



Agenda

Item 2:

Report of activities of the GESEA and Subgroups

b) ATM implementation. Progress of the Subgroups

ROADMAP 2022 – 2026: PERFORMANCE-BASED OPTIMIZATION OF SAM AIRSPACE

(Presented by the Secretariat)

SUMMARY

This working paper presents the progress of the activities for the elaboration of the Roadmap 2022 – 2026: Performance-based optimization of SAM airspace, and details the process of improving its texts as indicated by SAM/IG/26.

References:

- GESEA/SG1/2 Meeting summary
- SAM/IG/26 Meeting report
- GESEA/SG3/3 Meeting summary

1. Background

1.1. The Third Plenary Meeting of the SAM – GESEA Airspace Study and Implementation Group (GESEA/3) was held by videoconference from 16 to 18 March 2021. The first draft of the Operational Concept for the Efficiency and Capacity of SAM Airspace (CONOPS EC/SAM), prepared by the CONOPS task force, was presented and initially circulated to delegates and members.

1.2. GESEA/SG1/2 Meeting (27-29 April 2021) received the draft developed by CONOPS, with a view to providing comments and contributions to the document. Based on the comments received, the elaboration of a **Roadmap 2022 – 2026: Performance-based optimization of SAM airspace**, derived from the studies for CONOPS EC/SAM, was addressed.

1.3. The aforementioned Roadmap was presented to the SAM/IG/26 Meeting (Virtual, 20-23 September 2021), which agreed that the document should be circulated to States for additional feedback. After this process, contributions were received from Chile, linked to improvements in the drafting, and from Brazil, observing the tables used to show the progress in the implementation of the PBN in the States, based on data from the ICAO iSTARS platform. These comments were discussed at the GESEA/SG2/3 Meeting (Virtual, 6-8 April 2022).

2. Analysis

2.1 GESEA/SG2/3 reported that the iSTARS statistics account for the PBN procedures included in Jeppesen's publications, and is based on the comparison of international IFR thresholds equipped with Baro VNAV/LNAV procedures (according to Resolution A-37-11) and SID/STAR routes with respect to the total number of thresholds indicated for each State in the ANP Table AOP. States have noted that iSTARS shows some delay in updating data. It was informed that, in December 2021, a significant update of tables was carried out.

2.2 The Meeting agreed that, in the operational scenario, there are varied criteria for the implementation of procedures, noting that, in the Region, the SID routes are complemented by specific operational options of the PANS OPS document, such as omnidirectional exits, PBN arrival sections, as well as merge-point procedures. It was highlighted that the conditions of the orography, in States of the Andean area, leads to the implementation of PBN procedures for domestic airports, which are not included in the Tables of iSTARS.

2.3 Consensus was reached to resume Table XLS that was used until 2018 in the SAM/IG to monitor the implementation, with some improvements to simplify its use, in which the summary of the implementation for SAM international airports is presented. It was stressed that the above Table will be for internal use of SAM/IG/GESEA bodies, and that it is not intended to replace iSTARS.

2.4 The Meeting considered appropriate that this XLS Table be prepared to carry out the follow-up required by the Roadmap, amending the respective texts, and also that it be used as a reference for the progress of the PBN implementation in the Region, through the following link of the GESEA channel;

<https://oaci.sharepoint.com/:x/r/sites/SAM-CAR-ANS-GESEA/Shared%20Documents/GESEA/SG2%20PANS%20OPS/SEGUIMIENTO%20implant.%20PBN/GESEA%20SG2%20PBN%20progress.xlsx?d=w910ce628a6874dc49e52ae9f47cd4673&csf=1&web=1&e=N89mEn>

2.5 Therefore, in accordance with the suggestion of SAM/IG/26, the comments and contributions of the States have been analyzed and incorporated, resulting in the text presented in the **Appendix** to this working paper.

2.6 Airspace Optimization, with the application of PBN, PBCS and ATM automation has a high priority in the ATM Work Program of the South American Regional Office and many of its activities have been promoted by the Regional Project RLA/06/901, to support the planning and implementation of PBN in the region.

2.7 The Roadmap 2022 – 2026: Performance-based optimization of SAM airspace replaces and supersedes the CONOPS PBN, originally prepared in 2016, thus allowing continuity and harmonizing the efforts of the SAM Region to optimize the SAM Air Space.

3. Suggested actions

3.1 The Meeting is invited to:

- a) analyze the information provided in this working paper; and
- b) if agreed by the Meeting, approved the roadmap.



**INTERNATIONAL CIVIL AVIATION ORGANIZATION
SOUTH AMERICAN REGIONAL OFFICE**

PERFORMANCE-BASED OPTIMISATION OF SAM AIRSPACE

2022 - 2026 ROADMAP

Elaborated by TF – CONOPS Task Force of Sub-Group 1 of
GESEA.

Draft 2.1- 8 April 2022

PERFORMANCE-BASED OPTIMISATION OF SAM AIRSPACE

2022 - 2026 ROADMAP

CHANGE CONTROL

Version	Date	Change	Pages
DRAFT 1.0	20 July 2021	Drafting and update based on the previous 2018 - 2020 PBN CONOPS	All
DRAFT 2.0	1 March 2022	Re-Circulated at the request of SAMIG26. Letter SA5499. Contributions from Brazil and Chile	
DRAFT 2.1	8 April 2022	Revised in GESEA SG2/3 PANS OPS 6-8 April 2022. Approved for submission to SAMIG 27.	Improvements to PBN Progress Tables

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1 BACKGROUND

The SAM Region works in a coordinated manner, through the meetings of the SAM Implementation Group (SAM/IG) and its technical contributing body GESEA, in the development of tasks and actions that allow a sustained evolution towards the application of the global ATM operational concept.

In this regard, implementation programmes are developed, which have initially focused on the following:

- ATS optimisation in the SAM Region
- Implementation of performance-based navigation (PBN) for en-route, terminal area and approach operations
- Air traffic flow management (ATFM)
- CNS system enhancements; and
- ATM automation

The SAM/IG/10 meeting, held in October 2012, reviewed the SAM ATS Route Network Optimisation Action Plan and deemed it advisable to extend it to cover all phases of flight within SAM airspace, with a view to integrating ATS routes with terminal areas and instrument approaches.

Airspace optimisation with application of PBN, PBCS and ATM automation is a high priority in the ATM work programme of the South American Regional Office, and many of its activities, such as PBN workshops, and PANS-OPS courses and workshops have been promoted by Regional Project RLA/06/901 to support PBN planning and implementation in the Region.

This Roadmap replaces and supersedes the PBN CONOPS, originally developed in 2016, in view of the availability of the **SAM airspace efficiency and capacity CONOPS (SAM/EC CONOPS)** developed by the Airspace Study and Implementation Group - GESEA. Worth noting in this Roadmap is the consensus on the implementation dates of PBN components, and the supporting metrics to monitor such implementation.

This Roadmap will give continuity to, and harmonise, the efforts of the SAM Region to optimise SAM airspace through the implementation of PBN, and supplements the SAM/EC CONOPS.

2 CURRENT SITUATION

2.1 En-route PBN

En-route airspace optimisation is addressed by the GESEA SG1, based on the implementation of the corresponding ASBU elements, such as strategic direct routing and free route airspace.

Phase 1 of the Route optimisation programme was completed on 20 October 2011 with the implementation of RNAV 5, while RNP10 was maintained on some routes in the upper oceanic airspace, such as the EUR/SAM Corridor, the Lima-Santiago routes, and the South Atlantic Random Route System (AORRA).

Until March 2022, 138 ATS routes have been implemented in Region SAM under PBN criteria, leaving 23 conventional routes remaining, as shown in the following table:

Table 1

Total regional ATS routes in SAM upper airspace	Conventional routes	PBN routes	% routes implemented with RNAV 5 and/or RNP 10 PBN
161	23	138	85.7%

Source: Secretariat, april 2022

2.2 Terminal airspace optimisation

The training for, and monitoring of, PBN redesign of the main TMAs of the SAM Region is accomplished through GESEA SG1 and SG2, under the sponsorship of Regional Project RLA/06/901. It is important to note that STARs should only be published where there are specific operational requirements to overcome mountainous terrain or to reduce ATCO workload in high air traffic volume scenarios, by means of altitude restrictions between STARs - IAP and SIDs.

