ROYAUME DU MAROC
MINISTERE DU TOURISME, DU TRANSPORT AERIEN, DE L'ARTISANAT ET DE L'ECONOMIE SOCIALE

MOROCCO PBN PLAN

NATIONAL PLAN FOR IMPLEMENTATION OF PERFORMANCE BASED NAVIGATION (PBN)

Version 2.0

Versions

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1. Object

The following performance based navigation PBN plan emphasizes Morocco's commitment toward the modernization of its airspace and the services provided within it.

In fact, great advances have been achieved recently in GNSS based navigation techniques and systems which will allow extensive flexibility in the design and management of airspace permitting the reduction of separation between airplanes. Techniques such as continuous descent and climb operations will also improve fuel consumption and reduce pollution levels while ensuring a high level of flight operations safety.

The generic navigation requirements are defined in relation to the operational requirements. Users can evaluate the available applications for a given airspace and choose their preferred compliant navigation technique taking into account their investments plans and the interoperability between their embedded systems and ground facilities. Moreover, it should be noted that the choice of an application will be made in consultation with main stakeholders (DGAC, FRA, ONDA, Airliners…).

2. General context

2.1 ICAO resolution

The A37-11 resolution "global goals for performance based navigation" was adopted by ICAO Assembly at its 37th meeting (October 2010), and contained the following:

1. Urges all States to implement RNAV and RNP air traffic services (ATS) routes and approach procedures in accordance with the ICAO PBN concept laid down in the Performance-based Navigation (PBN) Manual (Doc 9613);

2. Resolves that: States complete a PBN implementation plan as a matter of urgency to achieve:

- Implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones;
- implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV-only minima, for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014;
- Implementation of straight-in LNAV-only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting available and where

there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5 700 kg or more;

2.2 Performance issues:

For the sake of competitiveness and attractiveness, Morocco gives great importance to ensuring the performance of air traffic management in terms of capacity, environmental protection and economic efficiency while maintaining a high level of flights safety. These commitments are the main findings in this national PBN plan.

One of the major fields this plan focuses on is the increasing of the capacity by reducing minimal spacing between aircrafts and allowing the introduction of GNSS based procedures in areas where ground based facilities are scarce or nonexistent.

Another aspect is trajectory optimization by introducing new methods of approach procedures design, including CDOs, thus reducing fuel consumption and flight time.

It should be noted that conventional approach procedures and facilities will be maintained to support airspace users who are not compliant with new requirement during the transitional period.

The augmentations of GNSS include Aircraft-Based Augmentation System (ABAS), Satellite-Based Augmentation System (SBAS) and Ground-Based Augmentation System.

2.3 The contributions of the PBN concept:

To achieve the global performance based navigation goals, it is necessary to establish a managing policy for the available capabilities provided by readily used navigation systems, aiming to reduce costly modifications of embedded systems.

Adopted navigation solutions should be tuned to appeal to different categories of airspace users (large companies, regional aviation, business aviation, aerial work, light aircraft ...), as well as deserved platforms, density of traffic, environmental conditions etc..

The PBN concept allows flexibility in the requirements necessary to establish this ambitious policy. The immediate expected benefits include:

- Increasing the number of routes allowing for optimizing flying levels and climb and descent profiles;
- Reducing the length of low level trajectories ;

- Generalizing vertical guidance on final approach ;and
- Continuous Descent and Climb operations
- Lowering operational minima.

2.4 Operational needs:

En route:

En route operations can be classified under following categories: oceanic, remote continental, and continental. Based on operational ATM needs adopted en route applications are:

RNAV-10, RNP-4, RNAV-5, RNAV-2 and RNAV-1.

Terminal Maneuvering Area (TMA):

TMA operations are characterized by a denser air traffic volume, tighter constrains on aircraft/obstacle minimal distances, and low performance aircrafts flying along commercial airliners. TMA requirements are RNAV-2 and RNAV-1 in radar controlled environments or RNP-1 otherwise.

Approach:

Approach requirements call for RNP-APCH and RNP AR APCH.

3. Navigation Strategy

Morocco's navigation strategy focuses on the following goals:

- Use of area navigation based on performance (RNAV / RNP) for all operations;
- Allow as much as possible the implementation of customers' preferred routes;
- Allow operations for non-equipped aircrafts as long as operations permit;
- Allow clients owning upgraded avionics to take full advantage of their financial investments;
- Provide positioning and navigation data in compliance with the requirements to support the various CNS / ATM applications;
- Promote the use of satellite based navigation systems and streamline ground facilities for all flight phases to allow smooth transition to GNSS in accordance with ICAO recommendations;
- Implement RNP 4D operations for the transition to full Gate to Gate flight management.

We consider the implementation of PBN in Morocco as a series of upgrades to aircraft, crew and ATM. Operators requiring a long time to perform the upgrades will continue to operate within the airspace without taking advantage of optimum flight patterns.

