AGÊNCIA DE AVIAÇÃO CIVIL

CABO VERDE PBN PLAN

Indices

1.INTRODUCTION

The continuing growth of aviation places increasing demands on airspace capacity and the need for optimum utilization of available airspace. With these needs and increasing fuel costs and higher concerns on aircraft/airport noise to the environment, aviation industry calls for new navigation technologies and operation procedures to be implemented. In respond to this call for actions, ICAO adopted several conclusions to promote the uses of Performance-Based Navigation (PBN) and Global Navigation Satellite System (GNSS) as the navigation elements of CNS/ATM systems. These navigation technologies and specifications have promising potentials to provide accurate, reliable and seamless position determination and navigation capabilities to airspace users.

ICAO adopted the Resolution A36-23 requiring Regions to complete PBN Implementation Plan by 2009 and ICAO Assembly Resolution A37-11 urges States to develop their own PBN implementation plan as a matter of urgency and is geared towards achieving the global PBN performance objectives. These global performance objectives are required to ensure that the national PBN implementation efforts, coordinated at the regional levels by the ICAO Regional PBN task forces, are aligned and consistent with the ICAO Global ATM operational concept and Air Navigation Plan.

The Global PBN performance framework was set by ICAO Assembly Resolution as follows:

a) Implementation of RNAV and RNP operations (where required) for en route and terminal areas; and

b) Implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or SBAS), for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016; and

c) Implementation of straight-in LNAV only procedures, as an exception to b), for instrument runways at aerodromes where there is no local altimeter setting available and where there are no aircraft suitable equipped for APV operations with a maximum certificated take-off mass of 5700 kg or more.

The implementation of PBN will aim to use the most appropriate navigation specification, whether it is RNAV or RNP, to suit customer operational requirements. The Global Navigation Satellite System (GNSS) is one way to introduce efficient airspace management. PBN implementation will encompass existing, as well as leading edge functionality to ensure that initially users are able to benefit and participate.

Two fundamental aspects of any PBN operation are:

- The requirements set out in the appropriate navigation specification and Navaid infrastructure (both ground and space-based) allowing the system to operate

A navigation specification is a set of aircraft and aircrew requirements needed to support a navigation application within a defined airspace concept.

The navigation specification defines the performance required by the RNAV or RNP system as well as any functional requirements such as the ability to conduct curved path procedures or to fly parallel offset routes.

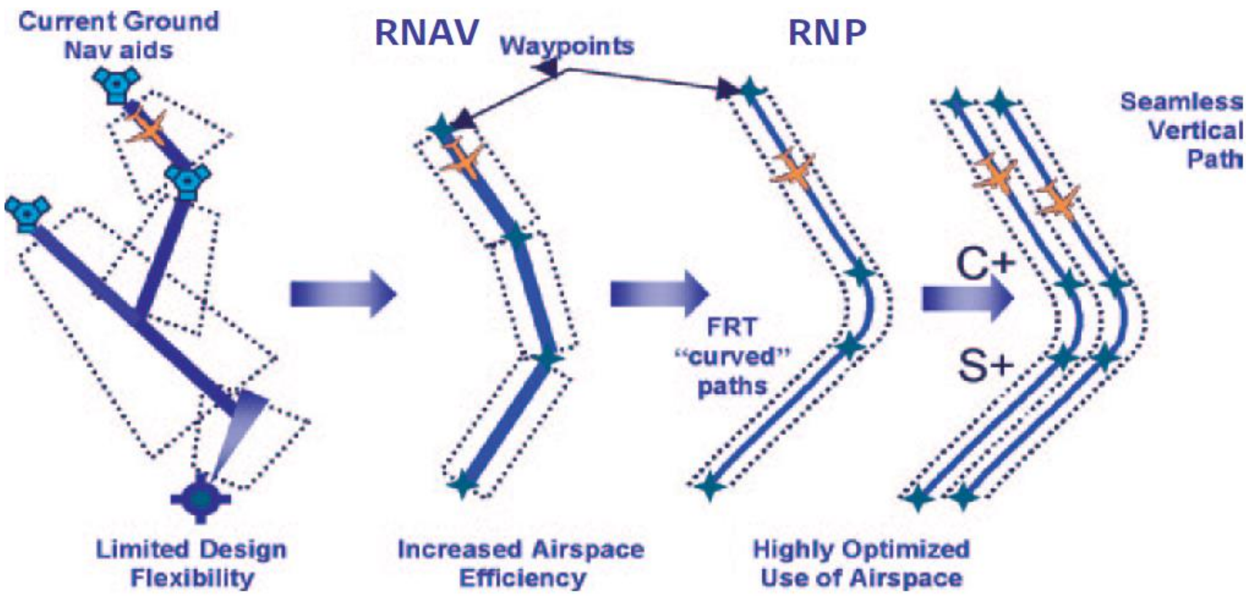

Fig.1 – Comparison between conventional navigation ground-based navaids, RNAV to RNP to PBN

Figure 1 shows the constraints associated with conventional, ground-based sensor specific routes/procedures and the flexibility and benefits of performance based navigation.

The ICAO Global ATM operational concept provides the basis for the introduction of PBN and outlines the technical recommendations regarding navigation, harmonisation and transitioning towards satellite navigation, curved RNAV approaches and implementation of APV to replace NPA (Non-Precision Approach).

2. PBN IMPLEMENTATIONS PLAN OBJECTIVES

The primary objectives of PBN roadmap in Cape Verde are as given below:

2.1. The PBN Roadmap will further provide a strategy for the evolution of the navigation applications to be implemented in Cabo Verde, in the short term (2013-2016) and long term beyond 2016. This strategy is based on the concepts of Area Navigation (RNAV) and Required Navigation Performance (RNP), which will be applied to aircraft operations involving instrument approaches, standard departure (SID) routes, standard arrival (STAR) routes, and ATS routes in oceanic and continental areas.

These objectives include Approach Procedures with vertical guidance (APV) for all instrument runway ends, either as the primary approach or as a backup for precision approaches.

2.2. To ensure that the implementation of the navigation infrastructure to support efficient CNS/ATM system is based on Regional (*AFI Regional PBN Implementation*) and Global operational requirements.