Regarding the state of PBN implementation in Terminal Area, for 62 TMA selected from the SAM Region, 35 TMA have been re-designed based on PBN criteria, that is, 56.5% progress is made until April 2022. See next Table:

Table 2

Redesign of selected TMA Airspaces based on PBN Planning *Updated during GESEA SG2/3 April 2022		
STATE		Implementation
*Argentina	1. Comodoro Rivadavia	Implemented
	2. Bahia Blanca	
	3. Mendoza	
	4. Tucumán	
	5. Rosario	
	6. Bariloche	
	7. Resistencia Corrientes	
	8. Jujuy	
	9. Esquel	
	10. Córdoba	August 2022
	11. La Rioja	November 2022
	12. Termas de Río Hondo	November 2022
	13. Chapelco	November 2022
	14. Parana Sauce Viejo	November 2022

Redesign of selected TMA Airspaces based on PBN Planning

***Updated during GESEA SG2/3 April 2022**

STATE		Implementation	
	15. Posadas	November 2022 – To be coordinated	
	16. Ushuaia/Rio Grande	November 2022 – To be coordinated	
	17. BAIRES FUTURO	2023	
*Bolivia	18. Cochabamba	review of design Phase	
	19. La Paz	Implemented march 2022	
	20. Santa Cruz	design Phase	
*Brazil	21. Brasilia	Implemented	
	22. Belo Horizonte		
	23. São Paulo (Changes partials)		
	24. Salvador		
	25. Manaus		
	(PBN SUL)	26. Curitiba	Implemented
		27. Florianópolis	
		28. Joinville	
		29. Navegantes	
		30. Porto Alegre	
		31. São Paulo	
		32. (cambios partials)	
	33. Rede de rota FIR CW		
34. São Paulo (TMA-SP Neo)	Implemented (mayo 2021)		
35. Fortaleza, Natal, João Pessoa, Recife	Nov 2022		
36. Campo Grande	Fecha TBD		
*Chile	37. Santiago (Sur)	Implemented	
	38. Routes network FIR Santiago		
*Colombia	39. Bogota	Implemented	
	40. Medellin	Dec 2023 advance 40%	
	41. Pereira	Dec 2025 advance 50%	
	42. Cali	Dec 2025	
	43. Cucuta	Dec 2024	
	44. Bucaramanga	Dec 2024 advance 50%	
	45. Barranquilla	Estimado Jul 2026	
46. San Andrés	Estimado Jul 2026		
*Ecuador	47. Guayaquil	Implemented	
	48. Manta		
	49. Quito		
	50. Galapagos		
Guyana	51. Georgetown	February 2020	
*Panama	52. Panama	<i>Pending.</i>	

Redesign of selected TMA Airspaces based on PBN Planning *Updated during GESEA SG2/3 April 2022		
STATE		Implementation
*Paraguay	53. Asunción	Implemented
Peru	54. Arequipa	First semester 2019
	55. Cusco	Implemented
	56. Juliaca	Second semester 2019
	57. Puerto Maldonado	Second semester 2019
*Surinam	58. Paramaribo	Implemented
Uruguay	59. Carrasco y Laguna del Sauce	Second semester 2020
*Venezuela	60. Maiquetia	Implemented
	61. Isla Margarita	Implemented
	62. Maracaibo	2 nd semester 2022

Prepared by: Secretariat April 2022

According to iSTARS application of ICAO, APV BARO VNAV/LNAV approach procedures have been implemented for 201 of 222 runway thresholds (baseline of Assembly Resolution A-37/11) at 100 international airports, reaching 90.5% progress (the global average is 74.2%). Regarding Standardized PBN routes, the iSTARS indicates that for 222 international runway thresholds an average advance of 68.9% was reached on SID routes and 51.8% on STAR routes.

However, the implementation of PBN approaches and SID/STAR PBN routes in SAM States is adequately reflected in terms of the specific operational needs of international airports, where not only SID/STAR PBN are being implemented, but also omnidirectional departures or specific PBN arrival legs. In this context, the PBN implementation of the SAM Region is presented in the Table "GESEA SG2 PBN progress Abril 2022.xlsx", Spanish only, available to be updated periodically by each State (according progress of implementation) in the SG1 folder called "4.Roadmap 2022 -2026, in the GESEA Channel link;

<https://oaci.sharepoint.com/f:r/sites/SAM-CAR-ANS-GESEA/Shared%20Documents/GESEA/SG1%20PLAN%20EA/4.%20Hoja%20de%20Ruta%202022%20-%202026?csf=1&web=1&e=QApx8p>

2.3 Implementation of ICAO GANP modules/elements

The following ASBU Block 0 and 1 modules, among other related applications, are considered for the short term:

APTA - Airport accessibility: Optimisation of PBN-based instrument approach procedures

APTA-B0/1	PBN approaches (with basic capabilities)
APTA-B0/2	PBN SID and STAR procedures (with basic capabilities)
APTA-B0/3	SBAS/GBAS CAT I precision approach procedures
APTA-B0/4	CDO (Basic)
APTA-B0/5	CCO (Basic)
APTA-B0/6	Point-in-space (PinS) PBN helicopter operations
APTA-B0/7	Performance-based aerodrome operating minima - Advanced aircraft
APTA-B0/8	Performance-based aerodrome operating minima – Basic aircraft

FRTO - En-route operations with enhanced trajectories: Capacity optimisation and flexible flights through enhanced en-route trajectories

FRTO-B0/1	Direct routing (DCT)
FRTO-B0/2	Airspace planning and flexible use of airspace (FUA)
FRTO-B0/3	Pre-validated and coordinated ATS routes to support flight and flow
FRTO-B0/4	Basic conflict detection and conformance monitoring
FRTO-B1/1	Free route airspace (FRA)

3 PBN NAVIGATION SPECIFICATIONS

The following is a summary of the navigation specifications set forth in ICAO Doc 9613. The appropriate specifications for the corresponding airspaces are defined further down, in accordance with the operational scenario identified.

Table 5 below presents a summary of the navigation specifications, divided by flight phase and NAVAID sensors required.

3.1 RNAV 10 (RNP 10)

The RNP 10 specification was developed to support reduced lateral and longitudinal separation minima for application in oceanic and remote areas where available NAVAIDs, communications and surveillance are limited.

The minimum spacing between routes when using RNP 10 is 50 NM.

RNP 10 operational requirements are defined in Part B, Volume II, Chapter 1, of ICAO Doc 9613.

3.2 RNP 4

The RNP 4 specification was developed for operations in oceanic and remote airspace, where no ground-based NAVAID infrastructure is available. GNSS is the primary navigation sensor to support RNP 4, either as a stand-alone navigation system or as part of a multi-sensor system. It supports the procedure-based separation defined in ICAO Doc 4444, PANS-ATM, with a minimum longitudinal separation of 30 NM and longitudinal separation of 30 NM. In order to use this spacing standard, RNP 4 must be combined with additional communication capabilities, specifically ADS-C.

RNP 4 operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 1.

3.3 RNP 2

RNP 2 was developed for en-route applications, particularly in geographic areas with little or no ground NAVAID infrastructure, and no or limited ATS surveillance. The use of RNP 2 in continental applications has a less stringent continuity requirement than that for oceanic and remote applications.

The RNP 2 specification is GNSS-based and shall not be used in areas of known GNSS signal interference. Operators relying on GNSS must have the means to predict the availability of GNSS failure detection to support operations along the RNP 2 ATS route.

RNP 2 operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 2.

3.4 RNAV 5

RNAV 5 operations are based on the use of RNAV equipment that automatically determines the position of the aircraft in the horizontal plane, using information from one or a combination of the following types of position sensors, together with means to establish and maintain a desired path:

- a) VOR/DME;
- b) DME/DME;
- c) INS or IRS; and
- d) GNSS.

In much of the airspace of the SAM region, RNAV 5 operations with VOR/DME and DME/DME sensors alone have limitations due to inadequate coverage and geometry of ground-based radio aids and insufficient number of stations to provide appropriate support infrastructure.

Direct pilot-controller speech communications are mandatory.

ATS surveillance may be used to mitigate the risk of gross navigational errors, provided that the route is within ATS surveillance and the volume of communication service and ATS resources are sufficient for the task.

3.5 RNAV 1 and RNAV 2

RNAV 1 and RNAV 2 specifications are applicable to all ATS routes, for both en-route and terminal area operations. It also applies to IAPs up to the FAF.

RNAV 1 and RNAV 2 specifications have been developed for RNAV operations in an ATS surveillance environment, but can be used in an environment without ATS surveillance if GNSS is required, and if the State of implementation ensures adequate system safety and responds for the lack of on-board performance monitoring and alerting.