Eventually, due to the need to apply RNP specifications, GNSS will become essential during the transition in the medium term. The SIDs and STAR RNPs will help to alleviate the congestion of the terminal areas. Morocco's navigation strategy takes into account the emergence of satellite technology and the role it will play in the global navigation environment. However, the pace of technological change and the time required to resolve the institutional limitations to the adoption of GNSS as a single system should for the foreseeable future require the upkeep of a terrestrial backup system.

4. PBN Navigation specifications

Area navigation (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. One not having such a requirement is referred to as an RNAV specification

Navigation specification	Flight phase							
	En-route oceanic/remote	En-route continental	Arrival	Approach				DEP
				Initial	Intermediate	Final	Missed[1]	
RNAV 10	10							
RNAV 5[2]		5	5					
RNAV 2		2	2					2
RNAV 1		1	1	1	1		1	1
RNP 4	4							
RNP 2	2	2						
RNP 1[3]			1	1	1		1	1
Advanced RNP (A-RNP)[4]	2[5]	2 or 1	1	1	1	0.3	1	1
RNP APCH[6]				1	1	0.3[7]	1	
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1	
RNP 0.3[8]		0.3	0.3	0.3	0.3		0.3	0.3

Navigation specification per flight phase

Notes

1. Only applies once 50 m (40 m, Cat H) obstacle clearance has been achieved after the start of climb.

2. RNAV 5 is an en-route navigation specification which may be used for the initial part of a STAR outside 30 NM and above MSA.
3. The RNP 1 specification is limited to use on STARs, SIDs, the initial and intermediate segments of IAPs and the missed approach after the initial climb phase. Beyond 30 NM from the ARP, the accuracy value for alerting becomes 2 NM.
4. A-RNP also permits a range of scalable RNP lateral navigation accuracies
5. Optional — requires higher continuity.
6. There are two sections to the RNP APCH specification (See DOC 9613): Part A is enabled by GNSS and baro-VNAV, Part B is enabled by SBAS.
7. RNP 0.3 is applicable to RNP APCH Part A (See Doc 9613). Different angular performance requirements are applicable to RNP APCH Part B only.
8. The RNP 0.3 specification is primarily intended for helicopter operations.

4.1 RNAV 10 (Designated and authorized as RNP 10)

RNAV 10 allows a lateral and longitudinal spacing equal to 50 NM over oceanic and remote airspaces.

Aircrafts must carry at least two independent long-range navigation systems (LRNSs) of any combination of INS/IRU and/or GNSS that meets RNAV-10 requirements. During RNP-10 operations the total lateral and longitudinal deviations off of the intended route must not exceed 10NM during at least 95% of total flight time. In regular operation any error or lateral deviation off of the system's calculated trajectory must be within 5NM. Brief deviations out of this range can be tolerated during or immediately after a turn without ever exceeding 10NM.

4.2 RNP 4

RNP-4 is intended to be used over oceanic and remote areas, where ground facilities are scarce or unavailable.

RNP-4 specification allows for 30NM lateral and 30NM longitudinal spacing between aircrafts on the same airway and requires the use of GNSS enabled avionics compliant with TSO-C129a or C145/6.

It should be considered that RNP-1 approved aircrafts are not automatically allowed to perform RNP-4 operations because in this case functional requirements are more constraining than precision required from the used navigation systems.

4.3 RNAV 5

RNAV-5 operations are based on the use of navigation systems capable of automatically switch between a broad variety of sensors to assess the position of the aircraft, the major means used in this regard are as follow:

- VOR/DME;
- DME/DME;
- INS or IRS;
- GNSS.

4.4 RNAV 1 and RNAV 2

RNAV-1 and RNAV-2 specifications can be used in most of flight phases including routes inside and outside radar controlled areas and standard departures and arrivals procedures (SIDs and STARs) as well as instrument approach procedures up to the FAF. In the case of Morocco it has been consented that RNAV-1 and RNAV- will be used in controlled areas with direct controller/pilot communication link (DCPC).

The following means are used to assess the aircraft position by RNAV-1 and RNAV-2 capable navigation systems:

- GNSS;
- Other positioning data might be used in conjuncture with GNSS if no error is induced;
- If the navigation equipment is compliant with TSO-C129, an integrity monitoring mean such as RAIM must be present.

4.5 RNP 1

RNP-1 specification is designed for SIDs and STARs in airports with limited or no radar control within 30NM of the reference point (ARP). Compliant STARs allow for precision connection between airways and IAFs or RNP APCH procedures and sometimes to an ILS approach. Compliant SIDs permits performing the first turn after take-off earlier than permitted with other specifications.

GNSS is the primary navigation system underlying the RNP-1 provided that it meets one of the following requirements:

- Onboard sensor compliant withTSO-C129a (B or C class);
- Onboard equipment is compliant with TSO-C145 or C146.

When performing RNP-1 operations the total lateral deviation off of the intended course must not be in excess of 1NM on either side during 95% of total flight time. In normal operation the navigational system cross distance to the calculated route (FTE) must not exceed 0.5NM on each side. Brief deviation exceeding this value can be admitted when performing turns or immediately after a turn but must be within the 1.0NM limit.

