



**INTERNATIONAL CIVIL AVIATION ORGANIZATION**

*A United Nations Specialized Agency*

# **PERFORMANCE BASED NAVIGATION (PBN) IMPLEMENTATION PROJECT**

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RO ATM/SAR

International Civil Aviation Organization



## **INTERNATIONAL CIVIL AVIATION ORGANIZATION**

*A United Nations Specialized Agency*

### **AGENDA**

- Assembly Resolution A37-11
- 4<sup>th</sup> edition of the Global Air Navigation Plan
- Aviation System Block Upgrades (ASBU), regional perspective
- Regional performance based air navigation implementation plan (RPB-ANIP)
- Implementation of performance based navigation (PBN)
- Regional PBN Progress
- Global & Regional report

# A37-11;



1. *Urges* all States to implement RNAV and RNP 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:
  - a) States complete a PBN implementation plan as a matter of urgency to achieve:
    1. implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones; and
    2. 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**; and
    3. 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;
  - b) ICAO develop a coordinated action plan to assist States in the implementation of PBN and to ensure development and/or maintenance of globally harmonized SARPs, Procedures for Air Navigation Services (PANS) and guidance material including a global harmonized safety assessment methodology to keep pace with operational demands;
3. *Urges* that States include in their PBN implementation plan provisions for implementation of approach procedures with vertical guidance (APV) to all runway end serving aircraft with a maximum certificated take-off mass of 5 700 kg or more, according to established timelines and intermediate milestones

# GANP (DOC 9750)

## GANP History

Appendix to FANS Report, 1992

Doc 9750 Edition 1, 1998

Doc 9750 Edition 2, 2001

Doc 9750 Edition 3, 2006

Doc 9854, 2005  
Global ATM Operational Concept

Doc 9882, 2008  
ATM System Requirements

Doc 9883, 2008  
Global Performance Manual

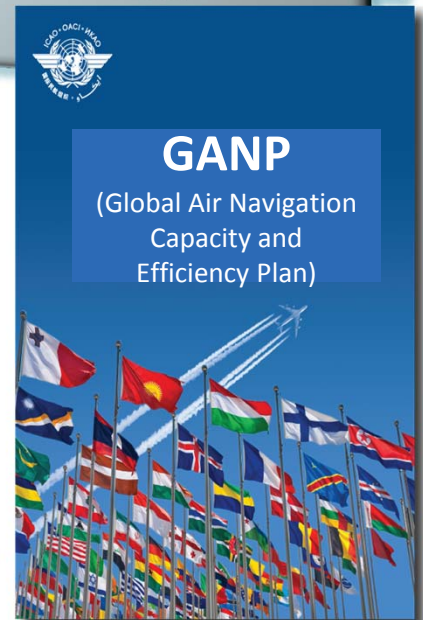
## Related documents

Addresses ANSP, Regulatory and User requirements

Includes ASBU Methodology

Encompasses Performance Framework

Doc 9750  
Global Air Navigation Plan, Edition 4  
2014-16



# ASBU: New National/Regional Plans - interoperability challenges



- Air traffic growth expands rapidly every 15 years
- Growth can be a double-edged sword. Challenge is how to achieve both safety and operational improvements
- The 37<sup>th</sup> session of ICAO General Assembly advised to redouble our efforts with focus on ensuring interoperability of systems while at the same time maintaining or enhancing aviation safety.



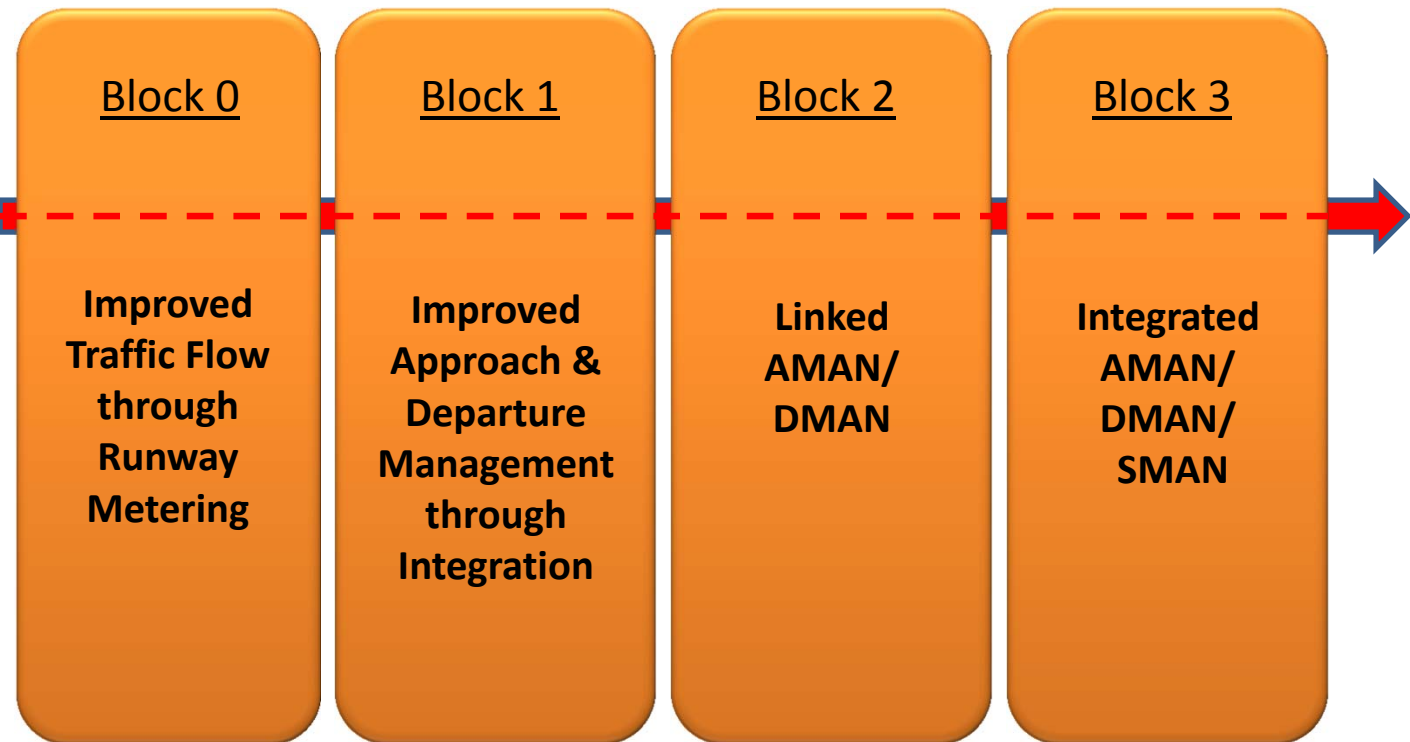
**Many Regional and National ATM modernization programmes are being developed worldwide**