2.3. To avoid unnecessarily imposing the mandate for carriage of multiple airborne equipment on-board or multiple ground systems.

2.4. To avoid the need for multiple airworthiness and operational approvals.

2.5. To prevent commercial interests driving the Aircraft and ATM operational requirements, resulting in unnecessary expenditure for Airlines and ANSPs)

2.6. Regarding the replacement of conventional NPAs by APV Baro-VNAV procedures, PBN enables a gradual decommissioning of conventional navaids such as VOR and NDB. On the other hand, the safety of approaches to airports without ILS (or as a back-up for unserviceable ILS) is enhanced by replacing by non-precision approaches (NPAs) with APV procedures that offer vertical guidance.

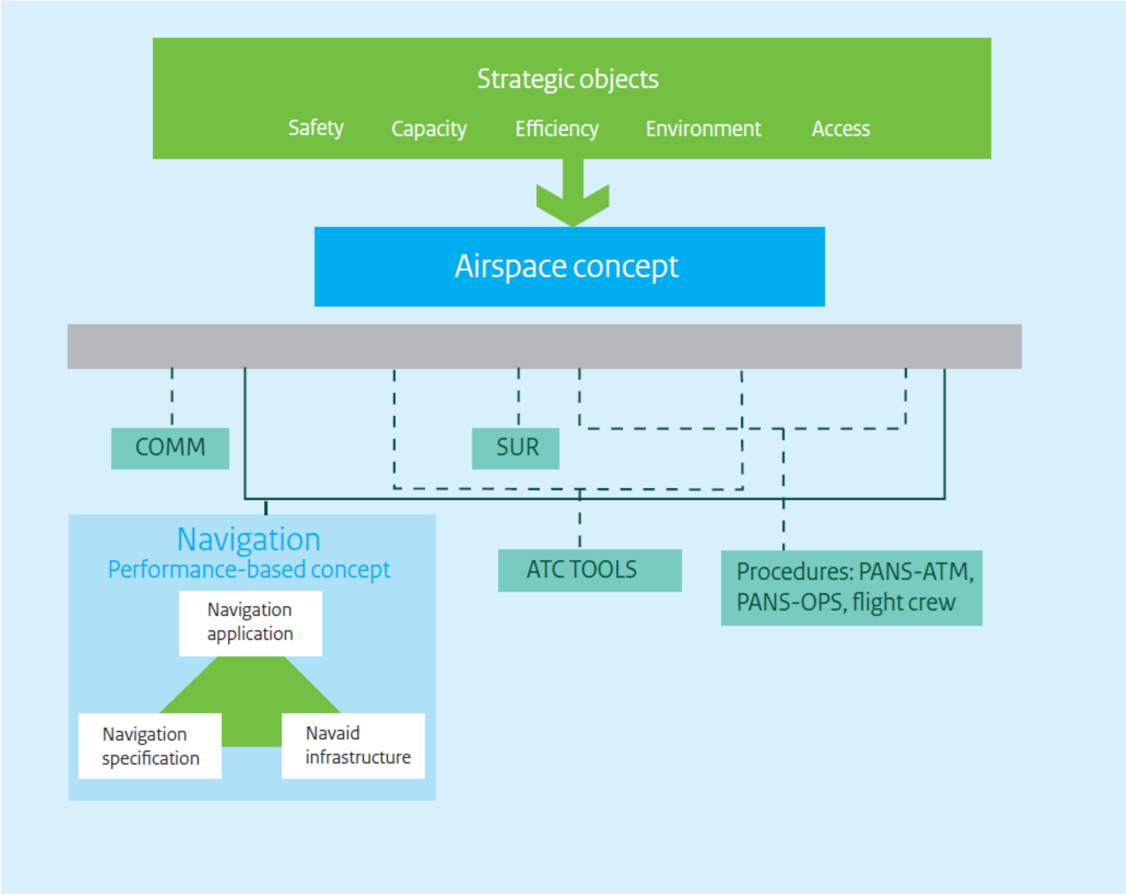

Fig.2 – Strategic objectives achieved by the introduction of PBN

3. PBN CONCEPT

PBN is a term used to describe the broad range of technologies that are reducing aircraft reliance on conventional, ground-based radio-navigation infrastructure. An aircraft flying a PBN path uses on board equipment and procedures to follow a defined trajectory.

PBN represents a shift from sensor based to performance based navigation.

Performance based navigation specifies Area navigation system performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in an airspace.

ICAO´s Performance Based Navigation (PBN) concept aims to ensure global standardisation of RNAV and RNP specifications and to limit the proliferation of specifications in use worldwide. It is a new concept based on the use of area navigation (RNAV) systems.

The aircraft system performance capabilities forms basis for the airspace design, obstacle clearance criteria, construction and implementation of flight procedures, application of aircraft separation minima, etc. Utilization of such procedures and to operate in the defined airspace the aircraft shall meet essential performance and operational capabilities.

Once the performance level (accuracy) is established on the basis of operational needs, the aircraft´s performance capability determines whether the aircraft can safely achieve the specified performance and thus quality for the operation. Within the framework of performance-based navigation, ICAO has defined RNAV and RNP specifications that can be satisfied by a range of navigation systems.

Performance requirements are defined in terms of accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept.

Performance requirements are identified in navigation specifications which also identify which navigation sensors and equipment may be used to meet the performance requirement. There are both RNP navigation specifications and RNAV navigation specifications. RNP specification includes a requirement for on-board performance monitoring and alerting and is designated as RNP-X. RNAV specification does not have such requirements and is designated as RNAV- X.

RNP operations introduce the requirement for on-board performance monitoring and alerting. A critical characteristic of RNP operations is the ability of the aircraft navigation system to monitor the navigation performance to achieve and inform the crew if the requirement is not met during an operation. This on-board monitoring and alerting capability enhances the pilot's situation awareness and can enable closer route spacing without intervention by the air traffic control (ATC).

RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency, and environmental effects.

4. PBN NAVIGATION SPECIFICATIONS

Two fundamental aspects of any PBN operation are the requirements set out in the appropriate navigation specification and the navigation aid infrastructure (both ground- and space-based) allowing the system to operate.