4.6 RNP APCH

RNP APCH specification can be applied to existing RNAV approaches. The following systems are compliant with this specification:

- Independent GNSS enabled systems (TSO-C129a, TSO C146);
- Multisensory systems containing GNSS capabilities.

4.7 RNP-AR-APCH

AR approached (Authorization required) will be published but only preformed with special permission as requirements to perform such procedures are exceptional. The aircraft performing RNP AR APCH procedures might be approved for RNP values as low as 0.1NM during initial, intermediate, final and interrupted segments. If the RNP value is 0.3 NM on any of the initial, intermediate and final segments or is less than 1NM on the interrupted approach segment the use of IRU is mandatory.

	Permitted Sensors					AFCS Requirement
	GNSS	IRU	DME/DME	DME/DME /IRU	DME/VOR	AP/FD
RNAV 10	✓	✓				FTE may be manually controlled by the pilot remaining within ½ full scale deflection of CDI with correct scaling for phase of flight
RNAV 5	✓	✓	✓	✓	✓	
RNAV 2/1	✓		✓	✓		
RNP 4	✓					
RNP 2 [2]	✓					
RNP 1	✓		✓ [3]			
A-RNP [2]	✓		✓ [3]			✓ [1]
RNP 0.3	✓					✓
RNP APCH	✓		✓ [3]	✓ [3]		✓
RNP AR APCH	✓					✓

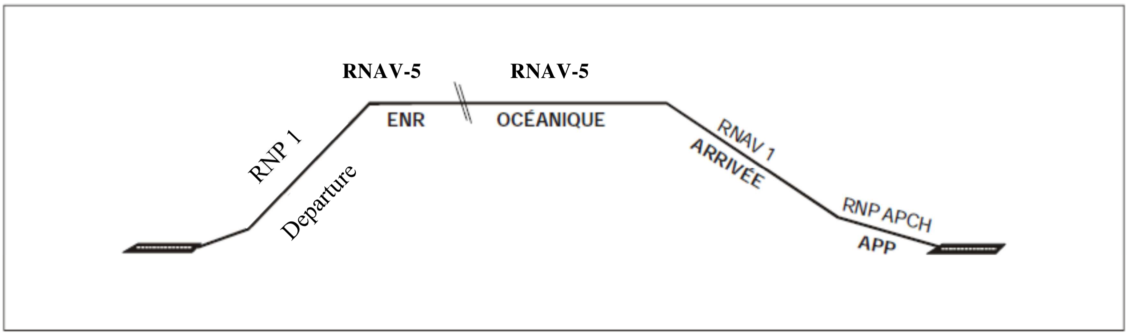
1. Although the A-RNP Nav Spec does not explicitly state FD/AP the RF appendix does and RF is a requirement for A-RNP
2. For Oceanic/Remote Continental operations dual independent LRNS (providing Higher Continuity) are required
3. Only when authorised by a specific State. Based on an available DME infrastructure and appropriate aircraft capability

5. Advantages of the PBN implementation

5.1 Safety:

The Implementation of PBN will improve safety by:

- Reduced risk of controlled flight into terrain (CFIT) due to the availability of vertical and horizontal guidance up to the runway.
- Reduced imprint of RNP AR APCH in high obstacles density areas.
- Reduced width of unidirectional ATS routes.



Example of an application of RNAV and RNP specifications to ATS routes and instrument procedures

5.2 Capacity:

In terms of capacity, the increased number of ATS routes leads to reduced congestion and independent RNAV SIDs and STARs can be executed simultaneously.

5.3 Effectiveness:

Reduces delays through effective designs of traffic flow, RNAV approach procedures, continuous descent approach(CDA) and the use of guidance on the interrupted approach segment in compliance with the preferred navigation specification.

5.4 Environment

In terms of environment, the benefits of PBN are:

- The raising of flyover heights and the reduction of the aerodynamic drag of aircraft contribute to the reduction of noise in the environment close to the runway.
- The reduction in the power delivered by the reactors and the number of change of regime makes it possible to significantly reduce the fuel consumption and the emissions of greenhouse gas effects.

5.5 Access

APV approaches can be performed using minimums close to those of ILS approaches on many runway ends in Morocco. The use advanced RNP specification combined with LPV approaches will improve access to airports in any weather condition.

6 Implementation of PBN operations in Morocco

6.1 Communications' infrastructure

6.1.1. Achievements

Very Small Aperture Terminal (VSAT):

Used for communication between the National Center for Aviation Safety and remote sites in areas where leased lines are not reliable or profitable. The national network includes 14 VSAT facilities: CMN, AGD, TAN, OJD AIRPORT, OJD MEG, JAD, SFI, IFR, MRK, ORZ, ALH, SMR, DKH, LAY.

Aeronautical Fixed Telecommunication Network (AFTN) and Aeronautical Message Handling System (AMHS):

The aeronautical messaging system is a critical support for exchanging information on flight planning; its main physical support is the AFTN

The AFTN was considered as an obsolete protocol and updated by the IP-based aeronautical message processing service (AMHS).

At the national level the AFTN is declassified and replaced by the AMHS.