- They are following ICAO's Global Air Navigation Plan and Operational Concept, but nevertheless they are different in their own way
- thus resulting in interoperability challenges

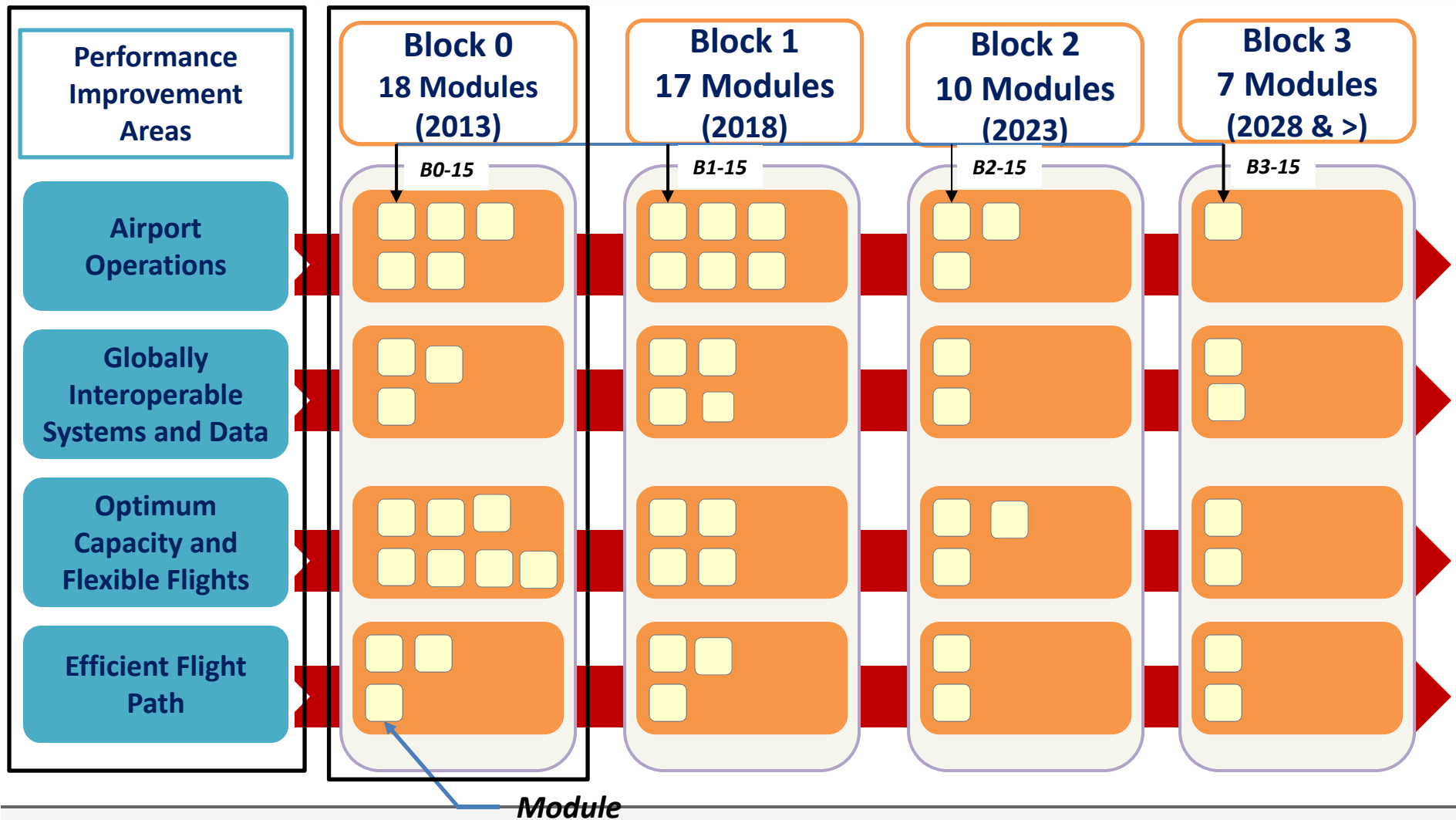
# Threads Between Modules... and Across Blocks