RNAV 1 and RNAV 2 operations are based on the use of the same aircraft receivers that are required for RNAV 5. There are additional functional infrastructure and aircraft navigation aid requirements needed to meet the more demanding RNAV 1 and RNAV 2 performance.

RNAV 1 and RNAV 2 routes are intended for direct pilot-controller speech communications.

3.6 RNP 1

The RNP 1 specification provides a means to develop connectivity routes between the en-route structure and the terminal airspace with or without ATS surveillance.

RNP 1 can be associated to RF path termination and baro-VNAV.

The RNP 1 specification is GNSS-based and shall not be used in areas where navigation signal (GNSS) interference is known. While DME/DME-based RNAV systems may have RNP 1 precision capability, depending on a robust DME station infrastructure, this navigation specification is primarily intended for environments where such infrastructure cannot support DME/DME area navigation for the required performance.

3.7 RNP APCH

The RNP APCH specification relies on GNSS to support RNP APCH operations down to LNAV or LNAV/VNAV minima.

RNP APCH does not include specific requirements for ATS communications or surveillance. Adequate obstacle clearance is achieved through aircraft performance and operating procedures.

3.8 A-RNP

For en-route and terminal applications, this navigation specification has requirements that only address the lateral aspects of navigation.

A-RNP is based on GNSS. Ground infrastructure with multiple DME is not required, but can be provided based on State requirements, operational requirements and available services.

RF is an additional functional element required in A-RNP. The following additional functional elements are optional:

- a) RNP scalability
- b) Greater continuity
- c) Fixed radius transitions (FRT)
- d) Time of arrival control (TOAC)
- e) Baro-VNAV

Advanced RNP is the only navigation specification that allows operations under other associated navigation specifications. The aircraft navigation precision and the functional requirements of other navigation specifications that are met when A-RNP certified are:

- a) RNAV 5
- b) RNAV 1
- c) RNAV 2

- d) RNP 2
- e) RNP 1
- f) RNP APCH

The A-RNP specification has a very wide operational application: for operations in oceanic/remote airspace, in the en-route continental structure, in arrival and departure routes, and in approach procedures. Operations would depend solely on the integrity of the RNP system without the capability of reversal to conventional means of navigation, as conventional infrastructure may not be available. Notwithstanding the above, the corresponding contingency procedures need to be developed and implemented.

A-RNP is planned to be implemented in support of the ICAO aviation system block upgrades and the Global Air Navigation Plan.

3.9 RNP AR APCH

The RNP AR APCH specification represents ICAO's global standard for developing IAPs for airports where obstacles exist that impose limitations or where significant operational advantages can be gained.

The higher risks and complexities associated with these procedures are mitigated by more stringent RNP criteria, advanced aircraft capabilities and better flight crew training.

RNP AR APCH implementations do not require specific considerations regarding ATS communications and surveillance.

Table 3

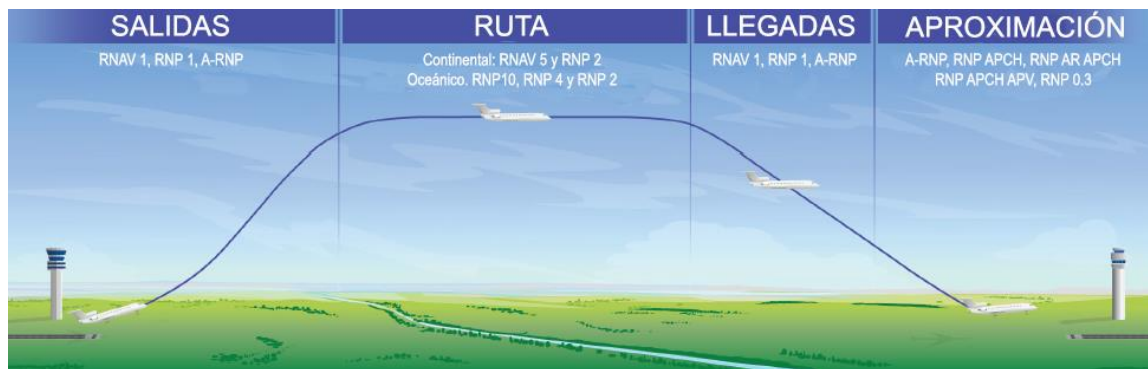
AIR NAVIGATION SPECIFICATIONS BY PHASES OF FLIGHT AND NAVAID REQUIRED SENSORS													
Air navigation Specifications	Phases of Flight								NAVAID sensors				
	Enroute Oceanic/remote	Enroute continental	Arrival	Approach				Departure	GNSS	IRU	DME/DME	DME/DME IRU	VOR/DME
				Initial	Intermediate	Final	Missed approach ¹						
RNAV 10 ²	10	N/A		N/A				N/A	O	O	N/A		
RNAV 5 ²	N/A	5	5	N/A				2	O	N/A	O	O	O
RNAV 2		2	2	N/A				1	O		O	O	
RNAV 1		1	1	1	1	N/A	1	1	O		O	O	
RNP 4	4	N/A		N/A				N/A	M	N/A	SR	SR	N/A
RNP 2	2	2	N/A	N/A				1	M				
RNP 1 ³	N/A		1	1	1	N/A	1	1	M				
RNP avanzada ⁴ (A-RNP)	⁵ 2	2 o 1	1	1	1	0,3	1	1	M	SR	SR		
RNP APCH ⁶	N/A			1	1	⁷ 0,3	1	N/A	M	N/A	N/A	N/A	N/A
RNP AR APCH	N/A			1-0,1	1-0,1	0,3-0,1	1-0,1	N/A	M				
RNP 0,3 ⁸	N/A		0,3	0,3	0,3	0,3	0,3	0,3	M				

O: Optional; **M:** Mandatory; **SR:** Subject to ANSP requirements

Notes:

1. Only applies once an obstacle clearance of 50 m (40 m, Cat H) has been reached after the start of climb.
2. RNAV 5 is a specification for en-route navigation that can be used for the initial part of a STAR outside 30 NM and above the MSA.
3. Use of the RNP 1 specification is limited to STARs, SIDs, initial and intermediate IAP segments and missed approach after the initial climb phase. Beyond 30 NM from the ARP, the alerting precision value becomes 2 NM.
4. A-RNP also allows for a range of scalable RNP lateral navigation decisions - see Part C, Chapter 4, 4.3.3.7.4. of Doc 9613.
5. Optional — requires higher continuity.
6. There are two sections in Doc 9613 for the RNP APCH specification: Section A is enabled by GNSS and baro-VNAV, Section B is enabled by SBAS.
7. RNP 0.3 applies to RNP APCH Section A. Different annular performance requirements apply only to RNP APCH Section B of Doc 9613.
8. The RNP 0.3 specification is primarily intended for helicopter operations.

Figure 1. Model navigation specifications by flight phase in SAM airspace



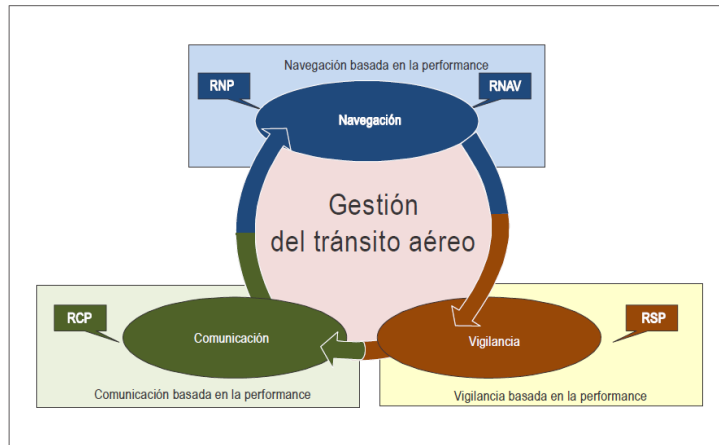
3.10 Performance-based communication and surveillance (PBCS)

The performance-based communication and surveillance (PBCS) concept provides objective operational criteria to evaluate emerging communication and surveillance technologies suited for the evolving needs of ATM functions. Once these criteria are established and accepted, the implementation of a specific ATM function, including its performance in technical and human terms, can be assessed against these operational criteria to determine its feasibility.

