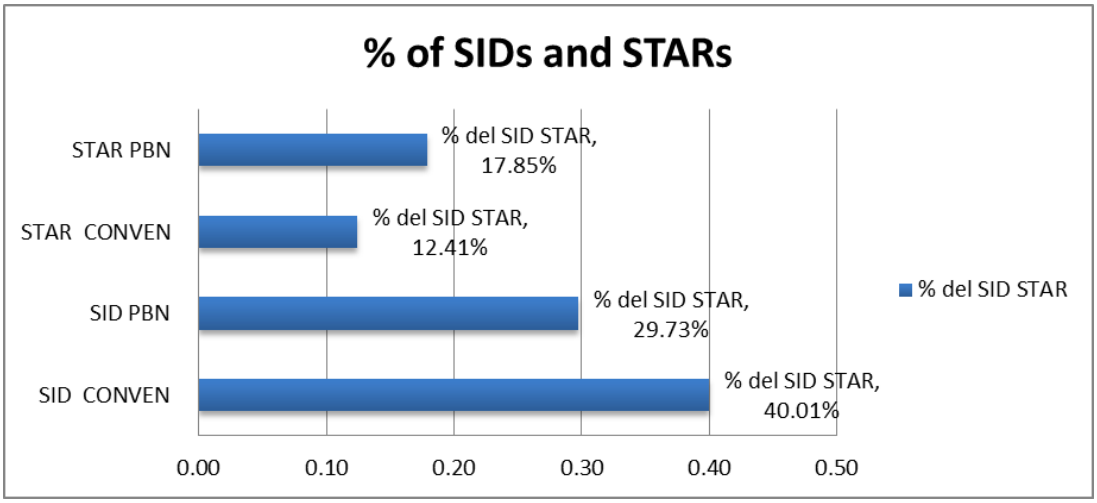
Status of Implementation of Standard Arrivals and Departures (STAR y SID) in the SAM Region

1.19 The SAM/IG/12 meeting took note of the following information concerning standard arrivals and departures:

a) Regarding standard arrival procedures (STARs), out of a total of **512 procedures**, 210 are conventional procedures (41%) and 302 are procedures developed based on the PBN concept (59%);

b) Regarding standard departure procedures (SIDs), it was noted that out of **1180 procedures**, **677** are conventional procedures (57%) and 503 are procedures developed based on the PBN concept (43%).

1.20 The following figure shows the different SID and STAR categories in graphical form:



1.21 In summary, a total of 1680 STAR and SID procedures have been designed and published for 99 international airports of the SAM Region, of which 878 (52%) are conventional procedures and 802 (48%) are based on the PBN concept.

Total number of airports	Total SIDs/STARs	Total number of PBN SIDs/STARs	ICAO indicator % PBN SIDs/STARs
99	1680	805	**48 %**