## Airport Operations



# ASBU: Understanding the Relationships

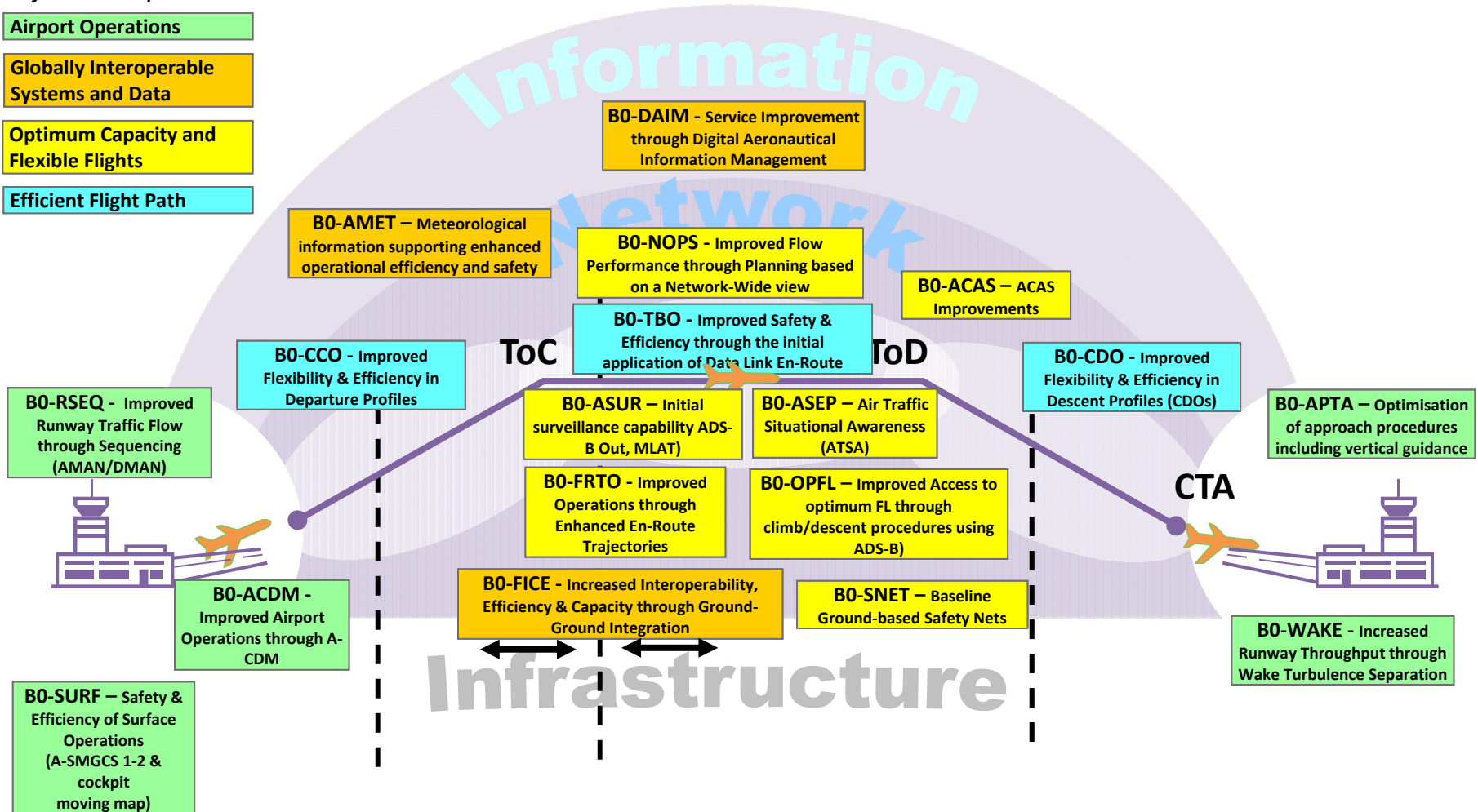


# ASBU Block 0 in Perspective



## Performance Improvement Areas

- Airport Operations
- Globally Interoperable Systems and Data
- Optimum Capacity and Flexible Flights
- Efficient Flight Path





# Block 0: Priority



- ✈️ Block 0 initiatives must leverage on existing on-board avionics
- ✈️ 3 Priorities have been agreed to by the Global community:
  - ✈️ Performance Based Navigation (PBN)
  - ✈️ Continuous Descent Operations (CDO)
  - ✈️ Continuous Climb Operations (CCO)



- Block 0 risks are minimum
  - Global Readiness Checklist is complete
  - The Modules are well understood and supported
- States need to ensure successful deployment of Block 0
  - If Block 0 is not implemented as a foundation, certain functionalities may not be available as enablers for future blocks
- Identify and resolve policies necessary to enable the future blocks now

# PBN Tools



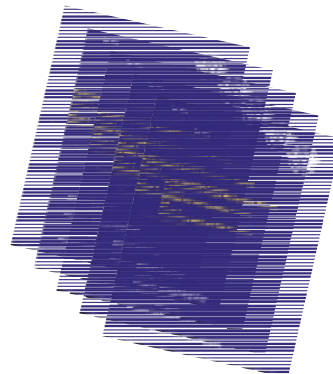
✈️ Global agreement on PBN

✈️ Complete ICAO tools



Annexes

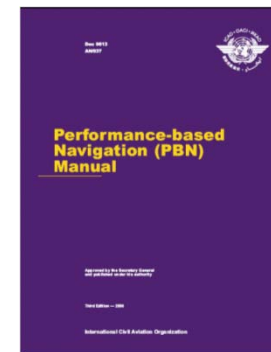
Guidance Material



Doc 9613 Manual  
PBN

Volumen I  
Parte A - Airspace  
Concept  
Parte B –  
Implementation  
Processes

Volumen II –  
Navigation  
Specifications



- ✈️ ICAO Doc 8168, PANS-OPS Vol II
- ✈️ Doc 9906, Vol I, FPD QA System
  - ✈️ Vol 2, FDP Training
  - ✈️ Vol 3, FPD Software validation
  - ✈️ Vol 5, Validation of FPD
  - ✈️ Vol 6, Flight validation, Pilot Training and evaluation
- ✈️ Doc 9905, RNP AR Procedure Design Manual
- ✈️ Doc 9902, PBN in Airspace Design
- ✈️ Doc 9933, CCO Manual
- ✈️ Doc 9931, CDO Manual

# NAM/CAR RPB-ANIP



- ✈️ Introduction
- ✈️ **Chp. 1** Traffic Growth and distribution in NAM/CAR regions
- ✈️ **Chp. 2** Aviation System Block Upgrades (ASBU) - B0
  - ✈️ Performance Improvement Area (PIA) Air Navigation Report Forms (ANRF)
- ✈️ **Chp. 3** – Regional Performance Objectives (RPOs)