Data exchange between ATS entities

Today, data communication between ATS entities is the OLDI system used for managing air traffic and relying on the ATN network which links Morocco's ACC to those at Canary, Seville and Lisbon.

Digital-Automatic Terminal Information Service (D-ATIS)

D-ATIS and D-VOLMET helps lessen controllers' workload in busy airspaces by providing automated means to rely aeronautical information to crews, mainly automated repetitive broadcasts containing wind shears and visibility condition

Two D-VOLMET are deployed at both: Agadir and Casablanca regional control centers and ten stations D-ATIS are installed at the following airports (Casablanca, Rabat, Fès, Marrakech, Oujda, Tanger, Agadir, Tetouan, Nador and Laayoune).

6.1.2. Prospects:

Very Small Aperture Terminal (VSAT)

More VSAT facilities are planned to enforce the existing network at the following sites:

- Tanger and Agadir Oufella for the year 2018.
- Merchich, Fès and Errachidia for the year 2019.

Aeronautical Fixed Telecommunication Network (AFTN) and Aeronautical Message Handling System (AMHS):

An OLDI link will be established with ALG.

The flight message transfer protocol (FMTP and OLDI over IP) Based on the IP protocol is the successor of OLDI (X25), was designed, standardized and implemented as a format for notification, coordination and transfer of flight messages.

Two links based on the AMHS protocol will be planned with Spain and Portugal control centers.

It is planned to install a new switching system AMHS at the Agadir regional control center.

Controller Pilot Data Link Communication (CPDLC)

CPDLC can contribute to reducing greatly the strain on communication channels by using text based messages to rely clearances and instructions from ATCOs to pilots; it may also reduce the controller's workload and the risk of miscommunication.

CPDLC is widely used for communication inside congested airspaces and future plans include introducing it in some of the busiest terminal areas.

Digital- Automatic Terminal Information Service (D-ATIS)

D-ATIS network will be extended to four other airports depending on traffic evolution.

6.2 Navigation infrastructure

The Navaid infrastructure in Morocco includes the following assets:

- 17 ILS ;
- 19 CVOR and 04 DVOR ;
- 41 DME; and
- 18 NDB scattered throughout the national