The PBCS concept is aligned with that of PBN. While the PBN concept applies required navigation performance (RNP) and area navigation (RNAV) specifications to the navigation element, the PBCS concept applies the required communication performance (RCP) and required surveillance performance (RSP) specifications to communication and surveillance elements, respectively. Each RCP/RSP specification includes criteria attributed to the components of the communication and surveillance systems involved.

Where beneficial, the RCP, RNP/RNAV and RSP specifications may be applied to the communication, navigation and surveillance elements to ensure the operational system and its components perform in accordance with the specifications. Figure 2 provides an overview of the performance-based communication, navigation and surveillance (CNS)/ATM model, which characterises the relationship of the performance-based specifications of the CNS elements supporting an ATM function.

Figure 2.- Performance-based CNS/ATM model



There are some differences between the PBCS concept and the PBN concept:

- a) The PBCS concept applies RCP and RSP specifications, which allocate criteria to ATS provision, including communication services, aircraft capability, and the aircraft operator; while the PBN concept applies RNP/RNAV specifications, which allocate criteria only to the aircraft capability and the aircraft operator; and
- b) The PBCS concept includes post-implementation local and regional monitoring programmes, with global exchange of information; while the PBN concept includes real-time aircraft capability monitoring and alerting functionality.

4 EN-ROUTE PBN OPERATIONS

4.1 Description of the concept

The implementation of strategic direct routing and free route airspace, in accordance with ASBU, will be the main feature of en-route airspace optimisation in the SAM Region, in order to take advantage of advanced aircraft navigation capabilities that, in combination with ATM tools, appropriate ATC sectorisation and traffic flow management, will support ATS routing that, as far as possible, meets the needs of airspace users, reduces controller and pilot workload and avoids concentrations of aircraft in portions of the airspace that could lead to system congestion.

The review and implementation of strategic direct routing and free route airspace will be carried out as a collaborative process among States, regardless of national borders, taking into account user requirements, airspace constraints and adapting to main traffic flows, with emphasis on the establishment of trunk routes.

It is expected that, by the end of the implementation period foreseen in this Roadmap, the upper continental airspace of the SAM Region, or part of it, will be PBN-exclusive with RNAV 5 navigation specification mainly, and RNP 2 or A-RNP specifications in those airspaces where it is necessary to increase airspace capacity by reducing spacing between main flows, close to TMAs.

RNAV-5 may be completely replaced by RNP 2 or A-RNP, but for this to happen the aircraft fleet must be equipped and the operators approved, and the cost-benefit analysis must offer a favourable equation.

This transition should be gradual, so it is expected that during this period routes may have more than one navigation specification. Under these conditions, aircraft meeting the more demanding specifications will derive greater operational benefits. See Annex 1 to this document.

Air operators increasingly require flexible routes that better suit their operational needs (EDTO; weather avoidance, airspace restrictions, etc.). The introduction of strategic direct routing and free route airspace and improvements in ATM systems would allow the implementation of these concepts.

Strategic direct routing and free route airspace can be defined by means of:

- Geographical coordinates that define them laterally,
- Entry/exit points to and from these airspaces; and/or
- Windows of specified levels.

In addition, strategic direct routing and free route airspace may be activated for certain periods of time.

In more complex airspaces, a fixed airspace structure will be maintained by means of a route network, combined with advanced on-board and ground capabilities, to ensure that system capacity and safety levels are maintained. The concept recognises that where traffic complexity is high, the required capacity can only be achieved at the cost of some limitation to individual optimal paths (for example, segregated paths may increase miles flown or affect optimal profiles).

In highly congested areas where upward and downward traffic flows prevail, it will be necessary to increase airspace capacity by implementing route structures that provide a higher degree of strategic segregation. The application of more advanced navigation specifications such as RNP 2 or A-RNP will allow for reduced route spacing.

Likewise, in congested areas, the flow of overflying aircraft must, as far as possible, not cross or interfere with the incoming and outgoing flow at the main TMAs, and the duration of eventual crossings must be minimised.

SAM airspace optimisation must also take into account ATC sectors, which must be adapted to the main traffic flows, to strategic direct routing/free route airspace and, where required and to a limited extent, to the route network. More ATC sectors shall be developed and put into operation where necessary (including vertical sectorisation). The design of ATC sectors must ensure that they are adaptable in shape and size (pre-defined) in response to variations in airspace demand and availability. It is expected that the need will arise to implement cross-border ATC sectors to support operations.

4.2 Specific objectives

Airspace optimisation in the South American Region is expected to contribute to ICAO's strategic objectives.

4.2.1 Principles

- i. The replacement of conventional ATS routes with RNAV routes in the upper airspace will continue, expecting to achieve 100% migration by 2023, considering the possibility that this PBN airspace, in the case of domestic and regional routes, will be exclusionary by virtue of regional agreement.
- ii. The implementation of strategic direct routing will start even with published RNAV routes. Gradually, starting in 2023, RNAV routes will start to be removed from airspaces with lower air traffic volumes and which have the necessary operational requirements (adequate VHF and ATS surveillance coverage as well as the required ATC systems).
- iii. Airspace optimisation will be based on operational requirements, regardless of national or FIR boundaries.
- iv. Airspace design will be a transparent process that takes into account the needs of all users, while negotiating safety, capacity, environmental protection, military and national security needs.
- v. The overall airspace structure will be developed establishing a close relationship among airspace design, airspace management and air traffic flow management.
- vi. Where required on oceanic routes, RNP 4/RNP 2 will be implemented with application of 23 NM lateral separation on parallel routes.
- vii. In continental airspace where operational advantages can be gained, RNP 2 or A-RNP routes will be implemented with the application of 15 NM spacing between parallel routes.
- viii. On unidirectional routes where the allocation of levels according to the semicircular table of headings is maintained, 10 NM separation may be applied with navigation specification RNP 2.
- ix. For dynamic airspace management, implementation of conditional routes will be considered, taking into account that no airspace should be restricted in a permanent or fixed manner, or restricted for an extended period of time. This will require effective civil-military coordination to achieve flexible use of airspace (FUA).
- x. Safety assessments will be conducted in the pre- and post-implementation phases.
- xi. Ensure connectivity of en-route airspace with terminal area SIDs and STARs. “Free Route Airspace” shall be obtained between the last point of the SID at the airport of origin to the first point of the STAR at the destination airport or, if no STAR exists, to the closest possible point of the initial approach fix (IAF).

4.3 Oceanic airspace

RNP10 (RNAV10) is applied in certain airspaces, such as the EUR/SAM Corridor, Lima-Santiago routes and the South Atlantic Random Routing Area and is expected to migrate to RNP4/RNP2, with the application of communication and surveillance performance, in order to allow separation reductions in accordance with Doc 4444, where safety enhancements and/or airspace capacity increases are required. Taking into account the low air traffic density in oceanic airspaces, significant changes to the current airspace structure are expected. The application of RNP 4/2 and PBCS will be required for the implementation of strategic direct routing and, subsequently, free route airspace in oceanic airspaces (see Annex 1).

Navigation in areas with random routes and /or User Preferred Routes (UPR) should consider PBCS and aircraft flying in these areas should be duly equipped with equipment that meets PBCS requirements.

Spacing between routes

In oceanic airspaces, the spacing between routes (parallel tracks) with PBN specification will be applied as described in the following table:

Table 4

Navigation specification	Minimum separation between routes	Performance requirements	
		Communication	Surveillance
RNAV 10 (RNP 10)	93 km 50 NM	Types of communication other than direct controller-pilot VHF voice communication	
RNP 4 RNP 2	42.6 km* 23 NM*	RCP 240	RSP 180
RNP 2	27.8 km** 15 NM**	Direct controller-pilot VHF voice communication	

* SLOPs will be applied up to 2NM

** SLOPs will be applied up to 0.5NM

Reference: Doc 4444, para 5.4.1.2.1.6

Note 1.— Guidelines for the implementation of the navigation capability supporting the lateral separation minima shown in the preceding table are contained in the Performance-based navigation (PBN) manual (Doc 9613). Information relative to the lateral separation minima shown in the preceding table is contained in Circular 349, Guidelines for the implementation of lateral separation minima.

Note 2.— Guidelines for implementation of communication and surveillance capability supporting the lateral separation minima shown in the preceding table are contained in the Performance-based communication and surveillance (PBCS) manual (Doc 9869) and the Global operational data link (GOLD) manual (Doc 10037).