A navigation specification is a set of aircraft and aircrew requirements needed to support a navigation application within a defined airspace concept. The navigation specification defines the performance required by the RNAV system as well as any functional requirements such as the ability to conduct curved path procedures or to fly parallel offset routes.

RNAV and RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting. A navigation specification that includes a requirement for on board navigation performance monitoring and alerting is referred to as an RNP specification.

RNAV specifications do not require on-board performance monitoring and alerting. An area navigation system capable of achieving the alerting performance requirement of an RNP specification is referred to as an RNP System.

The PBN concept specifies that aircraft area navigation system performance requirements be defined in terms of the accuracy, integrity, continuity and functionality, which are needed for the proposed operations in the context of a particular airspace concept; availability is a function of the navigation signal in space.

This represents a shift from sensor-based to performance-based navigation. Performance requirements are identified in navigation specifications, which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements

4.1 **RNAV 10 / RNP 10**

RNP 10 supports 50 NM lateral and 50 NM longitudinal distance-based separation minima in oceanic or remote airspace.

Aircraft equipped with at least two independent long range navigation systems; any combination of INS/ IRU or GNSS meets the RNP 10 requirements. During operations in airspace or on routes designated as RNP 10, the lateral total system error must be within ±10 NM for at least 95% of the total flight time.

4.2 **RNAV 5**

RNAV 5 is an en-route navigation specification which may be used for the initial part of the STAR outside 30NM..

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

- VOR/DME
- DME/DME
- INS or IRS
- GNSS IN ACCORDANCE WITH FAA TSO-C145, TSO C146, OR TSO-C129

4.3 **RNAV 1 AND RNAV 2**

The RNAV 1 and RNAV 2 Navigation Specification is applicable to all routes, inside or outside of controlled airspace, Standard Instrument Departures (SIDs), and Standard Arrival Routes (STARS).

It also applies to instrument approach procedures up to the Final Approach Course Fix (FACF). RNAV 1 and RNAV 2 routes are envisioned to be conducted in direct controller pilot communication environments (DCPC).

RNAV 1 is intended for application within radar coverage. RNAV 1 and RNAV 2 operations are based upon the use of RNAV equipment that automatically determines aircraft position in the horizontal plane using inputs from the following types of position sensors (no specific priority):

- GNSS in accordance with FAA TSO-C145, TSO C146, or TSO-C129
- Positioning data from other types of navigation sensors may be integrated with the GNSS data provided it does not cause position errors
- With TSO-C129, as a minimum, integrity must be provided by an aircraft-based augmentation system. (e.g. RAIM)

4.4 RNP 4

RNP 4 is designed for Oceanic or Remote area airspace (where ground-based NAVAID infrastructure is not available.

RNP 4 currently supports 30 NM lateral and 30 NM longitudinal distance-based separation minima in oceanic or remote area airspace and requires GNSS avionics such as TSO-C129a or C145/6.

At least two LRNSs (Long Range Navigation System) capable of navigating to RNP 4, and listed in the flight manual, must be operational at the entry point of the RNP airspace.

4.5 RNP APCH

RNP approach (RNP APCH) procedures include existing RNAV (GNSS) approach procedures.

The following systems meet the accuracy, integrity and continuity requirements of these criteria:

- GNSS stand-alone systems, TSO-C129a, TSO C146
- GNSS sensors used in multi-sensor system (e.g. FMS)

4.6 RNP AR APCH

Aircraft operating on RNP AR APCH procedures may have RNP as low as 0.1 on the Initial, Intermediate, Final and Missed approach. If any of the Initial, Intermediate or Final segments are less than RNP 0.3, or if the Missed segment is less than RNP 1.0, then IRU must also be used.

5. NAVIGATION FUNCTIONAL REQUIREMENTS

Both RNAV and RNP specifications include requirements for certain navigation functionalities. At the basic level, these functional requirements may include:

a) continuous indication of aircraft position relative to track to be displayed to the pilot flying on a navigation display situated in his primary field of view;

b) display of distance and bearing to the active (To) waypoint;

c) display of ground speed or time to the active (To) waypoint;

d) navigation data storage function; and

d) appropriate failure indication of the RNAV system, including the sensors.

6. PBN EXPECTED BENEFITS

The main strategy (benefits) is aimed at:

6.1 Increasing safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduces the risk of controlled flight into terrain (CFIT);

6.2 Improving airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints;

6.3 Enhancing reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors.

6.4 Improving efficiency and flexibility by increasing use of operator-preferred trajectories at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises;

6.5 Reducing workload and improve productivity of air traffic controllers;

6.6 Supporting continued operations of aircraft with lower capabilities as long as operational practical;

6.7 Use of the RNAV and/or RNP capabilities that already exist in a significant percentage of the traffic flying in EUR/SAM corridor;

6.8 Reduced aircraft flight time due to the implementation of optimal flight paths, with the resulting savings in fuel and environmental protection (noise protection);

6.9 Reducing the need to maintain sensor-specific routes and procedures, and their associated costs;

6.10 Facilitating the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

The implementation of this strategy will bring many benefits for operators and for air space service provider.

7. OPERATORS READNINESS STATUS

All major commercial aircraft manufacturers since the 1980's have included RNAV capabilities and also the commercial aircraft currently produced incorporate an RNP capability. Within the framework of this plan, APV Baro-VNAV and RNAV1 SID´s and STAR´s will be implemented no later than mid-2016 as expected. (See Appendix 1)

As seen in Appendix 3, most operators can fly these procedures. This is consistent with IATA position on APV Baro-VNAV stating that most commercial aircrafts can support APV Baro-VNAV (APIRG17, wp33).

Considering that after the implementation of the referred procedures some operators will still be operating with aircrafts not equipped to fly the above procedures, in the first phase (transition phase) it is necessary to accommodate mixed traffic. (See Appendix 2 and 3)

8. TRAFFIC DESCRIPTION IN CV AIRSPACE

There is a continuous growth of traffic in Cabo Verde airspace with a little decrease in 2008/2009 and also in 2012, probably due to the international financial crisis during the period 2007-2009

Year	Departure/landing	Over flights	Total
2005	33035	32507	65542
2006	35397	33755	69152
2007	32631	39683	72314
2008	31456	42586	74042
2009	31218	37731	68949
2010	33415	39219	72634

2011	36478	44165	80643
2012	35307	44026	79333

Table 1 – Traffic description

With a little decrease referred above, this table shows the increasing tendency of air traffic in Cabo Verde airspace. That growth will require infrastructure modernization in the air traffic management and procedures improvements based on the PBN.