Navaids and landing systems

NAVAIDS / AIRPORT	CVOR /DVOR			DME			ILS			NDB		
	Mark	Freq(Mhz) Indicative	Date of comissionning	Mark	Canal Indicatif	Date of comissionning	Mark	Freq(Mhz) Indicative	Date of comissionning	Mark	Freq(Khz) Indicative	Date of comissionning
AGADIR AL MASSIRA	AMS 1150	117,2/ADM	Juil-06	AMS 1119/R	119X/ADM	Juil-06				TELERAD	396/ALS	1991
				SELEX 1118A/L	40X/ADA	Juin-09	SELEX 2100	110,3/ADA	Juin-09	TELERAD	402/AML	1991
AGADIR INEZGANE				SELEX 1118A/L	32X/AGI	Déc-07	SELEX 2100	109,5/AGI	Déc-07	SA 50	371/AZR	2000
AL HOCEIMA	SEL 4000	115,0/ALM	1986	SELEX 1119A/R	97X/ALM	2010				TELERAD	401/ALU	1992
BENSLIMANE	AMS 1150	117,45/BNS	Mars-06	AMS 1119/R	121Y/BNS	Mars-06				NAUTEL VR125	275/CAE	Mai-17
BENGUERIR	AMS 1150	115,40/BGR	Juin-09	SELEX 1119A/R	101X/BGR	Juin-09						
				SELEX 1118A/L	22X/BNG	Aout 2010	SELEX 2100	108,5/BNG	Aout 2010			
BENI MELLAL	INDRA/VRB-53D	113,10/BML	fev- 2014	INDRA/LDB-103	78X/BML	fev- 2014						
BOUAARFA	AMS 1150	117/BRF	Sept-06	AMS 1119/R	117X/BRF	Sept-06						
CASA MOHAMMED V				THOMSON 740/R	116X/CBA	1995				DTR 110	413 / SAK	Mai-13
										NAUTEL VR250	345/CSD	Avr-17
35R	TECSAT 0100	114,0/BRC	Mars-06	WILCOX 5960/R	87X/BRC	2001				SA50	255/NUA	1998
35L	SELEX 1150A	112,5/SLK	Août-10	SELEX 1119A/R	72X/SLK	Août-10				SA 50	282/NSR	Juin-03
35R/CAT III				THALES AN415/L	36X/INR	Nov-11	NORMARC 7000B	109,9/INR	Déc-15			
35L/CAT III				FERNAU 2020/L	44X/INL	2004	NORMARC 7000B	110,7/INL	2004			
17R/ CATII				SELEX 1118A/L	20X/CAS	Août-09	ILS SELEX 2100	108,3/CAS	Aout 2009			
DAKHLA	WILCOX 5850	115,8/DKH	Fev- 2001	THALES AN 435/R	105X/DKH	Nov-11						
				2020 MOOG FERNAU/L	28X/DKL	Juil-15	NORMARC 7000B	109,1/DKL	Juil-15			
ERRACHIDIA	THALES AN431	117,1/ERA	Nov-12	THOMSON 740/R	118X/ERA	Nov-93				NAUTEL VR125	293/KSR	Mai-17
				THOMSON 740/L	30X/ERR	Nov-93	WILCOX MK 10	109,3/ERR	Nov-93			
ESSAOUIRA	WILCOX 5850	112,7/ESS	1996	WILCOX 5960/R	74X/ESS	1996						
FES-SAISS	THALES AN431	115,7/FES	Nov-12	THALES AN 435/R	104X/FES	Oct-02						
				THALES AN 415/L	34X/LFA	Aout 2003	THALES AN420	109,7/LFA	Aout 2003	SA 50	315/FEZ	Mai-13
GUELMIM	TECSAT 0100	114,3/GLM	Févr-04	SELEX 1119A/R	90X/GLM	Juin-09						
				2020 MOOG FERNAU/L	42X/GUM	Juil-15	NORMARC 7000B	110,5/GUM	Juil-15			
IFRANE										NAUTEL VR125	409/IFN	Mai-17
LAAYOUNE	TECSAT 0100	112,1/LAY	Févr-04	THOMSON 740/R	58X/LAY	1995						
				THALES AN 415/L	44X/AUN	Mars-03	THALES AN420	110,7/AUN	Mars-03			
MARRAKECH	SEL 4000	113.3/MAK	1993	THOMSON 740/R	80X/MAK	1994				SA 50	267/CNZ	Févr-03
				FERNAU 2020/L	34X/MAR	2000	NORMARC 7000A	109,7/MAR	2000			
NADOR	INDRA/VRB-53D	116,0/ARI	Avr-17	INDRA/LDB-103	107X/ARI	Avr-17						
				INDRA/LDB-103	24X/TZN	Févr-16	NORMARC 7000B	108,7/TZN	Févr-16			
OUJDA QFU 06	THALES AN 431	117,5/OJD	Nov-11	THOMSON 740/R	122X/OJD	1995						
QFU 13	AMS 1150	115,65 VDO	Juil-09	SELEX 1119A/R	103Y/VDO	Juil-09						
QFU 06				THALES AN415/L	38X/ODA	Juil-13	THALES AN420	110,1/ODA	Juil-13			
QFU 13				SELEX 1118A/L	18X/ANG	Juil-09	SELEX 2100	108,1/ANG	Juil-09			
OUARZAZATE	TECSAT 0100	116,7/OZT	Mars-04	THOMSON 740/R	114X/OZT	1995				TELERAD	384/ORZ	1971
				FSD 40/L	40X/IRZ	1997	SEL 4000	110,3/IRZ	1997			
RABAT/SALE	INDRA/VRB-53D	116,5/RBT	Avr-17	INDRA/LDB-103	112X/RBT	Avr-17				SA50	332/SBI	1996
				SELEX 1118A/L	46X/ RS	Juil-09	SELEX 2100	110,9/RS	Juil-09			
TANGER	THALES AN 431	115,9/TNG	Nov-11	SELEX 1119A/R	106X/TNG	Nov-11				SA50	374/TAN	1998
				THALES AN415/L	30X/TAG	Juil-13	THALES AN420	109,3/TAG	Juil-13			
TAN-TAN	SEL 4000	112,3/TNN	1995	SELEX 1119A/R	70X/TNN	Juin-09				NAUTEL VR125	274/TNA	Juin-17
TETOUAN	INDRA/VRB-53D	117,3/TTN	Mai-17	INDRA/LDB-103	120X/TTN	Mai-17						
				THALES AN 415/L	38X/TTN	Févr-08	THALES AN420	110,1/TTN	Févr-08			
ZAGORA										DTR 110	420/FJA	Mai-13

6.3 Surveillance infrastructures

- *Mode S Secondary Radar (MSSR)*

The Mode S secondary radar facilities set up in Morocco are mainly used for En route surveillance.

- MSSR facilities and setup dates:

1. Casablanca1, Safi, Ifrane and Agadir (1994) : Initially mono-pulse secondary radars updated to mode S in 2001

2. Oujda, El Oualidia and Tan-Tan (2004): secondary radars MSSR Mode S

3. Casablanca (CRD), Marrakech and Tanger (2012): secondary radars MSSR mode S

- *Primary Radar (PSR)*

Primary Radars are mainly used for surveillance in the vicinity of airports for the purpose of approach and departure control.

- Facilities and setup dates:

1. Casablanca1, (1994)
2. Casablanca (CRD), Tanger and Marrakech (2012)
3. Fès setup in progress

- Automatic Dependent Surveillance – Broadcast (ADS-B)

ADS-B is used to complement the radar coverage in the southern part of Morocco. Ground receptors are already in place providing radar like coverage allowing the deployment of advanced ATM concepts in this area.

Facilities and deployment date:

Laayoune, Dakhla, Smara, Agadir, Marrakech, Fes, Tanger and Oujda.