# Relationship RPOs with modules of Bloque 0

ASBU RPO	PIA1 Airport Operations					PIA2 SWIM			PIA3 Global Collaborative ATM							PIA4 Trajectory-based Operations		
	B01 5 RSE Q	B065 APTA	B070 WAKE	B075 SURF	B080 ACDM	B025 FICE	B030 DAIM	B0105 AMET	B010 FRTO	B035 NOPS	B084 ASUR	B085 ASEP	B086 OPFL	B0101 ACAS	B102 SNET	B005 CDO	B020 CCO	B040 TBO
PBN Implementation		X							X							X	X	
Implement FUA									X									
Improve DCB	X									X								
ATM Situational Awareness	X			X							X			X	X			X
Improve Cap/Efficiency Aerodrome Operations				X	X													
Optimization of COM infrastructure					X	X												X
Implement AIM							X											
Improve MET information								X										
Improve SAR																		

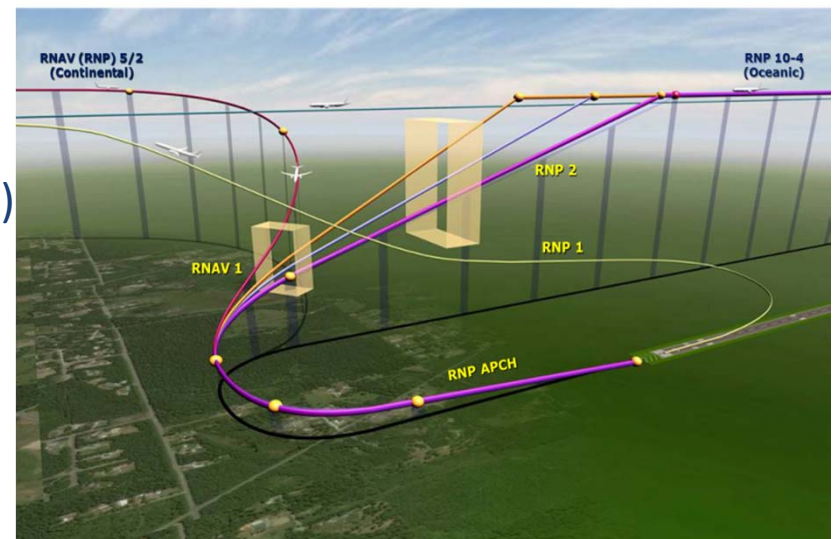
RPO completed: RPO5 New ICAO Flight Plan model implementation

RPO merged into other RPO: RPO on WGS-eTOD implementation and RPO on WRC- State support and best use of radiofrequency spectrum

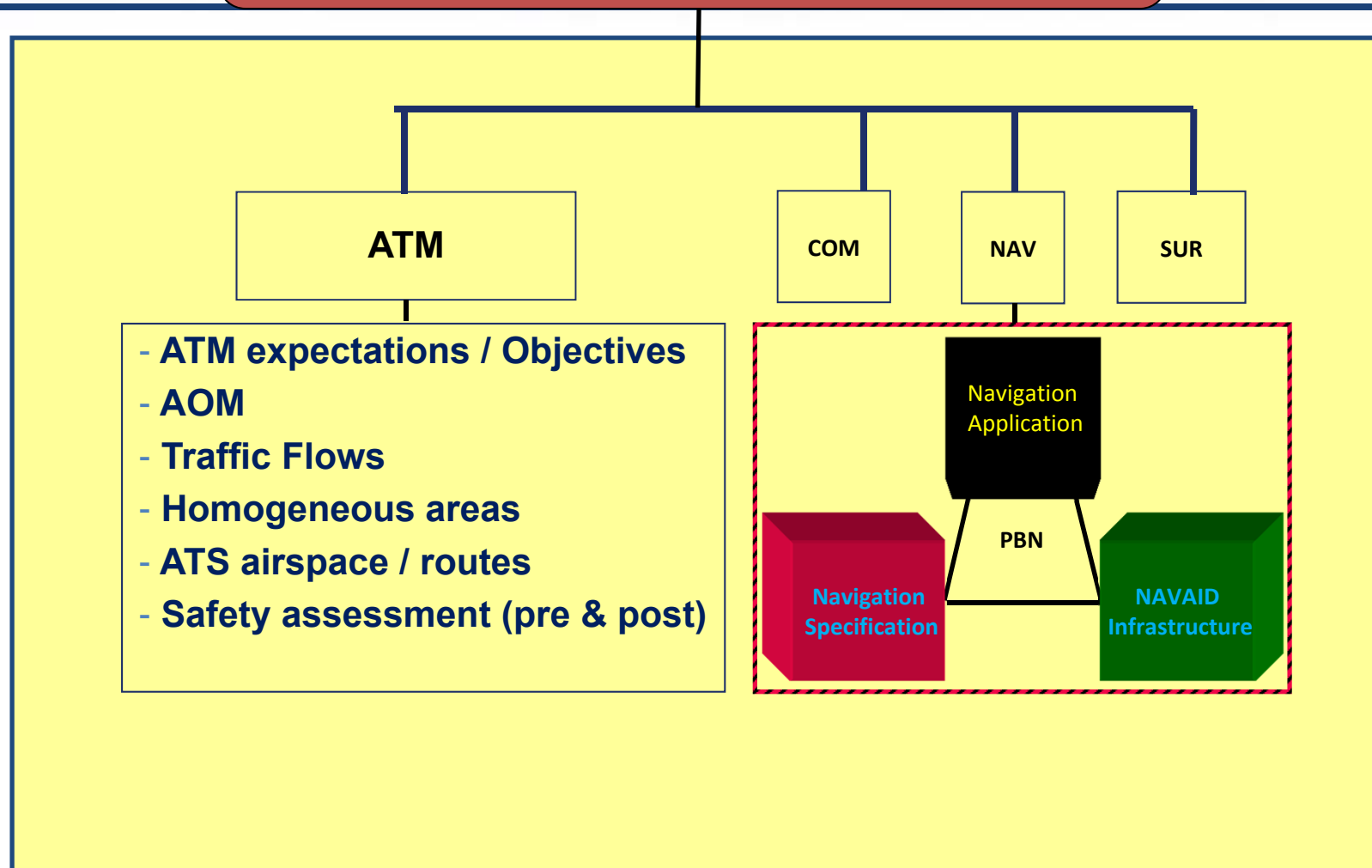
# PBN Airspace Concept implementation (Annex 11, Doc 4444, Doc 9613)



