Agenda Item 2: Optimisation of the SAM airspace

Results of the Fourth Workshop on PBN airspace design in the SAM Region (PBN/4)

(Presented by the Secretariat)

SUMMARY

This working paper presents a report on the results of PBN/4 workshop held in Lima, Peru, from 7 to 11 September 2015.

References:

- PBN/1, 2 and 3 workshops
- SAM/IG meetings

ICAO Strategic Objectives:	*A - Safety* *E - Environmental protection*

1. **Background**

1.1 SAM/IG/15 meeting was of the opinion that in order to continue with the established implementation strategy, States must complete the validation phase. It should be noted that the PBN/4 workshop should focus on the following aspects of the implementation stage:

a) Go/no-go decision.

b) Pre-implementation review:
- ATC system update.
- Training programme.
- Approach, arrival and departure charts.
- Area and en-route charts.
- Contingency and back-up procedures.
- Letters of Operational Agreement.
- ATC units procedures.
- User preparation.

1.2 Based on the above, and with a view to ensuring the success of the PBN/4 workshop, SAM/IG/15 meeting formulated following conclusion:

Conclusion SAM/IG/15-2: **PBN Implementation in South American TMAs**

That, in order to continue the PBN Implementation process in selected TMAs, States shall comply with the following requirements:

a) Submit a consistent and feasible Action Plan to the SAM Office for its inclusion in, and harmonisation with, the SAM PBN Implementation Plan and in harmony with the updated PBN National Plan.
b) Complete the validation of the PBN design of the TMA (SMS, IFSET, ground validation of procedures).
c) Prepare an ATCO training programme.
d) Complete the aeronautical charts (IAC, SID, STAR, ARC, ERC).
e) Prepare the Letter of Operational Agreement model.
f) Complete the "operational model"/ Operating Manual.
g) Participate in Project follow-up teleconferences on:
- 27 May
- 18 June
- 17 July
- 03 August
- 19 August (subject to subsequent confirmation)
h) Deadline for delivery of the material developed under items a) thru f): **3 August 2015**.
i) Participation in the PBN/4 Workshop: tentative date 7 to 11 September, 2015

1.3 Based on the above mentioned conclusion, the Fourth Workshop on PBN airspace design in the SAM Region was successfully held at the South American Regional Office, from 07 to 11 September 2015, with the participation of experts from aeronautical administrations, air navigation service providers as well as air operators of the South American Region.

2. Discussion

Summary of the status of implementation of PBN, by State/TMA

2.1 After presentations made by SAM States and the exchange of views and experiences during the PBN/4 Workshop, it was possible to reach a conclusion on the status of implementation of PBN in the South American TMAs. The following table contains a summary on the status of implementation of PBN by State/TMA. In this regard, the criteria used to assess the status of implementation were the phases foreseen in ICAO Doc 9992: Planning, Design, Validation and Implementation.

STATE	TMA	TENTATIVE DATE	STATUS OF IMPLEMENTATION
Argentina	BAIRES	30 Mar 2017	Planning
	12 TMAs (COR, MDZ, BRC, FTE, NQN, IGR, CRD, SLA, TUC, MVD, RGL and USH)	Nov 2015 / May 2016	Implementation
Bolivia	Cochabamba, La Paz, Santa Cruz	28 Abr 2017	Planning
Brazil	Brasilia, Belo Horizonte, Sao Paulo (changes)	12 Nov 2015	Implementation
	PBN SUR - Route Network + Curitiba, Florianópolis and Porto Alegre	30 Mar 2017	Design
Chile	Santiago - PAMPA SUR	15 Sep 2016	Implementation
Paraguay	Asuncion	23 Jun 2016	Implementation
Ecuador	Guayaquil	23 Jun 2016	Implementation
Panama	Panama	23 Nov 2016	Implementation
Peru	Arequipa, Cuzco, Juliaca and Puerto Maldonado	31 Mar 2016	Design
Uruguay	Carrasco and Laguna del Sauce	30 Mar 2017	Design
Venezuela	Maiquetía	28 Abr 2016	Implementation

Details on the status of implementation in each SAM State

2.2 The details on the status of implementation in each SAM State are shown in **Appendix A** to this working paper (summary of PBN/4 Workshop).

Survey on PBN/4 Workshop

2.3 The result of the survey on PBN/4 Workshop assessment is included in Attachment 1 of Appendix A to this working paper. The assessment average was 4.61 (values from 1 to 5). 67.33% of participants rated the workshop as excellent while 30.28% rated it as good

PBN implementation strategy in TMA

2.4 The PBN implementation strategy in TMA should be based on following events:

- ✓ Monthly teleconferences (last Thursday of each month);
- ✓ 2 PBN implementation workshops in 2016;
- ✓ 1 PANS/OPS workshop;
- ✓ Bilateral and/or multilateral meetings as required.