6.4 Airspace management

En –route:

- Direct routes were implemented in partnership with SJU, NAV-Portugal and TAP as part of the AIRE project, a joint initiative of NEXTGEN and SESAR programs. These actions fit with the strategic priorities of the ICAO's environmental protection. The implemented routes are as follow:

  - ESP (LISBOA FIR) - ESS (CASABLANCA FIR)
  - ESS - ECHED
  - ESS – BULIS

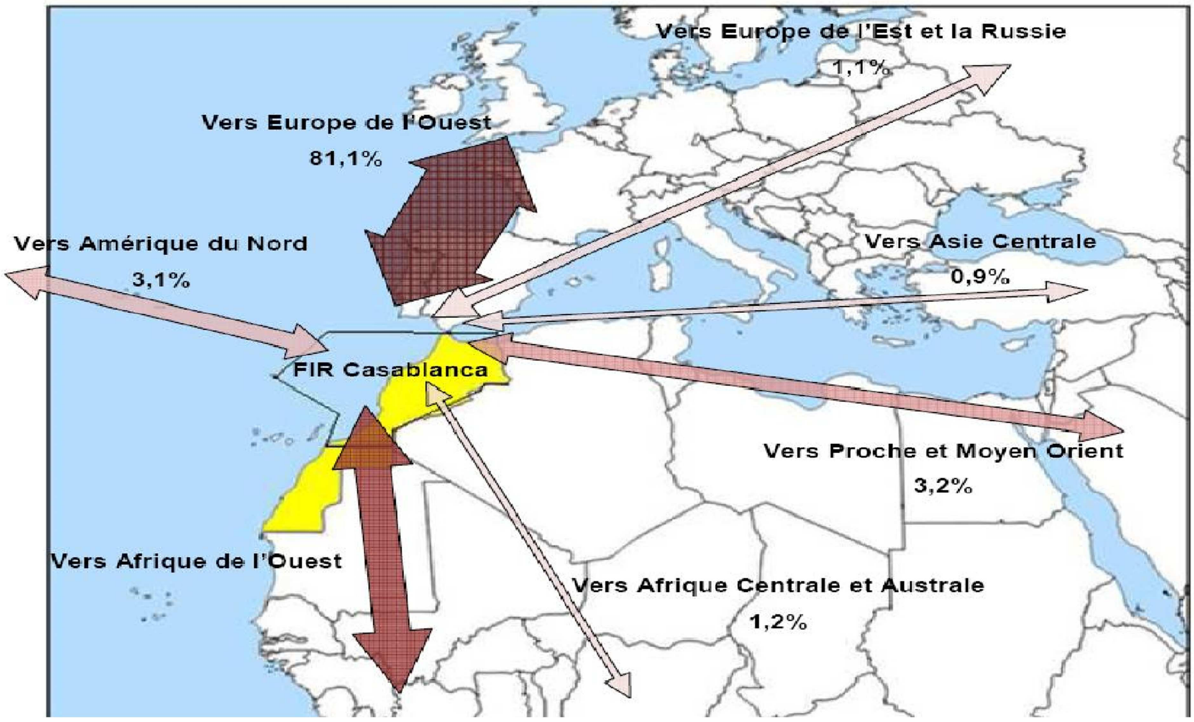
- A study for the reorganization of the Moroccan airspace named AERA-M was launched to establish and implement the business model best suited to meet the forecasted traffic demand in short, medium and long term (2012-2015-2020 and 2025). This study was set to be conducted in three phases:
  - Phase 1: Analyze the current airways structure and traffic evolution scenarios in short, medium and long term (2012-2015-2020 and 2025). 2018 has been taken into account in this analysis
  - Phase 2: Establish suggestions for the new airways network, sectors and classification of airspace and conduct safe case study.
  - Phase 3: Define the operational concept associated and develop a plan for implementation.
  - The following routes are classified as « RNAV-5 »: L 58, L 102, M 372, Q 401, Z 801, UL 58, UL 82, UL 102, UM 372, UM 999, UN 857, UN 858, UN 866, UN 869, UN 871, UN 873, UQ 401, UT 900, and UZ 801.

- **Approach and terminal area:**
  - RNAV-GNSS Approach procedures are published for the following airports: Tetouan, Ouarzazate, Oujda, Dakhla, Marrakech, Essaouira, Laayoune and Al-Hoceima.
  - SIDs and STARs RNAV are published for the following airports: Ouarzazate, Marrakech and Oujda.
  - Flight tests for CDA operation were conducted at Mohammed V Casablanca Airport.
  - LPV (APS-SBAS) procedure was tested at Al Hoceima and Tetouan airports.

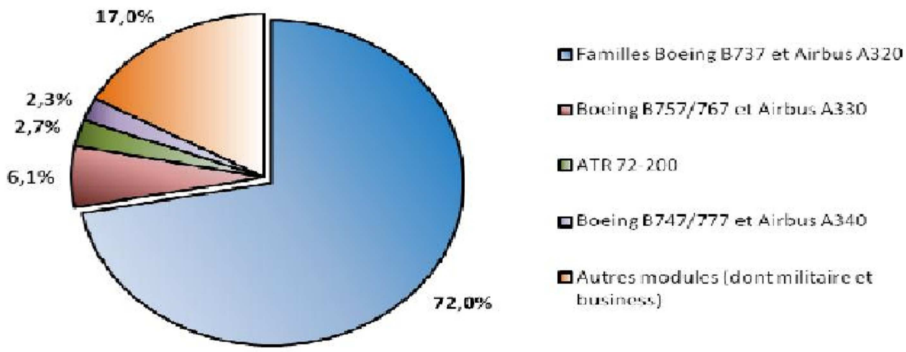
6.5 Air traffic flow

Casablanca FIR is experiencing an increase in air traffic volume. Major airways link Western Europe to Canary Islands.