- Airspace and Organization Management (AOM) Workshops planned for 2013-2015
  - Emerging ATC training techniques – Improve ATS Capacity
  - PBN Operational Approval (Doc 9997)
  - PBN Approach Procedures Design (Doc 8168, Doc 9905)
  - Safety Assessment (Doc 9859)
  
- Comprehensive PBN Airspace Concept redesign for en-route and TMAs airspace in CAR Region (Doc 9992)
  - 7 State projects ongoing
  
- Continuous Descent Operations /CDO (Doc 9931)
  - STARS
  - Potential benefit of 250 kg fuel per arrival
  
- Continuous Climb Operation /CCO (Doc 9933)
  - SIDs



## PBN AIRSPACE CONCEPT



# Airspace Concept

Assumptions: CNS/ATM/Traffic/RWY/MET

Inter-centre letters  
of Agreement

**Airspace  
Design:**

**Routes; Volumes;  
Sectors.**

Traffic assignment  
[incl. regulation]

Special techniques:  
CDA; Point Merge

*Flexible Use of Airspace*

*Airspace Classification*

# Airspace Concept

**Airspace Design:  
particularly  
Routes and  
IFPs**

## Conventional Navigation

**Airspace Design** based on assumptions that all aircraft equipped with NDB/VOR and/or DME and airspace designed

## RNAV (pre-PBN)

**Airspace Design** based on assumptions that 'RNAV equipped' aircraft can use RNAV routes. Exceptionally, Nav Spec required e.g. RNP 4.

## PBN

**Airspace Design** must in all cases match....

(a)  
**Aircraft fleet capability** which must match...

(b)  
An ICAO PBN +  
Navigation Specification

(c)  
... and available  
NAVAID Infrastructure



# PBN Airspace Concept, CAR Region



Stage	Operational improvement
<b>Stage I</b> (2010 2011)	<u>Review of ATS route network in the CAR Region</u> <ul style="list-style-type: none"> <li>• Gathering data on aircraft PBN capacity</li> <li>• Review of CNS infrastructure</li> <li>• Realignment and implementation of new RNAV routes in the upper airspace based on RNAV 5</li> <li>• Implementation of RNAV routes in the lower airspace based on RNAV 1, RNAV 2 and RNP 1, as required</li> <li>• Implementation of PBN approach procedures in accordance with Assembly Resolution A37-11</li> </ul>
<b>Stage II</b> (2011 2012)	<u>Review and interface of the ATS routes network in the CAR/SAM Regions</u> <ul style="list-style-type: none"> <li>• Realignment and implementation of new RNAV routes in the interface of the upper airspace between the CAR and SAM Regions, based on RNAV 5 or RNAV 2, as applicable</li> <li>• Implementation of CDO in international airports, as required</li> </ul>
<b>Stage III</b> (2012 2014)	<ul style="list-style-type: none"> <li>• Elimination of conventional ATS routes in the upper and lower airspace, as required</li> <li>• Implementation of random routes, by airspace altitude stratum</li> <li>• Review of the upper airspace configuration</li> <li>• Review of the lower airspace configuration</li> <li>• Implementation of flexible use of airspace (FUA)</li> <li>• Implementation of dynamic ATS route management</li> </ul>

# Air Navigation Reporting



## PROCESS

- PIRGs are progressing with planning and implementation of ASBUs
- The next step calls for an air navigation performance measurement, monitoring and reporting strategy.
- Methodology for reporting
  - States to send data to RO through Air Navigation Report Form (ANRF) or equivalent form/on ongoing basis
  - RO will consolidate data from all States and publish through Regional Performance Dashboard /on ongoing basis
  - HQ will consolidate data from all ROs and publish Global Air Navigation Report/annually

- The current Performance Framework Form (PFF) has been redesigned and aligned with ASBU framework and called the Air Navigation Report Form (ANRF)
- ANRF will be the basis for performance reporting of the ASBU implementation
- The ANRF templates for all the 18 Modules of ASBU Block 0 will be available in the upcoming Regional eANP.

# Regional Reporting

## Regional Performance Dashboard



Transparency and sharing of information are fundamental to a safe and efficient global air transportation system.



ICAO is introducing “Regional ‘Performance Dashboard’ - the homepages for every public website of the ICAO Regional Offices.

- These dashboards will illustrate the regional implementation status relating to the strategic objectives on Safety, Air Navigation Capacity and Efficiency, and Environmental Protection.
- The Dashboard will show targeted performance at the regional level and will, initially, contain graphics and maps with a planned expansion to include the Aviation System Block upgrades (ASBU) Block 0 Modules.
- This new interactive online system will be in place for March 2014 for the all ICAO regions and will be updated at regular intervals.
- Dashboard will be user friendly and able to deliver the message at glance.

# The Safety and AN System

## A Better Way for the Future?



**GLOBAL PLANS**

**Pending Council Approval**



*Feedback loop for continuous improvement*

**GLOBAL PERFORMANCE REPORTS**

**Available**      **April 2014**

**Outlines Global Priorities and Targets**  
*Reviewed by ANC; Approved by Council  
 Endorsed by Assembly*

**REGIONAL PERFORMANCE DASHBOARDS**

**Africa – Aug 2013**  
**All Regions - Mar 2014**

**Reporting against Global Priorities**  
*Global Reports (online) Annually  
 Special Version (print) for Assembly*

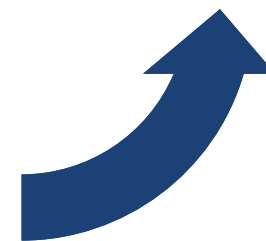
**PIRG-RASG** agreed to establish by certain dates:

**Safety**  
*(As soon as possible)*

**Air Navigation**  
*(May 2014)*



**Adopts Global Priorities, sets additional as needed**  
**Used by PIRGs and RASGs to Measure Performance**  
*Regional Office Updates Dashboard (online) semiannually*