2.5 Considering the status of implementation of each TMA, PBN implementation workshops should be distributed as follows:

First PBN Implementation Workshop (PBN/IMP/1) - Date TBD	
State	**Implementation**
Argentina (low complexity TMA)	May 2016
Brazil (Brasilia, Belo Horizonte, Sao Paulo) (modifications)	12 Nov 2015
Chile (Santiago - PAMPA Fase 2)	15 Sep 2016
Ecuador (Guayaquil)	23 Jun 2016
Peru (Arequipa, Cuzco, Juliaca and Puerto Maldonado)	31 Mar 2016
Venezuela (Maiquetía)	28 Apr 2016

Second PBN Implementation Workshop (PBN/IMP/2) - Date TBD	
State	**Implementation**
Argentina (BAIRES)	30 Mar 2017
Bolivia (Cochabamba, La Paz, Santa Cruz)	28 Apr 2017
Brazil (PBN SUR)	30 Mar 2017
Panama (Panama)	TBD
Paraguay (Asuncion)	23 Nov 2016
Uruguay (Carrasco)	02 Mar 2017

3. Conclusion

3.1 In general, during PBN/4 Workshop it was noted that States have evolved in their Action Plans for PBN implementation in TMAs.

3.2 The main factors allowing such evolution were the following:

- Continuity in participation of experts;
- Lessons learned sharing;
- Participation of leader operators for some States;
- Support of most Administrations to PBN Projects;
- Investment in personnel training in some States (Argentina, Ecuador, Peru).

3.3 Although there was some progress in the development of Action Plans, PBN/4 Workshop concluded that the regional process as a whole was delayed by at least 6 months. This, taking into account that the initial expectation was that the process of implementation would take around 18 months,

according to the successful experiences of Chile (Pampa Sur) and Peru (PROESA), which adopted, at least partially, the methodology applied in SAM PBN workshops.

4. **Suggested action**

4.1 The Meeting is invited to:

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

b) review, if necessary, the status and dates of PBN implementation in SAM TMAs;

c) analyse, make changes as deemed necessary and approve the PBN implementation strategy in TMAs;

d) propose RLA/06/901 RCC the conduction of events mentioned under paragraph 2.4.

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APPENDIX A

FOURTH WORKSHOP ON PBN AIRSPACE DESIGN IN THE SOUTH AMERICAN REGION

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

FOURTH WORKSHOP ON PBN AIRSPACE DESIGN IN THE SOUTH AMERICAN REGION

(Lima, Peru, 7 to 11 September 2015)

Taking into account Conclusion SAM/IG/14-2 "*Meetings and resources required for the conduction of activities under the South American Airspace Optimisation Action Plan*" and Conclusion SAM/IG/15-2 "*PBN implementation in South American TMAs*", it was decided to continue with the training programme for ATM experts of the South American Region, by convening the Fourth workshop on PBN airspace design in the South American Region, which was held in Lima, on 7-11 September 2015.

The PBN airspace design workshops were established to assist States in the implementation of PBN for the design of airspaces such as terminal areas (TMAs), ATS routes, and to train them in the assessment of ATM/COM/NAV/SUR capabilities of States, traffic volume and flow analyses, fleet mix and equipage, to solve real operational problems in a selected airspace. The philosophy is to apply an end-to-end approach to a major traffic flow.

The Third PBN workshop reviewed the validation phase of the proposed PBN designs and its related activities, noting some delay in the validation of several projects. As a result, it was necessary for States to focus as much as possible on validation as a prior step to implementation, which would be analysed at this PBN/4 workshop.

The main objective of the PBN/4 workshop was to discuss the implementation stage, in relation to the following aspects:

a) Implementation go/no-go decision
b) Pre-implementation review:
   - ATC system update
   - Training programme
   - Approach, arrival and departure charts
   - Area and route charts
   - Contingency and backup procedures
   - Letters of operational agreement
   - ATC unit procedures
   - User readiness

Regarding the above, the participating States made the following presentations:

ARGENTINA

Argentina started its presentation by showing the regulatory framework of Argentina, which served as support for the airspace re-structuring project. Based on these regulations, a team of experts was established with personnel from ANAC, DGCTA and Aerolíneas Argentinas, with the purpose of modernising Argentinian airspace.

One aspect to highlight is the cooperation agreement for the creation of a Standing Civil-Military Consultation and Cooperation Group to pursue a more flexible use of airspace, by revising some areas currently considered as reserved.

The delegation of Argentina pointed out that its PBN implementation plan had been presented at the SAM/IG/15 meeting, with tentative dates for the implementation of PBN

procedures at the main TMAs of the country. It also stated that the plan was being revised and updated by the aeronautical authority, and would be presented once completed.

The plan covers the terminal areas that serve the following airports: COR, MDZ, BRC, FTE, NQN, IGR, CRD, SLA, TUC, MVD, RGL, and USH. The activities carried out by the PBN team for those airspaces were shown.

A presentation was made of the revised action plan of the Baires TMA implementation project, covering all phases. It was estimated that its execution would require approximately 547 working days, and its commissioning was foreseen for 30 March 2017.

An important aspect of the implementation of improvements at the Baires TMA is the agreement required with Uruguay and Brazil on the entry and exit points of the aforementioned TMA. Information was provided on the efforts made by the three countries to reach an agreement that would benefit all parties.