9. CNS INFRASTRUCTURE

9.1 Global Navigation Satellite System (GNSS)

Global Navigation Satellite System (GNSS) is a satellite-based navigation system utilizing satellite signals, such as Global Positioning System (GPS), providing accurate and reliable position, navigation, and time services to airspace users.

GNSS supports both RNAV and RNP operations. Through the use of appropriate GNSS augmentations, GNSS navigation provides sufficient accuracy, integrity, availability and continuity to support en-route, terminal area, and approach operations.

Approval of RNP operations with appropriate certified avionics provides on-board performance monitoring and alerting capability enhancing the integrity of aircraft navigation.

GNSS augmentations include Aircraft-Based Augmentation System (ABAS), Satellite-Based Augmentation System (SBAS) and Ground-Based Augmentation System (GBAS). It is expected that EGNOS will support PBN operations in Africa and consequently in our national airspace.

The possibility of installation of GBAS will enhance efficiency and capacity by mitigating the need for critical area protection as it is the case during ILS operations. It will also reduce the reliance on the conventional ILS infrastructure.

9.2 Other CNS infrastructure

Other navigation infrastructure such as INS, VOR/DME may satisfy the requirements of RNAV navigation specifications, but not those of RNP.
INS will be used to support PBN en-route operations with RNAV-10 and RNAV-5 navigation specifications.

VOR/DME will also be used to support PBN en-route and STAR operations based on the RNAV-5 navigation specification.

Communications requirements for PBN implementation in accordance with ICAO PANS ATM (Doc 4444), ICAO RCP Manual (Doc 9869), and ICAO Annex 10 would be complied with for implementation of RNAV/RNP routes.

9.3 Cabo Verde – CNS infrastructure

9.3.1 Navigation and Surveillance

There are two VOR/DME stations installed in Cabo Verde for approach and en route navigation. One is located in Sal airport and another in Praia airport. Aircraft flight management system, with the location of VOR/DME stations and their exact coordinates, can calculate the deviation from the intended flight track. The limitation of VOR/DME utilisation is the low accuracy of radial angle measurement. Taking into account the navigation system errors (NSE) and the flight technical errors (FTE), VOR/DME can meet only RNAV5 navigation specification requirements not further than 110-120 km from their installation location.

VOR accuracy can typically meet the accuracy requirements for RNAV 5 up to 60 NM from the navigation aid.

DME signals are considered sufficient to meet the requirements of RNAV 5 whenever the signals are received and there is no closer DME on the same channel, regardless of the published coverage volume. Using two DME/DMEs, the navigation accuracy is about 1km, which allows this navigation infrastructure to meet RNAV 1 navigation specification requirements. The use of two DMEs will not be able to provide the necessary accuracy in all directions and it would be necessary to install at least another one DME station in Cabo Verde.

The introduction of RNAV1 SID and STARS will rely on the use of GNSS. RNP APCH operations (APV Baro-VNAV) will be based on GNSS and the vertical guidance will be based on barometric altimetry. Given that the vertical path is based on barometric inputs, it is very important that the correct local pressure setting (QNH) is entered into the system. The final descent is also influenced by temperature which must be published on the chart. Today in all airports there is reliable pressure and temperature information (QNH).

There are three radar stations installed in Cabo Verde, in Morro Curral (Sal), Monte Tchota (Santiago) and Pedra Rachada (Santo Antão). They are used to provide surveillance in Cabo Verde TMA and in most part of Sal Oceanic FIR as you can see in Appendix 3.
Additional surveillance is provided by ADS within and beyond radar coverage.
As long as there surveillance is always provided, it is foreseen the introduction of RNAV1 SIDs and STARs instead of RNP1 SIDs and STARs.
After safety assessment, in the framework of SAT, RNP 4 will replace RNP10 operations.

9.3.2 Communication infrastructure

Today there are two VHF ER stations providing stable and reliable communications for air traffic management in domestic and international operations. Beyond VHF coverage, communication is provided by CPDLC.

10. CV IMPLEMENTATION STRATEGY

Cabo Verde airspace (Sal Oceanic FIR) is located along EUR /SAM corridor.

The introduction of any navigation specification for upper airspace must be discussed with SAT members and be approved in this forum.

The PBN implementation plan in Cabo Verde includes implementation of PBN routes in Sal FIR and RNAV (GNSS) approach procedures, replacing the conventional procedures and reorganization of airspace if needed.

Flex routes may also be implemented. The Global Plan Initiative (GPI -7, doc 9750) states that routes need not to be fixed to pre-determined waypoints except where required for control purposes.

Flex routing structure was introduced in Sal Oceanic FIR in April 2011 (S01/2011). Its implementation aimed to remove the constraints imposed by the fixed route structure and through the optimized use of all the airspace benefits of capacity, flexibility, flight efficiency and cost savings, while maintaining safety standards.

RNP 10 was introduced in 2009 (AIC 002/2009), as was decided by SAT group.

The implementation of PBN is expected to be developed in two phases: phase I (near term) and phase II (medium term).

10.1 Phase I

This phase will allow the use of GNSS as a primary-means of navigation for en-route, and for NPA; and as a supplemental-means navigation system for TMA. Existing ground infrastructure remains intact.

Phase I	Period	Proposed Implementation Objectives
Near Term	2013 - 2015	
En route Oceanic		RNP10
Terminal Areas		RNAV 1 /Basic RNP 1

Approach		RNP APCH with Baro-VNAV at all International Airports (*)
Phase II		
Medium Term	2016 and beyond	
En route Oceanic		RNP 10 / RNP 4 (30NM / 30 NM)
Terminal Areas		RNAV 1 or Basic RNP1
Approach		RNP APCH with Baro-VNAV at international and domestic airports where required and agreed
(*) Following airports: GVAC, GVPN, GVBA, GVSV		

Fig. 3 – Implementation of planned objectives

The implementation targets are:

• RNP APCH (with Baro-VNAV) or APV in all instrument runways by 2016
• RNAV-1 or RNP-1 SID/STAR for all international airports by 2016
• RNAV-1 or RNP-1 SID/STAR for domestic airports where there are operational benefits
• Implementation of additional RNAV/RNP Routes if required.