The most common used aircraft types in the Moroccan FIR are the Boeing 737 and the Airbus A320 families particularly favored by Low-Cost air carriers.



International Moroccan air flows



Movements by type of aircraft

6.6 Implementation of PBN plan:

The following scheme is proposed for the implementation of PBN operations in Morocco. It establishes the working assumptions to be taken into account by all the stakeholders:

It is established over three phases:

- Short term (2013/2019) ;
- Medium term (2020/2023) ; and
- Long term (2024 and beyond).

a. Short term (2013/2019)

This phase is intended to be the first step in preparing full scale RNAV deployment and focuses on gathering the necessary means on technical and institutional levels to accommodate the upcoming changes:

- Establish a central workgroup that will be put in charge of defining the working hypotheses in partnership with major stakeholders,
- Continue the deployment of some PBN operations already started in Moroccan airspace, based on identified priorities

During this transition phase the navigation specification retained are as follow:

En-Route	• RNAV5 for all upper airspace • RNAV 5 for lower airspace (Some airways according to the criteria) • Free route for oceanic and west sectors.
Terminal	• RNAV1 or RNP 1 for airspace with TMAs.

Approach	• RNP APCH : ✓ BARO VNAV for runways not equipped with ILS or it is difficult to equip them in ILS and whose density of traffic is high. ✓ LNAV For all ends of instrument runways for aircraft with a maximum certificated take-off weight of 5700 kg or more. ✓ Reflection on RNP-AR-APCH. ✓ CCO, CDO for airports with TMAs, accommodating long-haul airplanes with a high traffic density.

En- Route

RNAV-5 routes have been in place within Moroccan airspace as early as 1998.

Terminal area

In the framework of a coordinated approach, Morocco has committed itself to the progressive implementation of RNAV1 trajectories in terminal control areas with radar surveillance.

The implementation of RNAV 1 trajectories should be extended progressively to all terminal areas in order to increase the operational benefits of users with RNAV 1

SIDs and STARs RNP 1 will be implemented at airports with limited or no surveillance, or the clientele is already adequately equipped and / or such modifications increase the efficiency of operations.

The following will be taken into account to establish a publishing plan for the upcoming years:

- Need to improve traffic flow ;

- Need to reduce environmental impact ;
- Equipment and needs of local users ;
- Phasing out of some navigation facilities and promoting the usage of RNAV-1 and RNP-1 instead.

To this end the PBN coordination comity must take into account feedback from airspace users, who will be invited to participate throughout the deployment of RNAV-1 and RNP-1 procedures.

Operational Benefits

RNAV-1 arrival and departure procedures should be designed to reduce low level flight distance and overall flight time through optimized flight profiles during landings and takeoffs. Users with RNAV 1 capability also benefit from time and fuel savings.

These trajectories RNAV 1 or RNP 1 will also improve the efficiency of the conduct of the descent and continuous climbing operations which make it possible to conduct the flight at the arrival or the departure of an aerodrome avoiding the bearings and reducing the Solicitation of engines

Streamlining of navaid facilities

These airspace restructurings will make it possible to evaluate the opportunity of maintaining certain navaids such as: NDB or VOR used only for en-route or terminal operations.

However, this process of rationalization must be weighed and the study will be carried out in coordination with the operators concerned.

The robustness of the replacement system will also determine the timing of alleviation of the radionavigation system network around a minimum system to be defined and to be developed in the light of the new available satellite navigation means and the published procedures.

Approach:

Progressive implementation of RNAV (GNSS)

GNSS based RNAV procedures are intended to be implemented for all runway ends before late 2019 at IFR controlled airfields. Some airfields will also benefit from procedures with vertical guidance (APV SBAS or APV Baro-VNAV).

The following will be taken into account to establish a publishing plan for the upcoming years

- Needs and equipment of local airspace users ;
- Need to improve safety (APV procedures to be deployed in airfields where no vertical guidance is available) ;
- Withdrawal of radio navigation aids ;
- Available data (recent surveys of obstacles in the vicinity of airfields) ;
- Category and equipment of a given runway.

The PBN comity is in charge of monitoring and acquiring feedback from users and designers.

During this phase consideration will be given to the implementation of RNP AR APCH procedures at airfields where complex operational environment is present.

Benefits and limitations of APV Baro-VNAV procedures

Today, most major aircraft manufacturers namely Boeing and airbus equip their aircrafts with APV Baro-VNAV capable avionics. These procedures will be implemented primarily in airports where commercial airliners have the biggest share of traffic volume.