4.4 Continental airspace

In the design, the main traffic flows will have higher priority over lower flows, applying the strategic direct routing/free route airspace concept and, where specific operational requirements exist, trunk PBN routes. Likewise, through an appropriate SID and STAR structure, main traffic flows will connect to major airports,

thus avoiding the proliferation of routes with low utilisation and/or that contribute to air navigation inefficiency.

In lower airspace, RNAV 5 will be implemented and, in selected airspaces, where necessary to reduce route spacing, RNP 2 or A-RNP, with mandatory application of GNSS, taking into account that the ground infrastructure does not support these navigation specifications. Lower and upper airspace PBN routes shall have as direct as possible paths and it is recommended that routes in both airspaces use the same reporting points. RNAV-5 may be completely replaced by RNP 2 or A-RNP, if the aircraft fleet is equipped and operators approved, within a favourable cost-benefit equation.

The Roadmap envisages that, in the lower airspace, the implementation of PBN routes aligned with the routes in the upper airspace will take a little longer depending on the equipage of the fleet flying in this airspace.

Spacing between routes

In continental airspaces, spacing between routes with PBN specification will be applied as described in the table below:

Table 5

Navigation specification	Minimum separation	Communication	Surveillance	Remarks
RNAV 5*	55.5 km 30 NM	Direct pilot-controller VHF (see Note 1)	Without surveillance	High traffic density
	33.3 km 18 NM		With surveillance	Opposite-direction traffic
	30.6 km 16.5 NM			Same-direction traffic
	19 km 10 NM			ATC intervention capacity permitting
RNP 2** or GNSS equipment	27.8 km 15 NM	Direct pilot-controller VHF	Without surveillance	Applied while an aircraft is climbing/descending through the level of another aircraft
	13 km 7 NM	Other than direct pilot-controller VHF		Applied while an aircraft is climbing/descending through the level of another aircraft
	37 km 20 NM			
<i>Note 1.- CPDLC is used in continental airspace in Brazil.</i>				

References:

*Doc 9613, Vol. II, Part B, Chapter 2, paragraph 2.2.3

**Doc 4444, paragraph 5.4.1.2.1.6

Also, taking into account the increasing importance of supporting the optimised application of PBN-based navigation specifications that are aimed at improving lateral separation, it is highly desirable to include in this roadmap the complementary optimisation of en-route longitudinal separation.

In this regard, it is proposed to consider the gradual reduction of conventional longitudinal separation from 80NM to 20NM, as well as of longitudinal separation based on ATS surveillance to 10 NM, in accordance with the commitments adopted by the States at the SAMIG meetings on this issue, and based on Doc 4444. It is also proposed to include this optimisation in the corresponding metrics and indicators.

5 PBN OPERATIONS IN TERMINAL AREAS

5.1 SID/STAR routes

PBN implementation will continue in the main TMAs of the Region, prioritising implementation based on the volume of traffic they support and considering proper integration with the route network. It is expected that non-PBN aircraft operations will still be allowed; the establishment of PBN-only TMAs will depend on the complexity and density of air traffic.

It is considered that SID and STAR design will be based mainly on RNAV 1 and RNP 1 navigation specifications, including environments without ATS surveillance, with mandatory application of GNSS, taking into account that almost all South American terminal areas do not have the necessary ground infrastructure to support these specifications, in order to allow the procedures to be used by a larger number of users.

The implementation of these navigation specifications will allow the development of segregated paths between PBN SIDs and STARs, with application of the lateral separation mentioned in Doc 4444.

In airspaces with low air traffic volume and low complexity or without significant terrain obstacles, the efficiency and safety justification of PBN STAR implementation should be assessed in order to avoid a result opposite of the one intended.

In environments of higher complexity due to obstacles or environmental constraints, where more advanced specifications are required, consideration will be given to applying the A-RNP specification in SID and STAR design, in order to take advantage of the functionality of RF legs and/or precision values of less than 1 NM and up to 0.3 NM. There are States that apply RNP AR criteria for SIDs, and other States may have the same need and could profit from available experiences (see Annex 2).

The implementation of fixed radius transitions (FRTs) in SIDs/STARs should also be pursued to reduce flying distances and fuel consumption.

Improved management of climb/descent flight profiles, together with the use of PBN, provides safer and more cost-effective operations in terminal areas. PBN procedures contribute to the increased use of CCO/CDO, which improves flight efficiency and reduces fuel consumption, CO₂ emissions and noise. States should take into account CCO/CDO operations in the design of SIDs/STARs, within the possibilities of each scenario considered. Work should be done in collaboration with operators to improve the prospects for successful validation and implementation of CCO/CDO.

At airports with a more complex operational environment, with a large number of SID and STAR procedures, the transition concept should be considered in the design and identification of charts to facilitate the pilot's access to the procedure authorised by the controller, as well as to avoid the ATCO having to memorise a significant number of SIDs/STARs. To this end, criteria should be established to standardise the application and nomenclature of transitions in the Region.

In adjacent or very close terminal areas, SIDs may be implemented that connect directly to a STAR in the next terminal area and *vice versa*, thus allowing the two-way traffic flow between two aerodromes to be channelled and strategically segregated (see Annex 3).

In the terminal area environment, in the vicinity of aerodromes, navigation precision often results in a concentration of perceived noise, due to more aircraft following the same approach profile. In some specific cases, mainly in the initial legs of SIDs, it may be necessary to allow for a greater dispersion of paths, despite the precision of RNAV systems, in order to mitigate the effects of aeronautical noise.

Consideration should be given to mitigating the environmental impact of noise on residential communities affected by the design of the procedures, which may have a cumulative effect of noise pollution over time, through noise mitigation measures, based on ICAO practices.

Omnidirectional SIDs will be applied where operational gains exist, mainly at airports with low air traffic volume and/or for use by non-PBN equipped users.

The treatment of VFR flights and the activities performed by these flights, as well as those airspaces that are intended to protect visual corridors for VFR aircraft operations, shall be included in planning and design.

5.2 Navigation specifications

The applicable navigation specifications in terminal areas are RNAV 1, RNP 1 or A-RNP.

Separations

In terminal areas, the separation between standard departure and arrival routes with PBN specification shall be applied as described in the following table:

Table 6

Navigation specification	Minimum separation	Communication	Surveillance	Remarks
RNAV 1	13 km 7 NM	Direct pilot-controller VHF	Without surveillance	Between any combination of RNAV 1 with RNAV 1, or RNP 1, RNP APCH or RNP AR APCH tracks
RNP 1	9.3 km 5 NM	Direct pilot-controller VHF	Without surveillance	Between any combination of RNP 1, RNP APCH or RNP AR APCH tracks

Navigation specification	Minimum separation	Communication	Surveillance	Remarks
Between conventional IFPs or between conventional IFPs and PBN	<i>See remarks*</i>	Direct pilot-controller VHF	Without surveillance	* Where the protected areas of tracks designed using obstacle clearance criteria do not overlap and provided operational error is considered.

References:

- *Doc 4444, paragraph 5.4.1.2.1.4*
- *ICAO Circular 324*

5.3 Instrument approach procedures – IAP

Within the considerations of this document it is not foreseen that SBAS or GBAS augmentation systems will be available in the Region for the development of approach procedures in the period considered herein.

Approach procedures with vertical guidance (APV) will continue to be developed for all IFR thresholds, with the purpose of increasing safety with stabilised approaches and reducing the possibility of CFIT. Priority will be given to their implementation at international airports and other controlled airports as determined by the competent authority of each State. The navigation specifications to be applied will be RNP APCH and A-RNP, with baro-VNAV for vertical guidance.

RNP approach procedures with authorisation required (RNP AR APCH) will continue to be developed at airports where there are clear operational benefits to be gained, and not only at airports with complex terrain. A solution has been found in the Region to interference between approach procedures at nearby aerodromes, through the application of RNP AR APCH procedures.

The design of RNP APCH procedures with RF leg will be encouraged, with a view to shortening approach paths, with the corresponding fuel and CO2 savings.