Another aspect to highlight has been the training of personnel through a course on conventional procedure design, conducted in March 2015, followed by the RNP APCH and Baro VNAV procedure design course in June 2015 and finally, the RNP AR procedure design course in August of the same year. Furthermore, in order to train as many experts as possible, workshops and seminars were held for air navigation inspectors and air traffic controllers.

Note was also taken of the activities carried out to assess nautical mile reduction as a result of the project and, thus, to calculate CO_2 emissions under the new plan, using the IFSET tool. Calculations for the Baires TMA, including PBN departures and arrivals, showed an annual reduction of 592,545 NM, a reduction of 1411 flight hours, and a reduction of 9877 tonnes of CO_2 emissions.

The presentation covered the process of validation of procedures in the Neuquén PBN Project, which was well received by workshop participants and considered as a model that could be used by SAM States.

Finally, the delegate of Argentina expressed some concerns that would require a regional solution, in relation to the following issues:

- Coding differences at regional level.
- Drafting of electronic charts.
- Application of the new ADVANCED RNP specification.
- Transition of the RNP chart nomenclature based on CIR 336, and publication of an AIC to inform all users about the inclusion of APCH in the name of approach procedures.
- Establishment of a work team to agree and jointly develop the airspace design for the Baires and Montevideo TMAs.
- Operator inputs for comparing CO_2 consumption using Lido.

PRESENTATION BY BOLIVIA

Following an analysis of the possible impact of PBN implementation in a single TMA, as initially planned in the Patujú Project, aimed at optimising the Viru Viru TMA, Bolivia saw the need and convenience of replacing it by a new project called "PBN - BOLIVIA" in order to make it more comprehensive. The project is divided into 3 phases:

- **Phase I**: PBN implementation in the terminal areas of: La Paz, Cochabamba, and Santa Cruz
- **Phase II**: Integration of the terminal areas of Tarija and Cobija
- **Phase III**: Integration of the TMAs of Trinidad, Puerto Suarez, and Rurrenabaque

During the process, the weaknesses and strengths of the ATM and CNS areas and the fleet operating in Bolivian airspace were analysed, based on which opportunities were assessed, especially focusing on PBN implementation in the TMAs of the trunk network and the upcoming implementation of the radar surveillance system, which would facilitate the implementation and the conduction of training programmes in parallel to the training of radar controllers.

Within PBN implementation plans and in order to reduce the number of ATS incidents and obtain more efficient airspace control, it was concluded that it was necessary to modify the structure of the lower airspace. The new structure of the lower airspace was presented, together with the creation of the new terminal areas that would be based on surveillance coverage, once available, and communications coverage.

Finally, Bolivia presented its new Action Plan concerning TMAs of the aforementioned Phase I, and shared with the workshop the main achievements and difficulties faced during the fulfilment of the different tasks for the optimisation of the selected airspaces. It is expected that implementation will take place on 28 April 2017.

PRESENTATION BY BRAZIL

The delegate of Brazil started his presentation with a video on air traffic in his State, showing the main airports that support the main air traffic flows, namely Sao Paulo, Rio de Janeiro, Belo Horizonte, and Brasilia.

The Brazilian project encompassed several TMAs, including the aforementioned airports, where the implementation date for airspace concept changes is 12 November 2015.

The main objective of the Brasilia TMA project was the implementation of independent simultaneous approaches at the Brasilia airport, with a view to improving operations during peak arrival hours.

At the Belo Horizonte TMA, the focus was on improving safety, taking into account that this airspace had been affected by various airspace changes in the route network and in the main TMAs that give origin to the main traffic flows into Belo Horizonte (Rio de Janeiro, Sao Paulo and Brasilia). Annual savings prospects in this project amount to 2,316 tonnes of CO_2/year.

Changes in the Sao Paulo TMA are related to the need to offer more flexibility to ATCOs so that they are not forced to use radar vectoring at the beginning of the STARs, and to reduce the number of delays. The initial conception of the new STARs for the Guarulhos and

Congonhas airports was modified following a CDM process with the main stakeholders, whereby the segment to be flown in the proximity of the airports was reduced.

The presentation also covered plans to implement SIDs/STARs using CDO/CCO techniques at the following airports: SBEG, SBBE, SBCY, SBSV, SBFZ and SBSG. In addition to the known benefits of CDO/CCO, the implementation seeks to attain the goals of the Declaration of Bogota.
The presentation focused on the optimisation of the southern airspace, also based on the phases of the airspace concept implementation process. The reference scenario includes Curitiba, Florianópolis and Porto Alegre. Sao Paulo was also considered, especially for the optimisation of the area south of that TMA.

A description was made of the existing airspace structure and aerodromes in southern Brazil, and of the restricted, prohibited, and dangerous airspaces involved, as well as the standard departures and arrivals currently in force, existing radio aids and radar coverage.

PRESENTATION BY CHILE

The delegation of Chile presented the action plan for the implementation of the PBN airspace concept in the Santiago TMA.

The workshop was presented with the complete PBN implementation action plan, briefly explaining each of the 17 tasks and the modifications made to improve the action plan. It is expected that the implementation will take place on 15 September 2016.