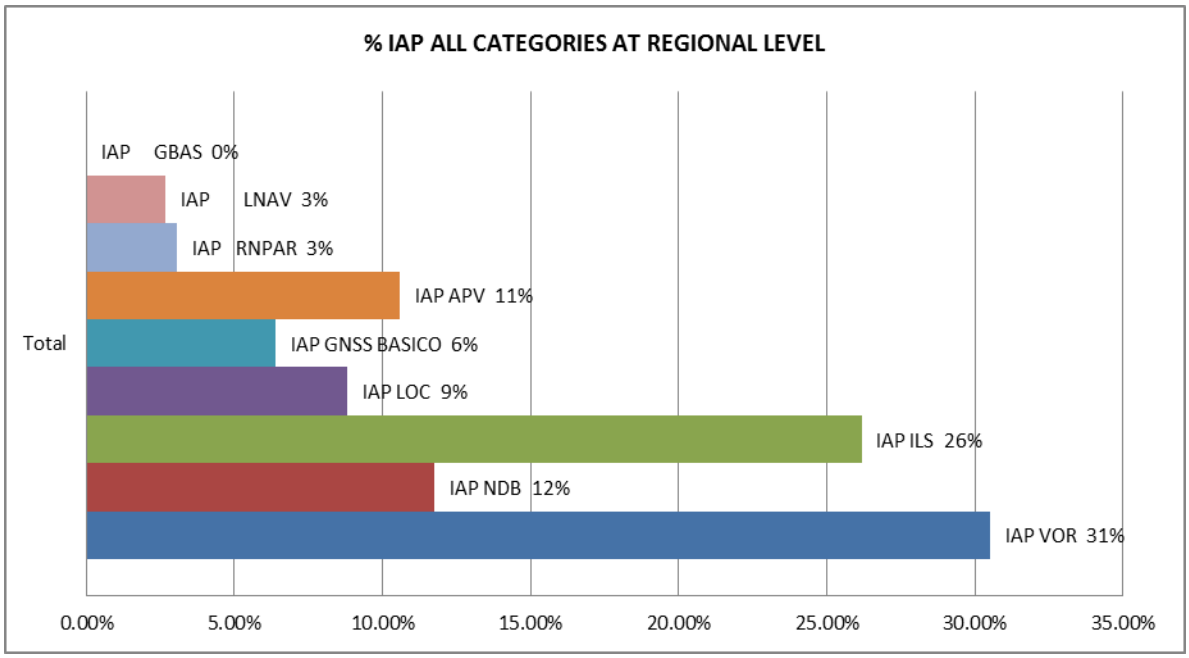
PBN Instrument Approach Procedures

1.22 The SAM/IG/12 meeting took note of the status of implementation of IFR approach procedures, where 783 approach procedures had been designed and published for 99 international airports.

1.23 The following breakdown identifies the number and percentage of procedures based on the categories analysed:

IAP percentage	VOR IAP	NDB IAP	ILS IAP	LOC IAP ONLY	BASIC GNSS IAP	RNP APCH VNAV / LNAV IAP	RNPAR IAP	RNP APCH LNAV IAP ONLY	GBAS IAP
Total	239	92	205	69	50	83	24	21	0
% of IAP	30.5	11.7	26.2	8.8	6.4	10.6	3.1	2.7	0

1.24 The following figure illustrates all IAP categories at regional level:



1.25 Of the total number of procedures, 77% (605) have been designed based on conventional radio aids (NDB, VOR, DME, LOC, ILS), while 23% (178) have been designed based on PBN. In this case, LNAV, RNP AR, APV procedures have been considered, including basic GNSS. In the SAM Region, GBAS IAPs have not been published yet for international aerodromes.

1.26 In the SAM Region, there are 783 approach procedures for 99 airports, 178 of which are PBN approach procedures, including GNSS IAPs, 107 of which (14%) are RNP APCH, distributed as follows: 83 APV Baro-VNAV (APV) procedures (11%) and 24 RNP procedures with authorisation required (RNP AR) (3%), as shown in the following table:

Total number of airports	Total IAPs	Total PBN IAPs	Total RNP APCH IAPs	% RNP APCH IAPs of total IAPs	ICAO indicator: % of aerodromes with APV
99	783	178	83 APV Baro VNAV	11%	**14%**
			24 RNP AR	3%	

1.27 Likewise, according to Assembly Resolution A37-11, instrument procedures have been developed to 175 of the 228 thresholds that exist for the 114 runways in the SAM Region. For these 175 thresholds, 107 APV procedures have been implemented, accounting for 61% of IFR runways.

Total runways	Total IFR runways	Total APV IAPs	ICAO indicator: A37-11 % APV for IFR runways
114	175	107	**61%**

PBN Implementation in SAM States

Brazil

1.28 The SIRIUS programme of Brazil is an important en-route and TMA airspace restructuring project that applies the PBN concept to optimise air traffic flow between the main terminal control areas (TMAs) of Brazil. The project consisted in the restructuring of the route network within the polygon that encompasses the TMAs of Vitoria, Belo Horizonte, Brasilia, Sao Paulo (SP), and Rio de Janeiro (RJ), covering a total surface of 250,000 SQ.NM.