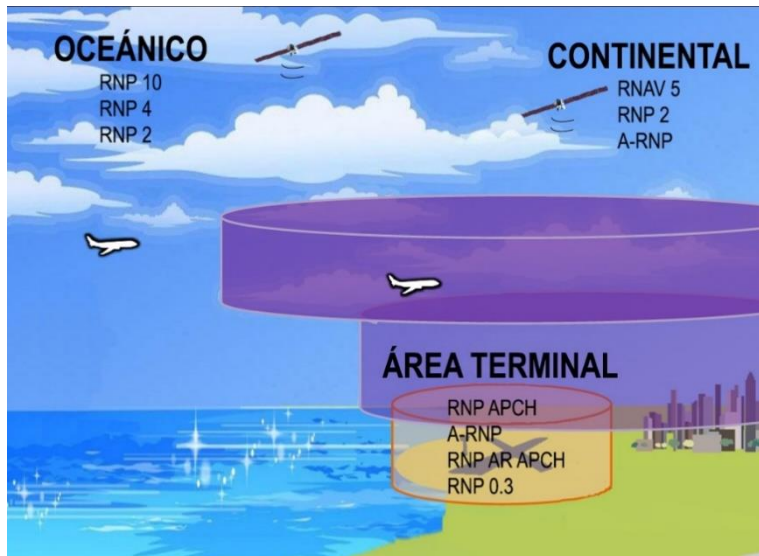
As RNAV 1 and RNP 1 specifications can be used up to the FAF, these specifications will be applied in the design of the initial and intermediate legs of ILS procedures.

This roadmap considers as a recommended alternative the implementation of PBN operations for visual runways at those airports that do not have instrument approaches, in order to reduce the probability of CFIT and loss of control in-flight, as well as non-stabilised approaches. CDM should be taken into account from the design phase. For this application, an implementation guide was developed for use by the States of the Region.

5.4 Navigation specifications

The applicable navigation specifications for instrument approach procedures are A-RNP, RNP APCH, RNP AR APCH, or RNP 0.3.

Figure 3. Model navigation specifications by airspace type



6 SUPPORTING METRICS

The following table 9 of **supporting metrics** is proposed to measure the degree of continuity of the implementation tasks planned for the period 2022-2026. These metrics do not replace and are not equivalent to key performance indicators (KPIs) defined in the GANP, 6th edition, which are used to assess the performance improvement in the implementation of certain ASBU elements.

Table 7

SUPPORTING METRICS FOR THE PERIOD 2022-2026				
ELEMENTS	SCOPE	METRICS	TARGET/DATES	STATUS AS AT JUNE 2021
1) Strategic direct routing in SAM FIRs	All FIRs (where communication and surveillance conditions are met)	Indicator: % of South American FIRs with EDE implemented. Supporting metrics: number of SAM FIRs with EDE implemented.	90% by 2022 100% by 2023	States started implementation in 2020.
2) Free route airspace in SAM FIRs	All FIRs (where communication and surveillance conditions are met)	Indicator: % de SAM FIRs with Free route airspace implemented. Supporting metrics: number of SAM FIRs with Free route airspace implemented.	10% by 2024 30% by 2025	N/A

SUPPORTING METRICS FOR THE PERIOD 2022-2026				
ELEMENTS	SCOPE	METRICS	TARGET/DATES	STATUS AS AT JUNE 2021
3) PBN SIDs SIDs at selected international airports with international operations. (alternatively, omnidirectional SIDs may be considered if air traffic volume is low)	International airports (where applicable)	Indicator: % of international airports with scheduled international operations with PBN SIDs	90% by 2022 100% by 2024	67.7% of 100 international airports with PBN SIDs implemented.
		Supporting metrics: number of international airports with scheduled international operations with PBN SIDs implemented.	Note: The new planning basis for the four-year period in reference to international airports is given in Table AOP-1 of the CAR/SAM ANP	

SUPPORTING METRICS FOR THE PERIOD 2022-2026				
ELEMENTS	SCOPE	METRICS	TARGET/DATES	STATUS AS AT JUNE 2021
4) PBN STARs STARs at international airports with scheduled international operations considered in 2014: 1680	International airports (where applicable)	Indicator: % of international airports with scheduled international operations with PBN STARs, where the use of STARs is justified.	90% by 2022 100% by 2024	52.5% of the 100 international airports with PBN STARs implemented.
		Supporting metrics: number of international airports with scheduled international operations with PBN STARs implemented, where such implementation is justified.	Note: The new planning basis for the five-year period in reference to international airports is given in Table AOP-1 of the CAR/SAM ANP	

SUPPORTING METRICS FOR THE PERIOD 2022-2026				
ELEMENTS	SCOPE	METRICS	TARGET/DATES	STATUS AS AT JUNE 2021
5) Application of the CCO and CDO technique to departures and arrivals	All States	Indicator: % of international airports with arrivals and departures with CCO and CDO applications. Supporting metrics: Number of international airports with arrivals and departures with CCO and CDO applications.	40% by 2022 60% by 2024 80% by 2026	20% of international airports with CCO/CDO implemented.
		Note:1) CCOs/CDOs cannot always be implemented together, as they depend on the complexity of the terminal area under consideration. Note:2) CDOs are not necessarily related to the implementation of STARs. The State may create specific procedures to ensure the implementation of CDOs in airspace with low air traffic volume, without applying STARs.		
6) PBN TMA design Baseline 2020: 54 TMAs selected	TMAs with INTL airports (where applicable)	Indicator: % of selected TMAs that apply the PBN airspace concept, serving international airports. Supporting metrics: Number of selected TMAs that apply the PBN airspace concept, serving international airports.	85% by 2022 90% by 2023 100% by 2024	(44/54) 81% of selected TMAs with PBN design according to the baseline considered.

SUPPORTING METRICS FOR THE PERIOD 2022-2026				
ELEMENTS	SCOPE	METRICS	TARGET/DATES	STATUS AS AT JUNE 2021
		Note: The baseline considered is 54 terminal areas (TMAs) of the most important international airports in the Region.		
<p>7) Reduction of the conventional longitudinal separation from 40 to 20 NM</p> <p>International FIR boundaries considered in the SAM Region: 50</p>	<p>All States (where communication conditions are met)</p>	<p>Indicator: % international FIR boundaries where the longitudinal separation reduction of 20 NM applies.</p>	<p>50% by 2022</p> <p>70% by 2023</p> <p>100% by 2024</p>	<p>(45 of 50) 90% of international FIR boundaries applies the 40 NM longitudinal separation at FIR boundaries.</p> <p>4 continental FIR boundaries of Brazil apply 20 NM.</p> <p>9 SAM States have common boundaries with the Amazonica FIR or the Curitiba FIR. 20 NM is applied for aircraft inbound in Brazil.</p> <p>Panama–Barranquilla applies 20 NM</p> <p>Montevideo–Buenos Aires applies 20 NM</p> <p>Mendoza–Santiago applies 20 NM.</p>
		<p>Note: Separations between internal FIRs within the same State are generally less than 40 NM.</p>		

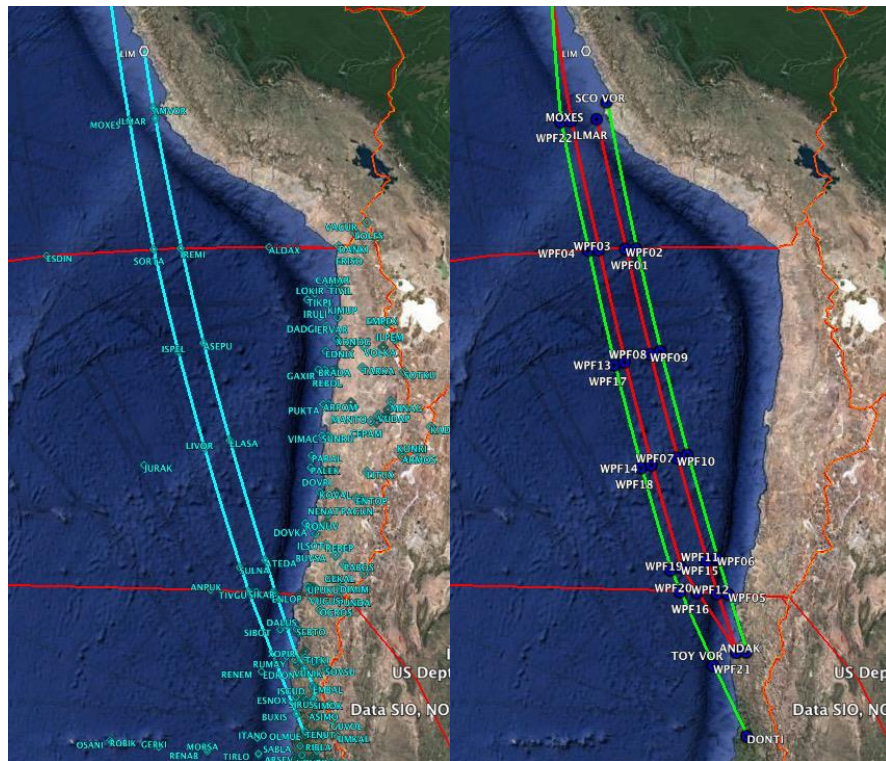
SUPPORTING METRICS FOR THE PERIOD 2022-2026				
ELEMENTS	SCOPE	METRICS	TARGET/DATES	STATUS AS AT JUNE 2021
<p>8) Reduction of the longitudinal separation with ATS surveillance to 10 NM</p> <p>International FIR boundaries considered: 50</p>	<p>All States (where communication and surveillance conditions are met)</p>	<p>Indicator: % international FIR boundaries where the reduction of longitudinal separation with ATS surveillance of 10 NM is applied.</p> <p>Supporting metrics: Number of international FIR boundaries where longitudinal separation with ATS surveillance of 10 NM is applied.</p>	<p>20% by 2024</p> <p>50% by 2026</p>	<p><i>Note. - Under ATC tactical coordination, 10 NM is applied on aircraft transfers between Montevideo-Curitiba and Montevideo-Buenos Aires.</i></p>
<p>9) Approaches with vertical guidance (APV) to international airport</p> <p>APV at international airports (ICAO Assembly Res. A37-11)</p>	<p>All States</p>	<p>Indicator: % of international airports with approach procedures with vertical guidance</p> <p>Supporting metrics: number of IFR runway thresholds at international airports with APV procedures in place</p>	<p>93% by 2022</p> <p>96% by 2023</p> <p>100% by 2024</p>	<p>(192 of 217) 88.5% of IFR thresholds at international airports with APV procedures in place.</p>