The Validation Phase was presented in detail, as well as the use of the IFSET tool for calculating CO_2 emissions. In this sense, it is expected that the implementation of the PBN concept at the Santiago TMA will save 19,156 tonnes of CO_2 emissions per year, as follows:

- SIDs: 17,541 tonnes
- STARs: 1,615 tonnes

The main traffic flows in the terminal area of Santiago, including both departures and arrivals, were then presented, with the existing configuration and the foreseen configuration upon completion of the project.

Regarding the air traffic controllers' training programme, an explanation was given of supplementary subject matters for air traffic controllers who would be providing control services for RNAV1, RNP1, RNP APCH navigation applications in the terminal area of Santiago. The following topics are included in the training programme:

Unit A: Navigation systems

a) Operation of area navigation systems, including functional capabilities and limitations:

   - Precision, integrity, availability, and continuity;
   - GPS receiver, RAIM, FDE, and integrity alerts; and
   - Fly-by waypoint concept compared to flyover waypoint (turn performance differences).

b) Flight plan requirements, including RNAV 1, RNAV 2, RNAV 5, RNP APCH, RNP 1 and RNP 2 applications; and

c) Considerations for requesting a flight route change during a procedure.

Unit B: ATC procedures

a) **ATC procedures**:

- Separation minima;
- ATC contingency procedures;
- Transition between different operating environments;
- Phraseology; and
- Considerations on PBN-based ATC procedures in flight operations and crews

b) **Control procedures related to RNAV1/ RNP1 STARs and SIDs**:

- Associated control procedures;
- Radar vectoring techniques;
- Open and closed STARs;
- Altitude restrictions; and
- Descent/climb clearances

c) **Lateral performance:**

- Route- or procedure-related;
- Parallel displacements, termination of displacements with RPN systems, and return to the original flight plan; and

d) **RNP approaches and related procedures**:

- Approach minima;
- Possible negative impact of issuing an amended clearance for a procedure when the aircraft is already established in it, due to the possible difficulty to meet visa procedure requirements.

Information was provided on the process concerning letters of operational agreement required for coordinating air traffic between ATC units. It was suggested to conduct this process during the early stages of the project so as to have them ready when the project needed to be implemented.

PRESENTATION BY ECUADOR

The delegation of Ecuador reported that its Administration, interested in the optimisation of navigation and air operations in Ecuadorian airspace, and based on ICAO guidelines, had drafted and developed the Preliminary PBN Implementation Project for the Guayaquil TMA, and had executed the activities described in the four main phases: Planning, Design, Validation and Implementation.

The purpose of the Project is to optimise airspace (TMA, routes, holdings) and all flight phases, from take-off, through climb, en-route flight, approach to landing, constantly reducing in flight distance, time and CO_2 emissions into the atmosphere, thus providing operational benefits to airline operators and users, complying with the highest safety standards required.

The Project also contemplates the application of the flexible use of airspace (FUA), based on improved civil-military coordination, enhanced air traffic management, and reducing the workload of both air traffic controllers and flight crews. It is expected that the

implementation of performance-based navigation (PBN) in the Guayaquil terminal control area will take place on 19 June 2016.

After a brief summary of the different phases, a detailed explanation was given of the structure of the existing reference airspace and the analysis conducted thereof. Traffic statistics and forecasts that served as the initial basis for the implementation programme were also shown. During the Guayaquil PBN airspace validation phase, the objective was to:

- Validate the Guayaquil airspace
- Validate PBN and conventional traffic flows
- Use IFSET for path validation
- Update the SMS validation based on project observations
- Identify and train the staff that will be in charge of providing ATM training
- Draft the ATCO pre-implementation training plan (ATM)
- Create the PBN Operations Manual model (ATM)
- Create the letter of agreement model for PBN operations (ATM).

In the design phase, concepts from ICAO documents were used, and simulations were conducted with 2-minute separation between departure and arrival flows to check the separation between flows in these routes. Each flow was independently checked, and they were divided into 5 arrival and departure flows. During the obstacle design and evaluation phase, it was noted that some, because of their location, might affect the approach and missed approach phases.

Following simulations, several comments were made, which have been taken into account for the study and design of the holding patterns recommended in support of mixed traffic management in the TMA, with the expectation that, at some point in time, the whole TMA will be PBN.

IFSET calculations for the Guayaquil PBN Project took into account each designed path, number of operations, path distances, CDO and CCO calculation data, tested in real-time simulations. Likewise, PBN and conventional paths were compared, the result being that the designs proved more efficient. In summary, after performing the calculations, PBN implementation in the Guayaquil TMA is expected to generate an annual reduction of 5’950,700 kg of fuel and an annual reduction of 18,804.21 tonnes of CO_2 emissions released into the atmosphere.

In order to meet the deadlines established in the Action Plan, it will be necessary to conduct a final verification and certification of ATM personnel that will be in charge of training, draft the operational and support documentation, and conduct training using all the necessary support material. Furthermore, the ATM administrative part needs to be integrated and sensitised as to the importance of the new designed model.

Likewise, it is recommended that training take place at the Development Unit of the Guayaquil Control Centre *(Unidad de Desarrollo - Centro de Control Guayaquil)*, since it has all the required simulation facilities.