1.29 Project implementation was divided into two phases: restructuring of routes (first phase) and restructuring of the TMAs of RJ and SP (second phase).

1.30 The first phase was implemented in 2012 with the restructuring of 5 RNAV routes and the adoption of additional parallel routes. SID/STAR procedures had to be adjusted to the new routes. Approximately 250 procedures were amended.

1.31 For the second phase (implemented in late 2013), new procedures were published for the RJ and SP TMAs and air traffic flow was completely reorganised with the creation of new arrival and departure sectors for these TMAs.

- 43 routes were created or realigned;
- 198 new SIDs/STARs were published; and
- Approximately 650 procedures were published or modified during a period of three years.

1.32 The project also incorporated the concept of conditioned flexible use of airspace during the night or during periods of inactivity, resulting in a significant reduction of the distance flown (between 30 and 50 NM) in the different portions of the affected airspace.

1.33 Other benefits of the SIRIUS programme include:

- Implementation of RNP APCH (Baro/VNAV) and RNP AR APCH procedures for the five largest airports in both TMAs, resulting in enhanced safety, efficiency and airport access;

- Creation of new control sectors in APP and ACC areas for approaches and departures, which improved the traffic flow and increased ATC capacity;

- A total reduction of approximately 930 NM in miles flown, resulting in annual savings of 203.000 metric tonnes of fuel. In terms of the environment, this represents a reduction of 630.000 tonnes of CO_2 per year; and

- Significant noise reduction through stabilized descents and paths projected over oceanic and unpopulated areas.

1.34 The success of the programme may be directly attributed to collaborative decision-making (CDM), involving more than 1,000 officials from all the areas concerned.

Chile

PAMPA Project

1.35 The main objective of the PAMPA project – Route optimisation in Chile, is to connect the busiest city pairs in the country through more direct routes, laterally separated from other routes and which permit the establishment of TMA entry/exit flows and climbs and descents with minimum restrictions.

1.36 The project had the following characteristics:

a) The RNAV airways between Arica and Santiago were optimised.
b) The conventional routes were not modified.
c) Bidirectional airways were established between pairs.
d) SIDs and STARs were segregated.
e) 64 procedures (SIDs, STARs) were modified and/or created.
f) CDOs and CCOs were considered.
g) Departures with different requirements were designed in SCEL.
h) LAN flight simulators were used for validating some procedures.
i) Time to implementation: 18 months.

1.37 Since 2009, the DGCA of Chile, together with LAN, has been conducting an RNP AR procedure design and implementation programme at various airports and aerodromes of the country. The publication of these procedures has been aimed at improving accessibility (lower approach minima), safety (through the inclusion of procedures with vertical guidance to reduce CFIT events), and reducing emissions throughout the country, since RNP AR procedures permit shorter paths and optimised descent profiles that reduce fuel consumption and, consequently, emissions.

1.38 To date, 10 RNP AR procedures have been published for the Iquique, Antofagasta, Calama, Concepcion, La Serena, Santiago, Temuco, Valdivia, Osorno, and Balmaceda airports.

1.39 Data captured by LAN during 2012 show that the RNP project reduced fuel consumption by 250 mil Gal (equivalent to 757 mil Kg of fuel) during this period, corresponding to 2.413 tonnes of CO_2 not released into the atmosphere.

Peru

1.40 The SAM/IG/12 meeting was pleased to note that, as a result of the PBN airspace design workshop conducted in March 2013 in Miami, and within the framework of the SAM airspace optimisation programme, Peru started the **Airspace reorganisation and performance-based navigation implementation programme - PROESA /PBN** in June of this year, an initiative that is aligned with the pre-publication of ICAO Doc 9992 "*Manual on the use of performance-based navigation in airspace design*", which sets forth an agile methodology for the implementation of PBN airspace in 4 phases divided into 17 activities.