At Sal airport, APV may be used as a backup for precision approach.

10.2 Phase II

In this phase sufficient capacity is needed to meet en route and TMA navigation requirements in Sal Oceanic FIR. GNSS will continue to be used as principal en route navigation.

Approach and landing phase: sufficient capability for APV1 national airspace. ILS will continue to be operationally where they are installed.

RNP 4 was developed for operations in oceanic and remote areas. The global navigation satellite system is the primary navigation sensor that supports RNP4, either as a stand-alone navigation system or as part of multi-sensor system. The implementation of RNP4 will be consistent with the decisions of SAT group for EUR/SAM corridor. The implementation of RNP4 will need a safety assessment to be done by SATMA.

All routes and coordinates may be based on WGS-84.

PBN SIDs and STARS would allow the following:

a) Reduction in controller-pilot communications;

b) Reduction of route lengths to meet environmental and fuel efficiency requirements;

c) Seamless transition from and to en-route entry/exit points;

d) Sequence departures to maximize benefits of RNAV and identify automation requirements for traffic flow management, sequencing tools, flight plan processing, and tower data entry activities.

For each identified runway the SIDs will be developed to accommodate as many aircraft as possible. These procedures will take into account obstacle clearance, airspace structure, aircraft performance and noise abatement. The departure procedure is to be developed as a route to link the aerodrome with a specified point, normally to where en route phase of the flights commences.

The STARs will be developed to guarantee efficient traffic routing and management. The arrival procedure will be designed and implemented to be compatible with efficient traffic flow and ATM needs, connecting the en route area with the runway end.

10.3 CDO AND CCO (CONTINUOUS DESCENT OPERATIONS AND CONTINUOUS CLIMB OPERATIONS)

Where operationally feasible, operational concepts and requirements for continuous descent operations and for continuous climb operations will be developed. This would reduce workload for pilots and controllers as well as increase fuel efficiency.

The deployment of departure procedures that allow the aircraft to fly optimum aircraft profile taking account of airspace and traffic complexity with continuous climb operations (CCOs) will increase the efficiency and flexibility of departures.

It is expected that the deployment of performance-based airspace and arrival procedures will allow the aircraft to fly optimum profile taking account of airspace and traffic complexity with continuous descent operations (CDOs). The figure 1 illustrates this concept.

The Fig. 1 shows an example of continuous descent operation using a single aisle jet. For fifteen operations there is a fuel consumption reduction of 6.1 ton of fuel and emission reduction of 19.15 ton of CO_2. This calculation was done with ICAO tool Ifset v.1.

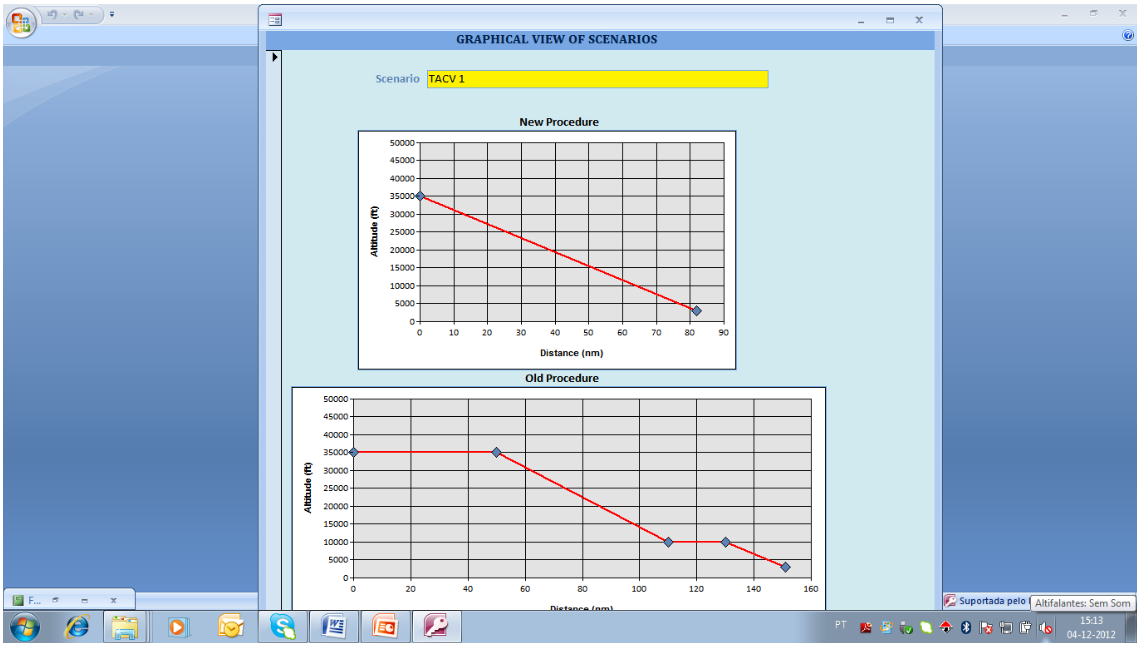

Fig. 4 – Illustration of the benefits of the introduction of new procedure (CDO)

The implementation of continuous descent and climb operations will be one of the tasks of the PBN Implementation Team.

10. 4 CHALLENGES

The following challenges are envisaged:

- Mixed fleet / system operations
- Integration of PBN capability into the ATM system (FPL)
- PBN capability register and aircraft minimum equipment lists (MEL)
- Safety monitoring of ATM system
- Approach naming and charting conventions
- Navigation database integrity and control
- GNSS system performance and prediction of availability service
- Continued involvement in CNS/ATM and PBN development
- Resources to implement PBN
- Education and training CAA staff, service provider and aircraft operators
- Environment (reduction of noise and CO_2 emissions)
- GNSS/RAIM prediction requirements
- Introduction of Automatic Weather Station (AWS) for APV Baro-VNAV
- Implementation of CCOs and CDOs
- Approval process

10.5 CNS INFRASTRUCTURE

The existing CNS infrastructure is sufficient to support the introduction of RNAV1 SIDs and STARs operations as well as the APV Baro-VNAV approaches. There is no need of additional ground infrastructure.
It is expected that some aircrafts will be not able to fly RNAV1 or APV Baro-VNAV procedures. There will be mixed operations for equipped and non-equipped aircrafts. This issue will be addressed by the PBN implementation team.