SUPPORTING METRICS FOR THE PERIOD 2022-2026				
ELEMENTS	SCOPE	METRICS	TARGET/DATES	STATUS AS AT JUNE 2021
<p>10) Approaches with vertical guidance (APV) to domestic airport</p> <p>APV at domestic IFR aerodromes, as well as aerodromes with selected visual flight runways.</p>	All States	<p>Indicator: % of domestic aerodromes with APV procedures</p> <p>Supporting metrics: number of controlled domestic aerodromes with APV procedures in place</p>	<p>40% by 2022</p> <p>60% by 2024</p> <p>80% by 2026</p>	<p>TBD</p> <p>By GESEA SG2</p>
<p>11) PBN routes (RNAV-5 or RNP2) in the upper airspace</p> <p>RNAV routes implemented in upper airspace where there is a need to channel large air traffic volume flows.</p>	All States	<p>Indicator: % of routes (RNAV-5 or RNP2) in upper airspace where there is a need to channel large air traffic volume flows.</p> <p>Supporting metrics: number of routes in upper airspace with some PBN navigation specification and a need to channel large air traffic volume flows.</p>	<p>90 % by 2022</p> <p>100 % by 2023</p>	<p>(136 of 165) 82.4% of routes (RNAV-5 or RNP2) of the upper airspace.</p>

Annex 1. Example of operational scenario with PBN routes between States

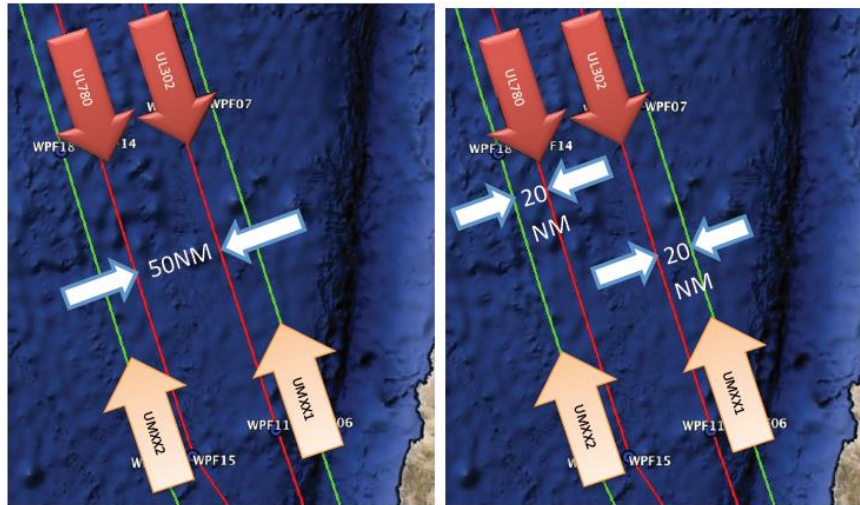
By way of example, Peru and Chile are countries that are actively working on improving their airspace using PBN, implementing segregated departure and arrival flows at their main TMAs: Peru through the PROESA project and Chile with the PAMPA project.

The flow linking the Lima and Santiago terminal areas has been structured since 2006 on the basis of a pair of airways, UL302 and UL780, declared RNP 10 (RNAV10) spaced 50 NM apart, and bidirectional. Some sectors have VHF voice communication deficiencies and no ATS surveillance due to being out of coverage, especially at the FIR boundary. (See figures.)



Considering the work in progress in both countries, the increase in traffic, traffic complexity in oceanic airspace and the need to increase the levels of safety at the transfer points between the FIRs involved, it is proposed to implement two new RNP 10 (RNAV 10) routes parallel to the existing ones. In this new scheme, the routes would be unidirectional. The current routes UL780 and UL302 would have a North-South direction and the two new routes would have a South-North direction. (See figure B2.)

These new routes will be spaced 20 NM apart from the current routes, which will maintain their 50 NM spacing. (See figure.)



Spacing between routes allows separation for "RNAV operations for which RNP is specified on parallel tracks or ATS routes", as described in Chapter 5 of Doc 4444. Thus, a minimum separation of 37 km (20 NM) between tracks may be applied while an aircraft is climbing/descending through the level of another aircraft when using a means of communication other than direct controller-pilot voice VHF, if RNP2 navigation performance **or GNSS equipment**, declared on the FPL by the letter G, is prescribed, considering that aircraft with RNP 10 approval meet the requirement for GNSS equipment and that the use of the letter G on the FPL implies that the GNSS receiver meets the requirements of Annex 10, Volume I.

In this situation, these airways will have dual navigation specification, RNAV 10 and RNP 2. The latter will have operational benefits in allowing level changes with respect to other RNP 2 aircraft flying on airways with only 20 NM separation and routes with 50 NM spacing, while those with only RNAV 10 certification will be able to do so only with respect to 50 NM routes.

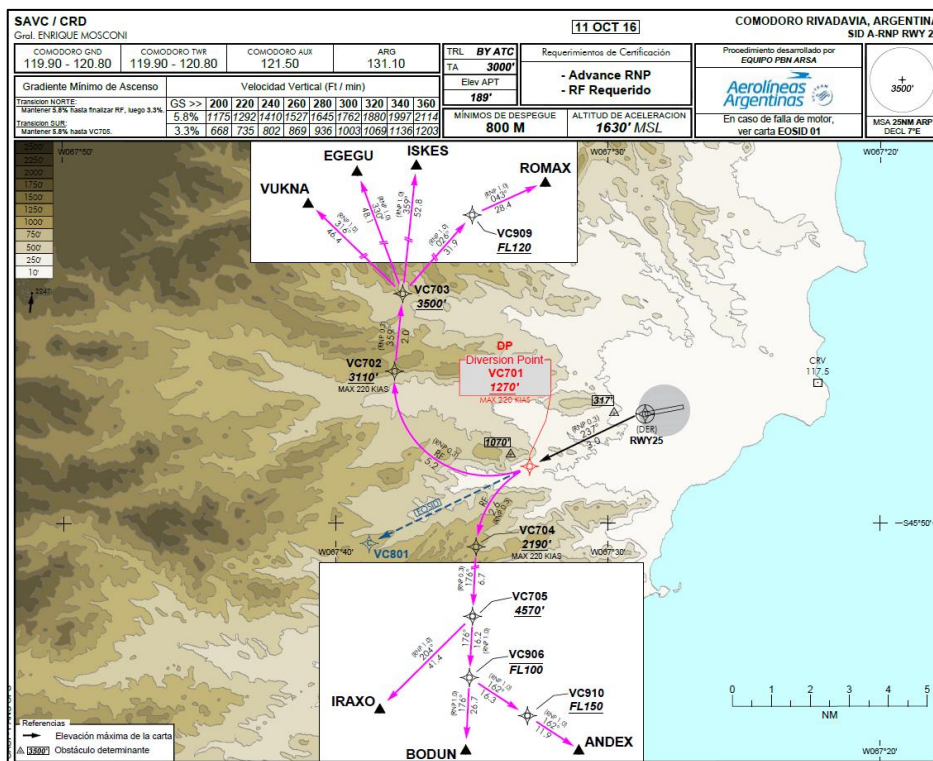
This airway configuration would mitigate potential operational coordination errors between ATS units, achieve short-term operational efficiencies by not restricting level changes by traffic in the opposite direction, if the aircraft involved have GNSS equipment, and support the estimated increase in traffic in the coming years.