1.41 The **PROESA** programme considers the participation of the ATM community and the national industry, as well as of international organisations, professional associations, and users in general.

1.42 During the first stage of diagnosis and planning, the DGCA, CORPAC, and air operators represented by IATA and LAN PERU are working together. The objective of this first stage is to restructure the Lima TMA, the Cusco TMA and the Lima-Cusco-Lima corridor, which is the most congested at present, foreseeing its implementation for the second quarter of 2014.

1.43 This reorganisation will be aligned and harmonised with regional route enhancement initiatives currently under way, and will expedite the implementation of RNAV/RNP procedures at the aerodromes of the country, as well as continuous descent/climb (CDO/CCO) operations.

1.44 Finally, **PROESA** will offer a new structure with more efficient routes, with less climb/descent restrictions, both en-route and at the TMAs, reducing pilot and controller workload, seeking to reduce the need for vector guidance by virtue of RNAV paths, decongesting frequencies and giving pilots and controllers more time to perform their respective activities, increasing situational awareness, upon transferring navigation to database coding of optimum flight paths.

ATTACHMENT A TO APPENDIX B

PBN OPERATIONAL IMPLEMENTATION PROJECT

SAM Region	**PROJECT DESCRIPTION (DP)**	DP N° A1	
Programme	**Title of the Project**	**Start**	**End**
PBN (Programme Coordinator: Julio Pereira)	PBN Operational Implementation *Project Coordinator: Alexandre Luiz Dutra Bastos (Brazil)*	2011	2018
Objective	Support the optimisation of the South American airspace structure through the optimisation of the ATS route structure in terminal (RNAV/RNP SIDs/STARs) and en-route (RNAV/RNP) airspace, as well as the implementation of PBN approaches pursuant to ICAO Assembly Resolution A37-11.		
Scope	The implementation project contemplates the optimisation of the South American airspace through the implementation of PBN and the application of the flexible use of airspace (FUA) concept, as well as the phased optimisation of the ATS route network of the region.		
Metrics	• Reduction of CO_2 emissions in tonnes for each route optimisation version. • Percentage of RNAV and/or RNP SIDs/STARs implemented at international airports. • Percentage of continuous descent and climb operations implemented at international airports. • Number of RNAV/RNP routes implemented, realigned and/or eliminated.		
Strategy	The conduction of project activities will be coordinated among project members, the Project Coordinator, and the Programme Coordinator, mainly at SAM/IG meetings. The Project Coordinator will coordinate with the Programme Coordinator the inclusion of additional experts, if warranted by the tasks and works to be executed. Furthermore, the States must check their respective national RNAV route implementation programme for consistency with the SAM RNAV implementation programme. Activities involving the review, implementation, modification, or elimination of routes in the SAM Reigon are foreseen in order to continue with the optimisation of the ATS route structure.		

Goals	• Compliance with goals established by ICAO Assembly Resolution A37-11 regarding approach procedures with vertical guidance (APV); • 60% of international aerodromes using PBN standard instrument departures (SID) / standard instrument arrivals (STAR) by 2016; • 60% of routes/airspaces with performance-based navigation (PBN) by 2016; • 40% of international aerodromes /terminal control areas (TMA) with continuous descent operations (CDO) by 2016; • 40% of international aerodromes /terminal control areas (TMA) with continuous climb operations (CCO) by 2016;
Rationale	The 36th and 37th ICAO General Assemblies requested the Council to encourage Contracting States to improve air traffic efficiency resulting in emission savings, to report the progress made in this field, and to expedite the development and implementation of routings and procedures that will permit efficient fuel burn to reduce aviation emissions.
Related projects	• Automation. • Air navigation systems in support of PBN. • Enhance demand and capacity balancing.