10.6 SBAS/GBAS IMPLEMENTATION

In relation with SBAS/GBAS development it must be stated that in near future SBAS or GBAS based operations are not expected to be implemented in Cabo Verde.

10.7 STAKEHOLDERS

The primary aim for this plan is to maintain and increase safety, air traffic demand and capacity, and services and technology in consultation with relevant stakeholders.

This PBN Plan was developed by the Cabo Verde CAA in consultation with the stakeholders concerned and is intended to assist the main stakeholders of the aviation community to plan a gradual transition to the RNAV and RNP concepts.

The main stakeholders of the aviation community that benefit from this PBN Plan, and were therefore included in the development process are:

- Cabo Verde Civil Aviation Administration
- Airspace operators and users
- Standard organizations

As driven by business needs, airlines and operators can use the Cabo Verde PBN plan to plan future equipage and capability investments. Similarly, the air navigation service provider can determine requirements for future automation systems, and more smoothly modernize ground infrastructure.

10.8 IMPLEMENTATION TEAM

In order to implement the PBN national plan there is a need to set up an implementation team to carry following functions:

- Development of GNSS non-precision approach procedures for agreed runways;
- WGS-84 surveys update;
- Development of SIDs and STARs in conjunction with GNSS approach procedures;

- Modification of airspace structure design to meet GNSS requirements;
- Development and preparation for publication of all relevant charts;
- Flight verification (inspection) of the GNSS procedures;
- Drafting of essential national GNSS legislation (regulations);
- Training

- Implementation team shall have the following composition:

❖ AAC NAV Inspectors
❖ AAC OPS Inspector
❖ Two representatives of ASA (DNA)
❖ One representative of TACV
❖ Two representatives of International Airlines operating in Cape Verde

11. AVIONICS

The aircrafts must have the following capability:

– PBN approach procedures can be flown with basic IFR GNSS avionics
– TSO C129 receivers with RAIM
– Basic IFR GNSS receivers integrated with Baro VNAV functionality to support vertical guidance to LNAV/VNAV minima
– Aircraft with SBAS avionics (TSO C145/146) can fly approaches with vertical guidance to LPV minima, as low as ILS Cat I minima
– Aircraft require TSO C161/162 avionics to fly GBAS approaches

2 12. CONCLUSION

There is a need to implement PBN because at a global level it aims to reduce controlled flight into terrain (CFIT), to increase efficiency, capacity, aerodrome access and address environmental issues.

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14. GLOSSARY

3D – Three Dimensional

4D – Four Dimensional

ADS B – Automatic Dependent Surveillance – Broadcast

ADS C - Automatic Dependent Surveillance – Contract

CNS – Communications, Navigation, Surveillance

GBAS – Ground-Based Augmentation System7

GNSS – Global Navigation Satellite System

INS – Inertial Navigation System

LNAV – Lateral Navigation

PBN – Performance Based Navigation

RAIM – Receiver Autonomous Integrity Monitoring

RNP – Required Navigation Performance

RSP – Required Surveillance Performance

SBAS – Satellite Based Augmentation System

SID – Standard Instrument Departure

SSR – Secondary Surveillance Radar

STAR – Standard Instrument Arrival

VNAV – Vertical Navigation

.

APPENDIX 1

PBN PLANNNING TIMETABLE

INTERNATIONAL ARPORTS			PBN PLAN				
Airport	Runway	Current Approach	RNP Approach	SID	STAR	TARGET LINE	**TIMELINE**
GVAC	01	VOR/ILS VOR/DME NDB/ILS NDB	ILS/APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016
	19	VOR/DME	APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016
GVNP	03	VOR/DME NDB	APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016
	21	VOR/DME NDB	APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016
GVBA	03	NIL	APV Baro-VNAV	RNAV 1	RNAV 1	30/06/2016	Dez 2016
	21	NDB	APV Baro-VNAV	RNAV 1	RNAV 1	30/06/2016	Dez 2016
GVSV	07	NDB, NDB/LOC	APV Baro-VNAV	RNAV 1	RNAV 1	30/06/2016	Dez 2016
	25	NIL	APV Baro-VNAV	RNAV 1	RNAV 1	30/06/2016	Dez 2016
DOMESTIC AIRPORTS							
GVMA	01	NIL	APV Baro-VNAV	RNAV 1	RNAV 1	30/06/2016	Dez 2016
	19	NIL	APV Baro-VNAV	RNAV 1	RNAV 1	30/06/2016	Dez 2016
GVSF	14	NIL	APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016
	32	NIL	APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016
GVSN	01	NDB	APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016
	19	NIL	APV Baro-VNAV	RNAV1	RNAV1	30/06/2016	Dez 2016

SAL OCEANIC FIR

En-Route		RNAV10/RNP10
	RNAV10/RNP10	RNP4/RNP2

APPENDIX 2

1. OPERATORS FLYING TO AND FROM - GVNP

AIRLINES	**AIPORT DESTINATION**	**TYPE A/C**	FORECAST OF MOVEMENTS (Mar - Oct 2014)
BINTER CANARIAS	**GVNP**	CRJ-900	120
		ATR 72	28
ROYAL AIR MAROC	**GVNP**	B738	173
		B73G	140
SENEGAL AIRLINES	**GVNP**	CRJ-900	198
TAAG	**GVNP**	B737-700	120
TAP	**GVNP**	A320	366
		A319	4
TACV	**GVNP**	B738	287
		B752	244
		ATR45	
		ATR72	