Given the importance of simulation training for Guayaquil ATCOs prior to implementation, it must be scheduled without interruptions, reason why it should be conducted at the Control Centre.

The established timetable should be maintained in order to complete implementation as scheduled.

The participants at the workshop considered that the documentation submitted by Ecuador to the ICAO SAM Regional Office was quite comprehensive and could serve as a model for SAM States.

PRESENTATION BY PANAMA

Panama presented the status of implementation of the Panama Terminal Area Optimisation Project, consisting of the implementation of PBN arrival and departure procedures, to be published on 17 September 2015. The objectives were as follows:

- Improve safety levels to address sustained air traffic growth.
- Improve efficiency through the implementation of continuous climb and descent procedures.
- Mitigate environmental impact, reducing CO_2 emissions with procedures to reduce miles flown.

To this end, an airspace design team was created, tasked with meeting the operational requirements of the Project, and made up by:

- Air traffic controllers rated in the approach area.
- Instrument procedure designer.
- Technical pilots.
- Other users.

The operational objectives were defined as follows:

- Tolerate a sustained annual growth of operations in the TMA of 8-10% during the next 10 years.
- Improve safety levels.
- Reduce the workload of operational personnel (air controllers, pilots, etc.).
- Increase the capacity of existing system (airport, runways, taxiways, airspace).
- Seek fuel use efficiencies, focusing on operators and the environment.

Next, a presentation was made of studies conducted to assess the current scenario, the percentage flow per quadrant of the reference scenario, the main entry and exit paths of the TMA, fleet capacity, especially that operated by its main user, concluding that only 3% of operators in the Panama TMA were not capable of conducting PBN operations.

Once the current scenario had been assessed, the design phase was started. In this design phase, it was noted that there was no consensus as to how the new scenario should be designed, and several proposals were presented during the workshop. This prevented adequate progress. However, a solution is expected soon through the establishment of a single work team, as originally planned. In order to improve interaction among the various parties, the workshop concluded that it would be advisable to conduct PBN workshops or seminars with broad participation by the aeronautical industry of Panama. This proposal is applicable to all PBN implementation teams of the States.

One proposal presented during the workshop referred to the use of the "*point of merge*" technique. Regarding this proposal, the workshop felt that:

- The proposed arc was too long, about 50 NM, while the segment in other implementations did not exceed 15 NM.
- In general, the technique could be considered as a way to disguise holdings.

- Taking into account that, in their plans, operators should consider flying over the whole proposed arc, they would be obliged to carry more fuel, thus generating a clear operational inefficiency. Furthermore, in longer flights, the carriage of additional fuel would require a reduction in payload (passengers and cargo).

  One of the proposed designs would allow for:

- A reduction of up to 26% in sequencing actions
- A reduction of up to 29% in potentially conflicting aircraft
- Savings of up to 99 gallons per arrival, in average
- Up to 67,000 tonnes less of CO_2 released into the atmosphere.

Accordingly, optimum paths will continue to be pursued, taking into account the operational area. Therefore, the foreseen implementation date might vary, which will be informed to the Regional Office as soon as known.

PRESENTATION BY PARAGUAY

The delegation of Paraguay presented its project «*Implementation of the Performance-Based Navigation (PBN) Concept in the Asunción Terminal Control Area*», Validation Phase.

The presentation started by recalling that the Third PBN workshop had identified differences in some aspects, which should be taken into account in low traffic and medium/high traffic volume environments. The Asunción TMA is a low traffic environment, enabling the use of more direct horizontal flight profiles like, for instance, directly from the initial STAR segment to the IAF. In this regard, the workshop considered that the airspace design of the Asunción TMA could serve as a model for low traffic environments, respecting the specifics of airspaces where such design would be applied.

Then, an analysis was shown of the existing scenario and the PBN arrival and departure scenario for runways 02/20. Likewise, an explanation was given of activity 11 on concept validation, which was carried out using:

- Work done on the airspace concept.
- SMS analysis, hazard identification and mitigation.
- Calculation of operational benefits, fuel and CO_2 savings (IFSET).
- Re-evaluation of the basic validation process, considering a low traffic density TMA scenario (direct paths to the IAF).

A fuel consumption table was shown, comparing the current situation with the future situation once the PBN is implemented in the Asunción TMA, showing a total annual fuel reduction of 240,000 kg and, thus, a reduction in CO_2 emissions of 758,400 kg.

Regarding the risk analysis conducted during the Validation Phase, it was concluded that, by taking some mitigation measures, PBN implementation in the Asunción TMA would not affect aircraft operations, and the risk would be acceptable.

Once the Validation Phase (Activity 11) was completed, activity 12, *completion of air navigation procedures*, and phase 13, *gound validation using airspace modelling*, were started.

Once the Validation Phase was completed, the Implementation Phase started with the updating of the ATC system, modification of the flight data processor (FDP), and changes to the radar data processor (RDP), which together with activity 15, *Awareness raising and development of training material*—already underway—will permit readiness for implementation in April 2016.

In order to create awareness amongst those involved in this programme, talks have been held with air traffic controllers, pilots, and airlines, to brief them on PBN concepts and on the PBN Implementation Project in the Asunción Terminal Area.