When the need to increase airspace capacity warrants it and the fleet operating on these airways is ready, it will be possible to consider, using the same route structure, the implementation of a more advanced navigation specification such as RNP 2 on an exclusionary basis.

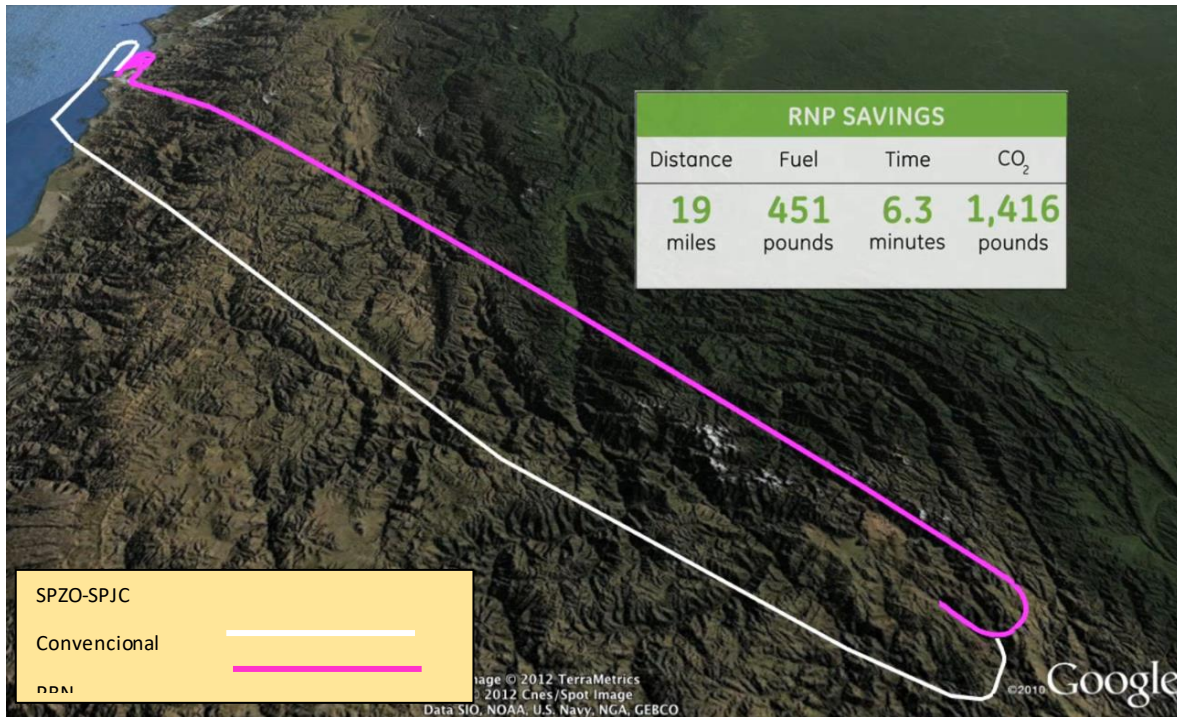
Annex 2. Example of A-RNP SIDs and RNP AR SIDs

As an example, SID charts developed with application of A-RNP and RNP AR are presented.

1. In Argentina, the company Aerolíneas Argentinas found a solution to develop instrument departures at two airports with complicated settings such as San Martín de los Andes (SAZY) and Comodoro Rivadavia (SAVC), through the application of the A-RNP specification with required RF. Initially, these SIDs will be for private use by Aerolíneas while coordination with the Argentinean authority to make them public is being completed.



- Before the introduction of the A-RNP specification in Peru, there was a need to develop instrument departures from Cusco to connect with the new RNAV 5 route to Lima. Considering that the RNP 1 specification did not provide an adequate solution for the development of instrument departures, RNP AR SIDs were developed. In this way, it was possible to develop a completely PBN alternative from the departure in Cusco to the arrival in Lima: RNP AR SID - RNAV 5 Route - RNP 1 STAR - RNP AR APCH IAP.



Annex 3. Example of an operational scenario with SIDs and STARs in one State

As an example, the scenario of arrivals and departures between adjacent or very close terminal areas is shown below.

Ecuador, in its airspace optimisation process, has implemented PBN in the terminal areas of Quito and Guayaquil. In this process, it has developed standard departure and arrival routes connected to each other at a common point. This has strategically segregated two-way traffic flows between Quito and Guayaquil airports (which are separated by 149 NM).

This SID and STAR configuration reduces points of conflict and facilitates the application of CCO/CDO, reducing pilot and controller workload. See figure.

Figure



Appendix A. Acronyms and Abbreviations

A-RNP	Advanced RNP
ADS-B	Automatic dependent surveillance - Broadcast
ADS-C	Automatic dependent surveillance - Contract
AIP	Aeronautical information publication
ANSP	Air navigation service provider
AORRA	Atlantic Ocean Random Routing Area
APCH	Approach
APV	Approach procedure with vertical guidance
ASBU	Aviation system block upgrades
ATC	Air traffic control
ATFM	Air traffic flow management
ATM	Air traffic management
ATS	Air traffic service
CCO	Continuous climb operations
CDO	Continuous descent operations
CDM	Collaborative decision-making
CDR	Conditional route (non-permanent ATS route)
CNS	Communications, navigation and surveillance
CPDLC	Controller-pilot data link communications
DME	Distance-measuring equipment
e-ANP	Electronic Air navigation plan
EDTO	Extended diversion time operations
FAF	Final approach fix
FANS	Future air navigation systems
FPL	Flight plan
FUA	Flexible use of airspace
GA	General aviation
GANP	Global air navigation plan
GBAS	Ground-based augmentation system
GLS	GBAS landing system
GNSS	Global navigation satellite system
GPS	Global positioning system
IAP	Instrument approach procedure
IFP	Instrument flight procedure
ILS	Instrument landing system
INS	Inertial navigation system
IRS	Inertial reference system
IRU	Inertial reference unit
MLAT	Multilateration
NAVAID	Aid to air navigation
PBCS	Performance-based communication and surveillance
PBN	Performance-based navigation
PBS	Performance-based surveillance
RAAC	Meeting of Civil Aviation Authorities of the South American Region
RNAV	Area navigation
RCP	Required communication performance
RF	Fixed radius turn

RNP	Required navigation performance
RPAS	Remotely-piloted aircraft systems
RSP	Required surveillance performance
SAM/IG	South American Implementation Group
SAM-PBIP	Performance-based navigation system implementation plan for the South American Region
SARPs	Standards and recommended practices
SATVOICE	Satellite voice communications
SBAS	Satellite-based augmentation system
SID	Standard instrument departure
STAR	Standard instrument arrival
SUA	Special-use airspace
VFR	Visual flight rules
VHF	Very high frequency
VNAV	Vertical navigation

Appendix B. Reference Documents

The following ICAO documents are related to the Roadmap:

- Doc 9750 GANP, Sixth edition 2019
- Doc 9854 Global air traffic management operational concept
- Doc 9883 Manual on global performance of the air navigation system
- Doc 9882 Manual on air traffic management system requirements
- Doc 4444 Procedures for air navigation services - Air traffic management (PANS-ATM)
- Doc 8168 Aircraft operations, Volume II
- Doc 9613 Performance-based navigation (PBN) manual
- Doc 9905 Required navigation performance authorization required (RNP AR) procedure design manual, first edition
- Doc 9924 Aeronautical surveillance manual, first edition
- Doc 9931 Continuous descent operations (CDO) manual, first edition
- Doc 9992 Manual on the use of performance-based navigation (PBN) in airspace design, first edition
- Doc 9993 Continuous climb operations (CCO) manual, first edition
- Doc 9997 Performance-based navigation (PBN) operational approval manual, first edition
- ICAO Circular 324 Guidelines for lateral separation of arriving and departing aircraft on published adjacent instrument flight procedures