2. OPERATORS FLYING TO AND FROM GVAC

AIRLINES	AIPORT DESTINATION	TYPE A/C	FORECAST OF MOVEMENTS (Mar - Oct 2014)
BINTER CANARIAS	**GVAC**	CRJ-900	28
		ATR 72	
EUROPE AIRPOST	**GVAC**	B737-700	48
LUX AIR	**GVAC**	B737-800	
NEOS SPA	**GVAC**	B737-800	32
TAP	**GVAC**	A320	
		A319	4
THOMSON AIRWAYS	**GVAC**	B757	
TACV	**GVAC**	B737-800	101
	GVAC	B757	
XL AIRWAYS	**GVAC**	B737-800	12

3. OPERATORS FLYING TO AND FROM – GVBA

AIRLINES	AIPORT DESTINATION	TYPE A/C	FORECAST OF MOVEMENTS (Mar - Oct 2014)
EUROPOST	GVBA	B737-700	48
LUXAIR	GVBA	B737	16
NEOS SPA		A319	150
THOMAS COOK AILINES	GVBA	A319	16
TAP	GVBA	A320	120
THOMSON AIRWAYS	GVBA	B757	298
TRAVEL SERVICE CZECH	GVBA	B737-800	48
TRAVEL SERVICE POLSKA	GVBA	B737-800	2
TRAVEL SERVICE SLOVAKIA	GVBA	B737-800	20
TUI FLY GMBH	GVBA	B737-800	81
TACV	GVBA	B738	51
JET AIR TUI AIRLINES	GVBA	737-800	198

4. OPERATORS FLYING TO AND FROM - GVSV

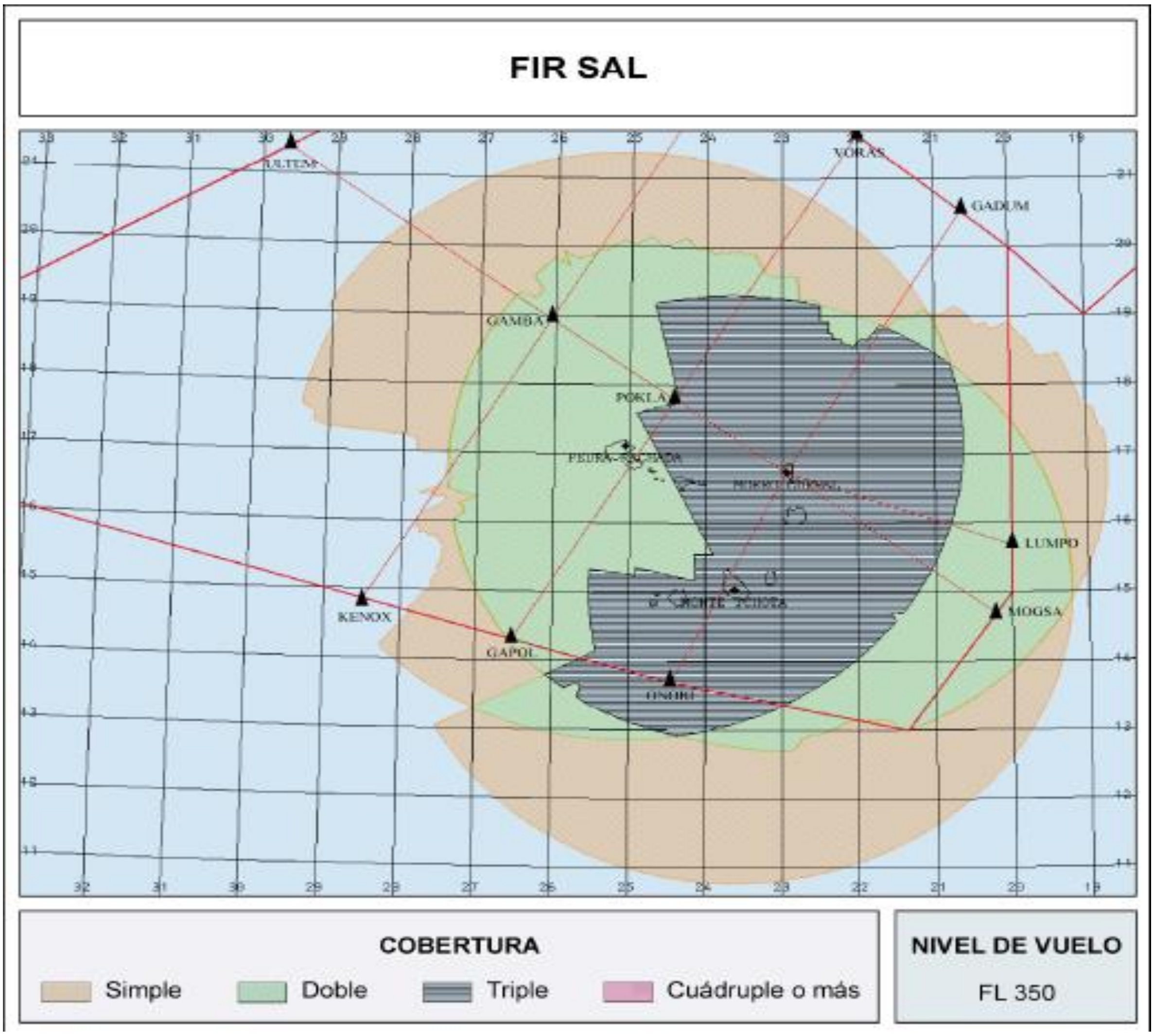
AIRLINES	AIPORT DESTINATION	TYPE A/C	FORECAST OF MOVEMENTS (Mar - Oct 2014)
TAP	VXE	A320	120
TRANSAVIA.COM	VXE	B737	14
TACV	VXE	B738	91
		B752	31
		ATR72 ATR52	