# Regional Performance Dashboard Indicators/metrics for Air Navigation



## AIR NAVIGATION

### Metrics

- PBN TERMINAL**  
*% of international aerodromes with APV*
- PBN ENROUTE**  
*% of PBN routes/airspaces*
- CDO**  
*% of international aerodromes/TMAs with CDO*
- CCO**  
*% of international aerodromes/TMAs with CCO*
- Estimated Fuel Savings/ CO2 Emissions Reduction Based on IFSET**
- ATFM**  
*% of ATS Units/international aerodromes providing ATFM service*
- AIM**  
*% of needed elements (from AIS to AIM Roadmap) facilitating the transition from AIS to AIM that have been implemented – PHASE I*



# Annual Global Air Navigation Report

## An initial dataset



This initial dataset for both Regional Performance Dashboard and the Global Air Navigation Report was recently agreed by the PIRG Chairs in a coordination meeting held on 19 March 2013



- 1. Performance Based Navigation (PBN) - Terminal**  
*% of international aerodromes with APV*
- 2. Performance Based Navigation (PBN) - Enroute**  
*% of PBN routes/airspace*
- 3. Continuous Descent Operations (CDO)**  
*% of international aerodromes/TMAs with CDO*
- 4. Continuous Climb Operations (CCO)**  
*% of international aerodromes/TMAs with CCO*
- 5. Estimated Fuel Savings/ CO2 Emissions Reduction Based on IFSET**
- 6. Air Traffic Flow Management (ATFM)**  
*% of ATS Units/international aerodromes providing ATFM service*
- 7. Aeronautical Information Management (AIM)**  
*% of needed elements (from AIS to AIM Roadmap) facilitating the transition from AIS to AIM that have been implemented – PHASE I*

# PBN implementation progress



## 100% NAM/CAR PBN implementation action plans

### EN-ROUTE

- ✈️ RNP 10 and random RNAV routes have been implemented in WATRS oceanic airspace, the Gulf of Mexico, and the Houston and Miami Oceanic FIRs.
- ✈️ Random RNAV routes have been also implemented in the Piarco FIR.
- ✈️ RNAV 5 routes in the upper continental airspace.

### TMA

- ✈️ 60% of international airports have implemented SIDs/STARs with PBN navigation specifications and continuous descent and climb operations (CDO/CCO) criteria.

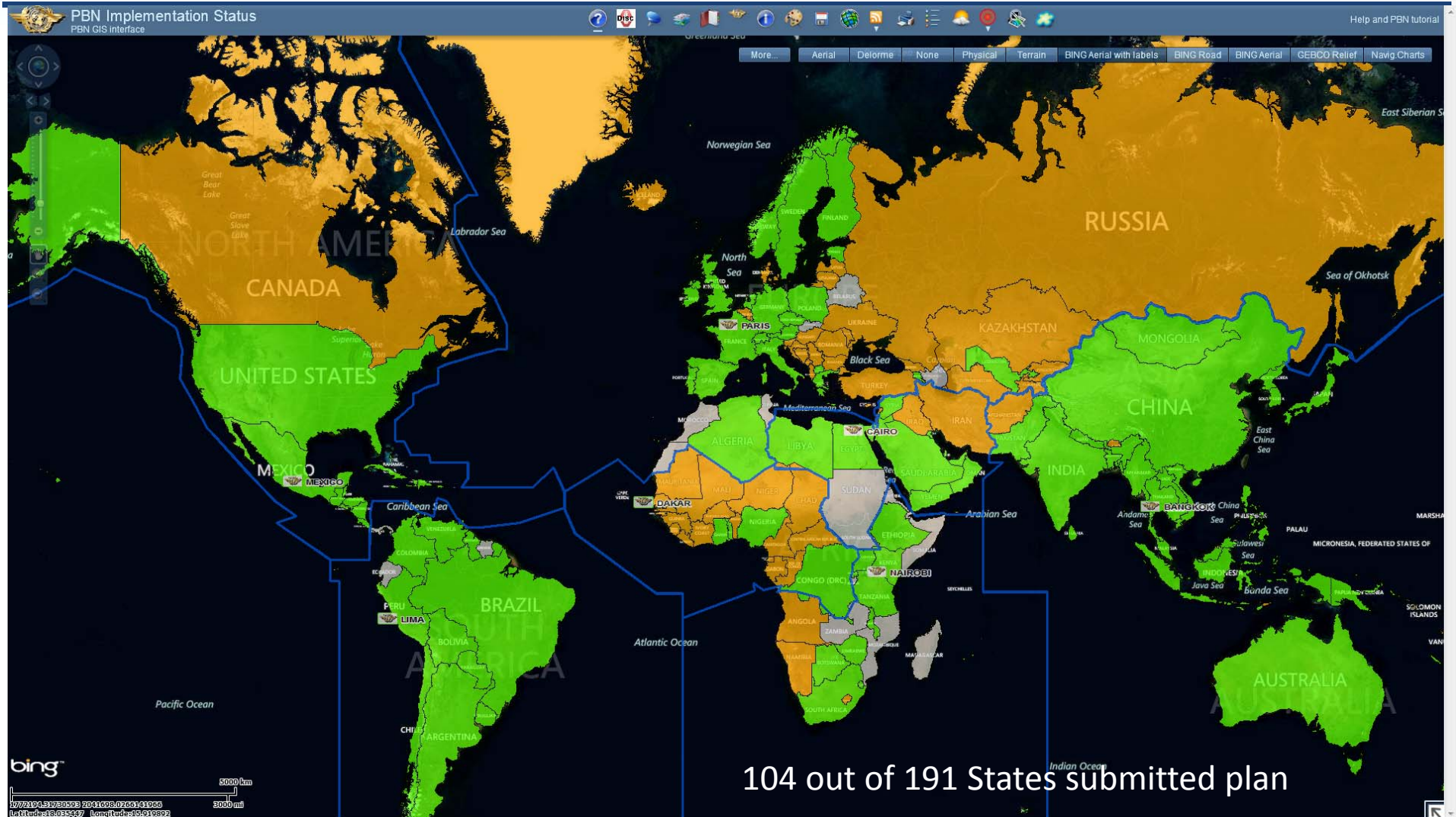
### Approach Procedures (A37-11 = 30% by 2010, 70 % by 2014)

- ✈️ 60% of aerodromes have instrument approach procedures with vertical guidance (APV), (BARO-VNAV and/or GNSS augmentation) whether as primary approach or as support to precision approaches.