Although these approaches have vertical guidance they do not reach the accuracy of ILS systems and will be activated as backups during maintenance or failures of the ILS. The decision height (DH) associated with these procedures can be as low as 250ft above threshold level and can thus be applied to improve safety on runways where no ILS equipment is available.

Also some CAT I ILS procedures could be replaced by an APV one. These changes must be conducted taking into account the following factors:

- environment (obstacles) ;
- Frequent users’ equipment ;
- Profitability (traffic volume justifying the investments) ;
- Existence of a delegation or public service obligation ;
- Existence of special activity (pilot training…);

b. Medium term (2020/2023)

In this second phase the PBN comity must assess and consolidate the choices and assumptions of the initial phase. The main aim is to continue the upgrade process by introducing even more RNAV procedures and implementing more accurate navigation specifications.

Different navigation specifications to be considered during this phase are as follow:

En route	• Advanced RNP (Some airways according to criteria) • RNAV 2
Terminal	• RNAV2 • RNP 1 • RNAV 1 • And Reflections on the application of Advanced RNP
Approach	• RNP-APCH • BARO VNAV (Achievement) • RNP AR APCH (To improve access to airports surrounded by Obstacles, to avoid areas with special status and close to the FIRs adjacent)

The following assumptions above will be gradually adjusted to comply with international practices.

En- Route:

The use of upper airspace specifications should be studied as needed on a per-case basis.

Special attention will be given to the question of using future advanced RNP for upper airspace routes in the attempt to reduce routes spacing.

Terminal area: Widespread deployment of RNAV-1 and RNP-1

To increase the flow of traffic through a larger number of independent paths, the deployment of RNAV-1 has to be generalized in all terminal areas as the number of equipped airplanes is expected to reach the threshold for operational application by the start of this phase.
These actions will also be accompanied by an increased deployment of Continuous Descent and Climb operations (CDO and CCO).
Finally, the usage of advanced RNP and features such as Constant Radius Turn RF could offer new design solutions in complex TMA environments.

Radio Navigation Facilities streamlining in terminal areas:

Thanks to the widespread deployment of RNAV 1 procedures and an increasing fleet equipment rate, this phase should lead to the establishment of a first reduced network of radionavigation means used for en-route or terminal areas, and usable as a backup of GNSS.

This network should rely mainly on the DME and VOR

The gradual establishment of this reduced network will be monitored by the PBN coordination committee in consultation with the main air operators concerned

Approach

This phase should conclude the implementation of RNAV (GNSS) procedures for all runways ends with increased number of APV procedures used by aircrafts equipped with SBAS or Baro-VNAV enabled avionics.

New RNP AR APCH procedures will be eventually deployed at airfields with complex operational environments.

Landing systems streamlining

As in the case of the means used for en-route or terminal operations, this phase should lead to the establishment of a first reduced network of radionavigation means used for the approach (ILS cat I VOR And NDB), at least in the case of controlled IFR aerodromes.

The gradual introduction of this reduced network will be monitored by the coordinating committee within the framework of the governance of the PBN plan

c. Long term (2024 and beyond)

The third phase will be characterized by the deployment of the IR PBN as the regulatory framework for all mandatory specification, equipment and operational constrains.

En-route	• Advanced RNP (continuity) • Free route for all upper airspace
Terminal	• RNAV1 • RNP1 • Advanced RNP
Approach	• SBAS • GBAS • Advanced RNP • RNP-AR-APCH

Acronyms:

ABAS: Aircraft Based Augmentation System

APV: Approach with vertical guidance

ATM: Air Traffic Management

ATIS: Automatic Terminal Information Service

CCO: Continuous Climb Operation

CDO: Continuous Descent Operation

CPDLC: Controller Pilot Data Link Communication

CVOR: Conventional Very High Frequency Omni-directional Radio Beacon

DVOR: Doppler Very High Frequency Omni-directional Radio Beacon

DA: Decision Altitude

D-ATIS: Digital-Automatic Terminal Information Service

DH: Decision Height

DME: Distance Measuring Equipment

DCPC: Direct Controller Pilot Communication

GBAS: Ground Based Augmentation System

GNSS: Global Navigation Satellite System

ILS: Instrument Landing System

IFR: Instrument Flight rules

INS: Inertial Navigation System

IRU: Inertial Reference Unit

LNAV: Lateral Navigation

LOC: Localizer

LPV: Localizer Performance with Vertical guidance

NDB: Non Directional Beacon

NM: Nautical Mile

NOTAM: NoTice for Air Men

NPA: Non Precision Approach

ICAO: International Civil Aviation Organization

PBN: Performance Based Navigation

PinS: Point-in-Space

RF: Radius to Fix

RNAV: Area Navigation

RNP: Required Navigation Performance

RNP AR: RNP with Required Authorization

SBAS: Satellite Based Augmentation System

SID: Standard Instrument Departure

STAR: Standard Terminal Arrival Route

TMA: Terminal Maneuvering Area

VNAV: Vertical Navigation

VOR: Very High Frequency Omni-directional Radio Beacon

WGS 84: World Geodetic System 1984