APPENDIX 3

FLEET CAPACITY

OPERATORS	FLEET	PBN CABACITY
TRANSAVIA	B737-800	Fleet full equipped for RNAV/RNP operations
AIR SENEGAL	CRJ-100	Capacity to fly RNAV5 and B-RNAV
TUI FLY	B737-800	They can fly all procedures we intend to implement
THOMAS COOK	A319	They can fly: • P-RNAV (RNAV1) • RNP 10 (RNAV10) • B-RNAV (RNAV5) • RNP APCH (LNAV) (RNP 0.3)
THOMSON AIRWAYS	B757	• With A/C types B737 & B787 no problem with any of the procedures. • For B737 & B767 they cannot carry out Baro-VNAV procedures. • Ok with all other procedures
JET AIR TUI AIRLINES BELGIUM	B737-800	They operate in Sal and Boavista with B737 having the following capabilities: • RNAV-10 (RNP-10) • RNAV-5 (B-RNAV) • RNAV1 (P-RNAV) • RNP APCH –LNAV • RNP APCH-LNAV/VNAV B767 has the same PBN capabilities as those above with the exception of RNP APCH –LNAV/VNAV
EUROPE AIRPOST	B737-700	• All aircrafts and crew are RNAV5 capable • All aircrafts and crew are RNAV1 DME/DME capable • Only (4 Aircrafts) the B737-700 are RNAV GPS CAPABLE • Only the B737-700 and crew are RNP APCH capable
LUXAIR	B737	• Boeing fleet approved to operate B-RNAV and P-RNAV • They are also approved to operate RNP values 5/1 • They are preparing the approval for the RNP LNAV and RNP LNAV / Baro-VNAV by mid-2015
TACV	B757-200 B737-800 ATR72-500 ATR42-500	• The Boeings 757 and 737 are able to fly RNP APCH and RNAV1 SID´s and STAR´s • For B737-800 RNAV1 SID and STAR´S procedures developed and certification achieved • Ongoing certification process for B737-200 • Procedures develop for RNAV1 SID´s and STAR´S • The ATR42 and ATR72 can fly RNAV1 SID and STAR´s
TAP	A319 A320	

APPENDIX 4


FIR SAL
VORAS
GADUM
GAMBA
POKLA
LUMPO
KENOX
MOGSA
GAPOL
COBERTURA
Simple
Doble
Triple
Cuádruple o más
NIVEL DE VUELO
FL 350

APPENDIX 5

S.Pedro airport

1. Air temperature

Montly average temperature - in Centigrades

Year	Month												Annual
	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2010	23,1	23,4	23,8	24,4	24,5	24,8	25,7	26,8	27,4	26,6	25,3	24,2	25,0
2011	23,1	22,3	21,9	22,7	23,7	24,7	25,5	26,5	27,1	26,6	24,5	23,2	24,3
2012	21,6	20,5	21,7	22,0	23,5	24,4	26,0	27,4	27,8	26,9	25,2	22,3	24,1
2013	21,3	21,3	22,2	22,6	25,0	24,8	26,3	27,6	27,7	27,6	25,5	23,8	24,6

Maximum temperatur - in Centigrades

Year	Month												Annual
	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2010	30,8	30,6	32,3	29,5	29,0	31,0	31,3	36,0	33,0	31,5	31,7	30,6	36,0
2011	28,5	28,0	26,3	29,8	28,2	32,5	30,6	31,6	34,8	33,5	29,1	30,3	34,8
2012	27,6	25,2	29,5	26,8	33,0	30,3	32,7	34,0	35,2	34,0	30,8	30,2	35,2
2013	27,5	27,5	29,2	29,5	32,8	30,8	36,1	34,2	33,1	34,1	32,3	31,5	36,1

Minimum temeparature values - in Centigardes

Year	Month												Annual
	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2010	15,2	17,7	19,5	20,0	21,2	21,7	22,2	22,0	23,5	22,2	19,5	18,2	15,2
2011	17,0	18,2	17,6	17,1	19,2	20,2	21,7	23,6	23,2	21,6	19,8	18,5	17,0
2012	17,0	17,5	17,0	17,5	19,7	21,6	22,1	22,8	23,3	21,3	21,0	17,1	17,0
2013	16,1	15,3	15,8	17,1	18,6	21,5	22,2	23,8	23,8	23,6	18,7	19,6	15,3

ATMOSPHERIC PRESSURE: 2010 - 2013

Mean values at station level

Year	Month						
	Jan	Fev	Mar	Apr	May	Jun	Jul
2010	1013,7	1012,4	1013,0	1011,8	1012,7	1013,5	1012,2
2011	1012,3	1013,8	1013,1	1012,2	1012,6	1013,1	1012,6
2012	1014,4	1012,5	1013,2	1013,5	1013,2	1013,7	1012,0
2013	1013,7	1013,2	1013,2	1013,2	1013,2	1013,6	1013,1

Maximum value at station level

Year	Month						
	Jan	Fev	Mar	Apr	May	Jun	Jul
2010	1018,3	1017,8	1016,7	1014,7	1016,6	1016,5	1016,0
2011	1016,9	1019,0	1017,9	1015,7	1015,9	1017,4	1017,0
2012	1020,0	1017,8	1017,6	1016,4	1016,7	1017,2	1016,0
2013	1018,3	1016,9	1017,3	1018,0	1016,5	1017,4	1017,0

Minimum value at station level

Year	Month						
	Jan	Fev	Mar	Apr	May	Jun	Jul
2010	1008,6	1007,6	1010,3	1008,2	1009,0	1008,2	1007,9
2011	1008,1	1008,7	1009,5	1008,3	1009,5	1005,6	1007,4
2012	1010,6	1007,6	1009,5	1010,1	1007,3	1010,0	1006,6
2013	1008,8	1009,9	1008,1	1009,3	1010,2	1009,9	1007,7

Month

Mean values at sea level (hpa)

Year	Month						
	Jan	Fev	Mar	Apr	May	Jun	Jul
2010	1016,0	1014,8	1015,3	1014,1	1015,0	1015,8	1014,5
2011	1014,6	1016,1	1015,3	1014,5	1014,9	1015,4	1014,9
2012	1016,7	1014,7	1015,5	1015,8	1015,5	1016,0	1014,3
2013	1016,0	1015,5	1015,5	1015,5	1015,5	1015,9	1015,4

Maximum value at sea level

Year	Month						
	Jan	Fev	Mar	Apr	May	Jun	Jul
2010	1020,6	1019,5	1019,0	1017,0	1018,9	1018,8	1018,3
2011	1019,2	1021,3	1020,2	1018,0	1018,3	1019,7	1019,3
2012	1022,3	1019,5	1019,5	1018,7	1019,0	1019,5	1018,2
2013	1020,6	1018,4	1019,7	1020,4	1018,9	1019,7	1019,3