### BENEFITS

- ✈️ States use the IFSET electronic tool to report estimated fuel savings resulting from operational improvements.
  - ✈️ In January 2013 of RNP 10 implementation in the upper airspace of the Gulf of Mexico indicates total fuel savings of 712,066 kg, resulting in cost savings of approximately \$1,491,807 per month.

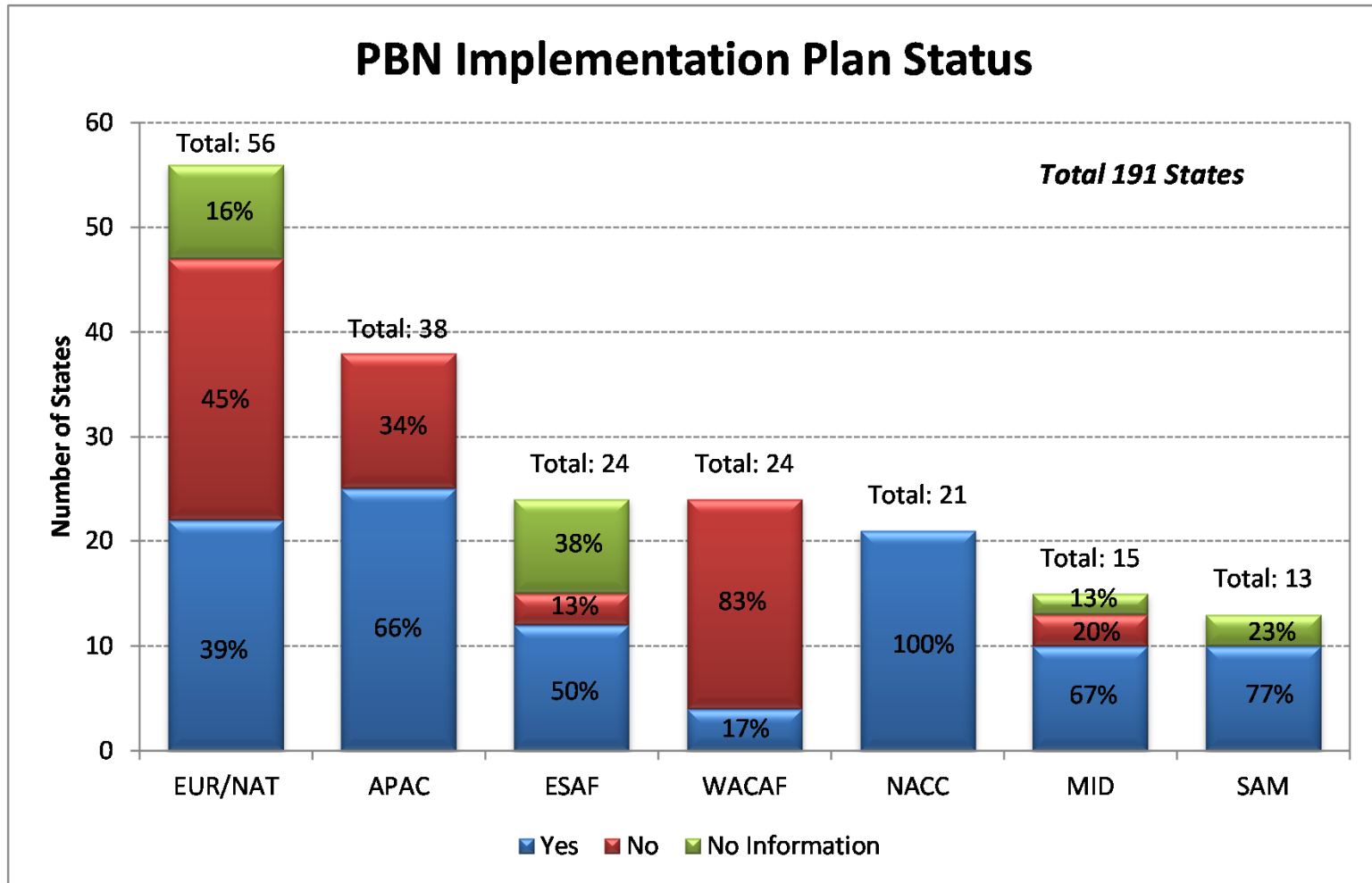