It is expected that data on AIS and the processed material will be delivered for publication as soon as possible, in order to meet the established deadlines, so that users can have them available sufficiently in advance to the effective date.

Finally, it was noted that, based on activity 17, post-implementation system oversight has been scheduled through the collection of operational data to ensure continuing safety and determine if strategic objectives have been met.

PRESENTATION BY PERU

The delegate of Peru started his presentation by explaining the process carried out by Peru since the beginning of PBN implementation through the PROESA Project. Once PBN implementation in the Lima TMA was completed, which involved the optimisation of some ATS routes to help improve the structure of the Lima TMA, Stage 2 of the PROESA project started with PBN optimisation in the Cusco and Arequipa TMAs.

The background of the PROESA Project was presented, with the preliminary designs developed in Stage I. The first stage was completed on 24 July 2014, covering RNAV 5, en route, lower airspace, and RNAV1/RNP1 for TMA SIDs/STARs connecting with Cusco and Arequipa.

As part of post-implementation assessment of the first stage of PROESA, some adjustments were made to departure procedures in the Lima TMA.

Regarding Stage 2, the Cusco TMA was redesigned, and the airspace of the Arequipa, Juliaca y Puerto Maldonado TMAs was reorganised. To this end, a multidisciplinary working team was established, in addition to target agreements and design criteria.

As part of this process, RNP AR departure and approach procedures for Cusco, which were only available for LAN Perú, were published starting on 5 February 2015, through AIP Supplement 01/15. It is expected that operators will develop their respective emergency procedures in case of one engine inoperative (OEI) for missed approach segments and departures.

A detailed explanation was then provided of activities 1 to 6, on planning, and 7 to 8, on the design phase of the Action Plan for improvements under Stage II.

The design not only included arrivals and departures in the aforementioned TMAs, but also flows from Cusco to Lima, Puerto Maldonado and Arequipa, with an analysis of path separation to keep air traffic smooth and safe.

One of the proposals that were submitted involved the possibility of SID/STAR integration into some operational environments, without the use of ATS routes. The direct link between a SID and the IAF of the approach procedure at the destination airport can be

considered as a model for SAM States with operational environments that are similar to the one presented by Peru. An example would be the link between Carrasco and Aeroparque.

The GAXUN 1B exit connecting Cusco to the route to Lima was published on 23/07/15, effective on 17/09/15. RNP AR approval is required and a reduction of 9 NM per flight with respect to the current TAUJA 2 GAXUN exit is expected, thus saving 135 NM per day. Likewise, arrival and departure paths to Lima will permit a reduction of 4 NM per flight, totalling 48 NM per day of operation.

PRESENTATION BY URUGUAY

The delegate of Uruguay briefly explained the activities carried out within the context of the Action Plan for PBN implementation in the Carrasco and Laguna del Sauce TMAs, expecting effective implementation in March 2017. Since the airspace design of the Carrasco and Laguna del Sauce TMAs is closely related to the restructuring of the Baires TMA, meetings are being held between the authorities of the two countries to reach an agreement on the optimisation of the two TMAs and to ensure that PBN implementation is done simultaneously in both terminals.

Next, the standard departure/arrival procedures to/from Laguna del Sauce and Carrasco airports were explained, taking into account Restricted Area 5 located a short distance from Carrasco's runway 24.

Training has been provided to the aeronautical community operating in said airports, focusing on PBN and the main characteristics of the FMS.

Similarly, operational agreements have been drafted between the Carrasco APP and TWR that supplement the criteria established in the PANS ATM, the provisions of the AIP and the RAUs. These procedures will be ready and available when the final implementation date is agreed.

A final agreement on the paths between the Baires and Carrasco TMAs has not been reached yet, and it is expected that the new proposal will save about 26,790 kg fuel per year, and thus about 85.6 tonnes of CO_2.

PRESENTATION BY VENEZUELA

A presentation was made of the project of Venezuela, called Chévere Phase III, starting with the conclusions and lessons learned since the PBN 2 workshop.

In this regard, the data collection and processing model used was shown, and it was noted that since the second PBN workshop, updated information on city pairs had been received from the Maiquetía ATM in order to have a more realistic idea of traffic flows to and from Maiquetía, verifying the initial hypothesis of major flows coming from the east and true west. Information was also obtained on the fleet operating in the Maiquetía FIR. This analysis showed that there is a low percentage of PBN-approved aircraft and operators, which points to a potential difficulty in addressing TMA optimisation in Venezuelan airspace. However, the data obtained is not fully reliable, so this issue must be analysed again.

Taking into account the comments made by experts of the Region, and based on these suggestions, paths were redesigned to optimise the initial project by simplifying the TMA entry and exit points. Airspace classification was also reviewed in order to respond to operational practice.

Regarding the Validation Phase, note was taken of the agreement reached concerning the new design that would improve the existing path of the DME arc, which, in practice, is replaced by radar vectoring. In this phase, the PBN design of the Maiquetía TMA was submitted to the consideration of the operational area, pilots of two operators, ATFM personnel, and the ARO/AIS representative, under the assumption and in the understanding that the proposal sought to optimise airspace use, reduce controller workload, and take advantage of aircraft on-board capacity as approved by the aeronautical authority.