Project deliverables	Relationship with the performance-based regional plan	Responsible party	Status of Implemen-tation*	Delivery date	Comments
Implementation of version 01 of the ATS route network, based on RNAV, with the necessary PBN values to meet current requirements of airspace users.	PFF SAM ATM 01	Alexandre Luiz Dutra Bastos		October 2010	**FINALISED**
Implementation of RNAV5 in the SAM Region.	PFF SAM ATM 01	Alexandre Luiz Dutra Bastos		October 2011	**FINALISED**
Action plan for the implementation of version 02 of ATS route network optimisation.	PFF SAM ATM 01	Alexandre Luiz Dutra Bastos		ATS/RO/3	**FINALISED**
Traffic data to understand airspace traffic flows.	PFF SAM ATM 01	ICAO coordinator		SAM/IG/6	**FINALISED**
Fleet navigation capacity.	PFF SAM ATM 01	Alexandre Luiz Dutra Bastos		SAM/IG/9	**FINALISED**

Project deliverables	Relationship with the performance-based regional plan	Responsible party	Status of Implemen-tation*	Delivery date	Comments
Listing of gateways of the main TMAs in the SAM Region.	PFF SAM ATM 02	Alexandre Luiz Dutra Bastos		SAM/IG/9	Few States have provided the data requested. The SAM/IG/11 meeting agreed to support States in the design of their TMAs so as to expedite PBN implementation.
Letters of Agreement and Contingency with adjacent States	PFF SAM ATM 01	Alexandre Luiz Dutra Bastos		SAM/IG/10	**FINALISED**
Detailed study of the SAM ATS route network, route network version 02	PFF SAM ATM 01	Alexandre Luiz Dutra Bastos		April 2012	**FINALISED**
Risk analysis for the implementation of Version 02 of the ATSRO Programme	PFF SAM ATM 01	External consultants		SAM/IG/10	**FINALISED**
"*Airspace Modelling*" studies and Fast-Time Simulation to assess the scenarios developed in the detailed study of the SAM ATS route network.	PFF SAM ATM 01	Alexandre Luiz Dutra Bastos		December 2014	This task is subject to the availability of Brazilian technical support and facilities in Jose dos Campos
Develop the terminal area optimisation planning strategy		SAM/IG/12		October 2013	Complete training of experts with two courses/workshops on airspace planning

Project deliverables	Relationship with the performance-based regional plan	Responsible party	Status of Implemen-tation*	Delivery date	Comments
Prepare and conduct a course/workshop on the design of terminal areas applying PBN		ICAO instructors		May 2014	Bogota and Asuncion TMAs
Develop a workshop for the analysis on the design of terminal applying PBN in the rest of participant States		ICAO instructors		September 2014	At least 1 TMA in each participant State
Develop guides for the design, assessment, and selection of the navigation specification to be applied in TMAs where required		External consultant		2014-2016	
Develop concept verification and validation and risk analysis procedures		External consultant		2014-2016	
Identify implementation restrictions and develop guides for pre-implementation training		External consultant		2014-2016	

Project deliverables	Relationship with the performance-based regional plan	Responsible party	Status of Implemen-tation*	Delivery date	Comments
Plan of action for Version 03 of the SAM ATS route optimisation programme		External consultant		October 2015	
Design the necessary tasks for the implementation of version 03 of the SAM ATS route optimisation programme		External consultant		2016-2018	
Regional strategy and work programme for the implementation of the flexible use of airspace, applying a phased approach, starting with a more dynamic sharing of reserved airspace		External consultant		2013-2018	
Resources required	Designation of experts in the execution of some of the deliverables.				

*

Grey	Task not started
Green	Activity underway as scheduled
Yellow	Activity started with some delay but expected to be completed on time
Red	It has not been possible to implement this activity as scheduled; mitigating measures are required

-END-