For validation purposes, PANS-OPS 8168, Doc 9906, Doc 9613, Doc 9931, Doc 9992 and Doc 9993 were used as support documentation. As to the quality of data, the runway threshold coordinates used were based on geodetic surveys validated by the *Instituto Geográfico Simón Bolívar* and the SRTM (Shuttle Radar Topography Mission) terrain database validated by the *Dirección General de Geografía y Cartografía* (General Bureau of Geography and Mapping) of the Armed Forces. Regarding paths and magnetic variation, it was noted that all paths were defined with courses to the hundredth of a degree, to which the magnetic variation had been added. Data will be fed to the simulator of the evaluation aircraft, and a simulation run in order to have the paths loaded before in-flight validation.

One aspect identified as a problem was the training of controllers and particularly, the use of the appropriate PBN phraseology. In this regard, there was consensus among the participants of the workshop as to the need to have a phraseology validated by ICAO. In this sense, it was noted by the Secretariat that a proposal of amendment to the phraseology to be used in PBN operations is already being circulated.

It was explained to the workshop that the conclusion reached based on the risk analysis exercise was that the safety risk index was acceptable and that implementation was at a moderate tolerability level. The administration would provide continuous recurrent training, conduct periodic assessments of controllers, and constantly oversee the navigation aid system, which implied a periodic maintenance plan, and would conduct a constant monitoring of the system in order to keep it at an acceptable safety level.

Finally, after the optimisation of the Maiquetía TMA foreseen for 28 April 2016, monthly savings were expected in the order of 65,800 kg of fuel, 207,928 kg of CO_2, totalling 2,495,136 tonnes per year of CO_2.

AEROLINEAS ARGENTINAS – Operator's viewpoint

The presentation by Aerolíneas Argentinas focused on the establishment of the PBN Task Force and its duties, on the PBN courses conducted for pilots, especially in relation to flight checklists and contingencies, on projects associated to PBN implementation foreseen by the aeronautical authority, the validation of procedures in the flight simulator, and the conclusions reached following this process.
It was noted that the PBN Task Force was composed of the three entities directly involved: ANAC, DGCTA and Aerolíneas. The courses provided to airline pilots focused mainly on contingency procedures in the event of one engine inoperative in the SIDs designed for some of the TMAs selected by the aeronautical authority for PBN implementation.

Validation of some of the procedures in the flight simulator started in July 2015, and simulations will continue until the procedures are published.

The Aerolíneas Task Force underlined the benefits of joint interdisciplinary work among those involved to improve safety based on positioning accuracy, increase and improve payload calculations, use FOQA as a useful tool to obtain detailed information on paths, wind, and identify procedures that could generate destabilised approaches and, especially, the link between concurrent training and procedure design.

Summary of the Status of Implementation of PBN, by State /TMA

The following table contains a summary of the status of implementation of PBN by State/TMA. In this regard, the criteria used to assess the status of implementation were the phases foreseen in ICAO Doc 9992: Planning, Design, Validation, and Implementation.

State	TMA	Tentative date	Status of implementation
Argentina	BAIRES	30 Mar 2017	Planning
	12 TMAs (COR, MDZ, BRC, FTE, NQN, IGR, CRD, SLA, TUC, MVD, RGL and USH)	Nov 2015 / May 2016	Implementation
Bolivia	(Cochabamba, La Paz, Santa Cruz)	28 Apr 2017	Planning
Brazil	Brasilia, Belo Horizonte, Sao Paulo (changes)	12 Nov 2015	Implementation
	(PBN SUR – Route Network + Curitiba, Florianópolis and Porto Alegre)	30 Mar 2017	Design
Chile	(Santiago – PAMPA SUR)	15 Sep 2016	Implementation
Paraguay	(Asunción)	23 Jun 2016	Implementation
Ecuador	(Guayaquil)	23 Jun 2016	Implementation
Panama	(Panama)	23 Nov 2016	Implementation
Peru	(Arequipa, Cuzco, Juliaca and Puerto Maldonado)	31 Mar 2016	Design
Uruguay	(Carrasco and Laguna del Sauce)	30 Mar 2017	Design
Venezuela	(Maiquetía)	28 Apr 2016	Implementation

Note: The Appendix to this Executive Summary contains the results of the survey carried out during the Fourth Workshop on the Use of PBN in Airspace Design in the SAM Region.

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ATTACHMENT 1

FOURTH WORKSHOP ON THE USE OF PBN

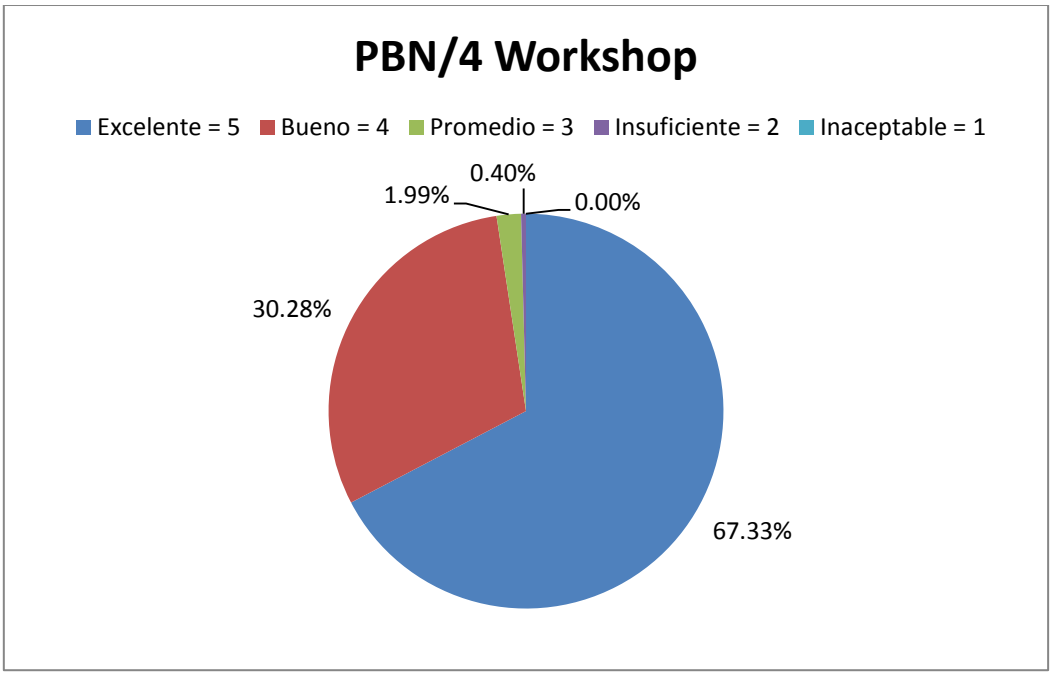
IN AIRSPACE DESIGN IN THE SAM REGION

SURVEY RESULTS

ASSESSMENT OF COURSE CONTENTS

(**Rating**: **5** = *Excellent* / **4** = *Good* / **3** = *Fair* / **2** = *Inadequate* / **1** = *Unacceptable*)

	Average
a) How relevant were the topics discussed?	4.89
b) How do you rate the training programme of the PBN workshop?	4.61
c) How do you rate the training material?	4.46
d) Is the theory reinforced with excercises and practices?	3.93
e) Are topics related to reality and/or applicable to real cases?	4.79
f) How do you rate the level of information?	4.71
g) Has the workshop met your expectations?	4.71
h) Is the information provided sufficient to carry out the PBN implementation plan in your State or company?	4.71
i) Would the material and information provided in the workshop permit the conduction of a course/workshop in your State or company?	4.64
General average	4.61



What would you suggest to improve the workshop?

- The truth is that the workshop has met by far all my expectations.
- Organise more workshops in order to increase interaction among the various participants.
- Information from the States should be more available before the workshop.

- The workshop was fine and allowed for the exchange of knowledge and experiences. However, additional topics have emerged, such as PANS-OPS, coding, and others that should be addressed. Maybe another workshop in parallel?
- For this type of workshop/meeting, States should be requested to prepare a set of questions and concerns to be presented at the workshop for resolution by all the participants, since the answer could help one or more States.
- Everything was fine. Congratulations.
- More workshops should be held so that planners can share experiences and help States to improve.
- More participation by airlines. Presentation by airlines on PBN.
- Encourage participation by more operators in order to generate multiple results and benefits.
- I would like database providers to participate, since they are also stakeholders in PBN implementation, and it would help unify coding tables in the region.

Comments

- Information should be shared on the ICAO website.
- I wish to thank ICAO authorities for kindly inviting us to present to the participating States the work being carried out by the operator (in this case, Aerolíneas Argentinas).
- Thank you for providing a space to present the PBN viewpoint of the operator.
- Thank you for the time and space offered to Aerolíneas Argentinas to present the problems involved in the application of PBN concepts to engine failure procedures.
- Thank you to ICAO officers, coordinators and instructors for helping develop the PBN concept in our States.
- Thanks to the Regional Office for its efforts and dedication towards the organisation and conduction of the workshop.
- Participation by some of the users is essential for the workshop.
- Very good and appropriate to the requirements. It offers an opportunity to conduct a comparative analysis of what our State intends to achieve.
- Teleconferences should continue, even after PBN implementation in the States. Workshop on PANS-OPS design.
- Conferences addressed to PANS-OPS experts on aircraft performance and the use of FMS in the cockpit.
- Conduction of follow-up workshops to consolidate tasks and share lessons learned.
- Insist with the authorities on the importance of PBN and their commitment.
- Conduct implementation workshops. Conduct PANS-OPS workshops.
- The Secretariat should prepare a PANS-OPS workshop to standardise the nomenclature to be used in the Region.
- I think the meeting should be called PBN implementation, since it goes beyond training. It does include training, but tasks are more related to regional planning and implementation.
- I think training and workshops on coding and databases are needed.
- The topics were well developed.

- ¡Excellent workshop, congratulations!

11 September 2015

-END-