# PBN Implementation Plans



104 out of 191 States submitted plan



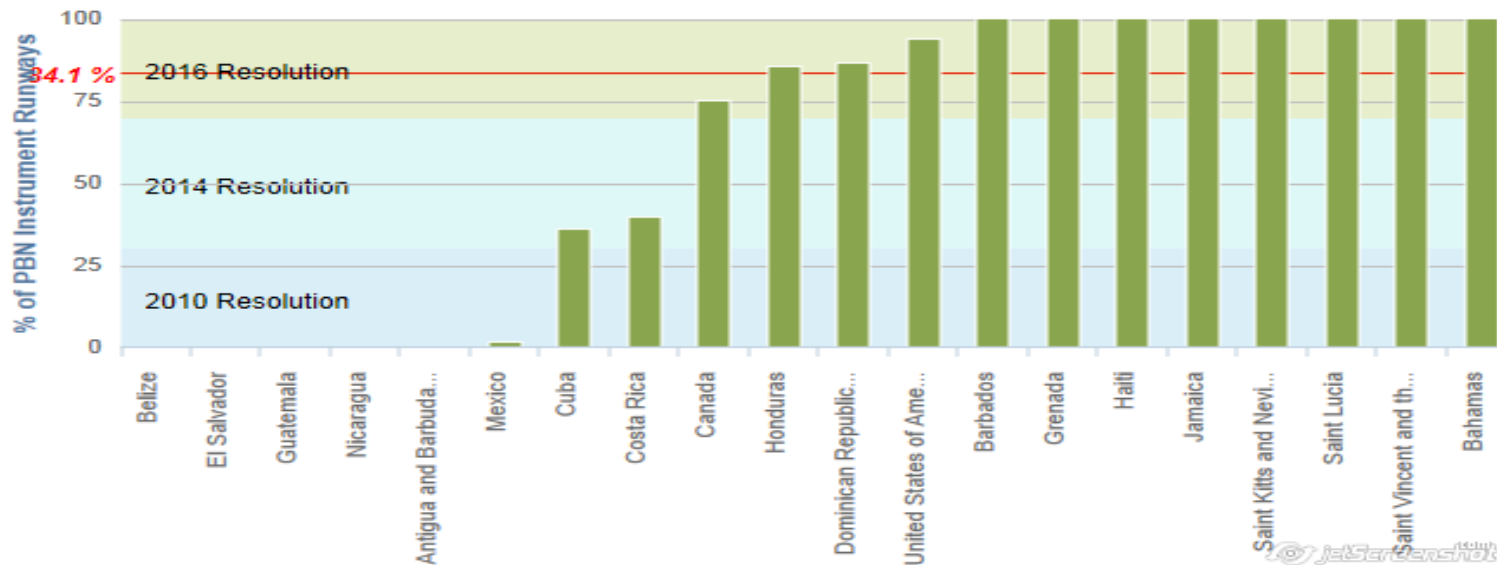
# Planes de Implementacion PBN, presentados a la OACI



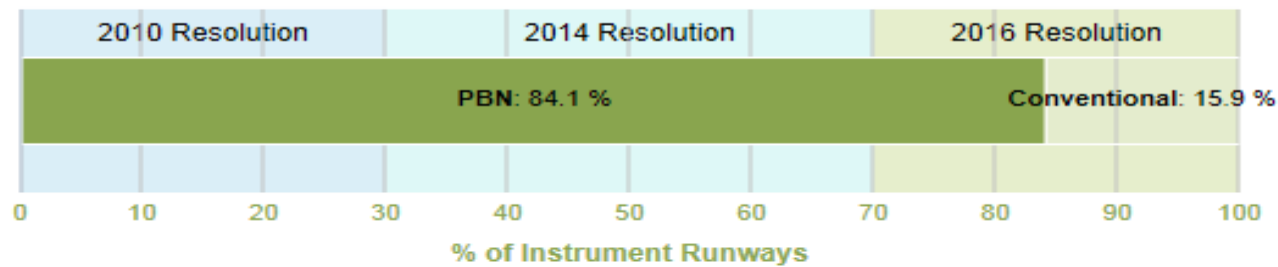
# PBN Implementation



Regional PBN Implementation  
% of PBN Runways per Country for NACC



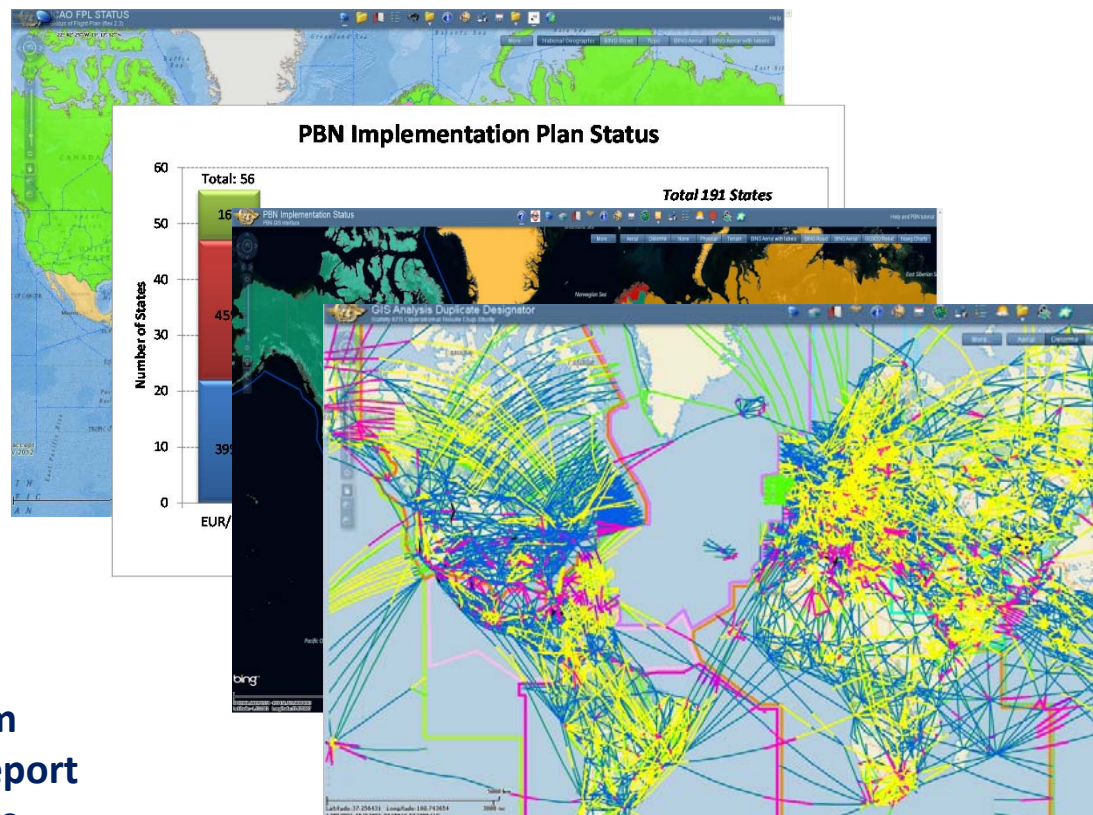
PBN RWYs vs CONVENTIONAL RWYs  
% of Runways for NACC



# Annual Report (ANRF): 2014



- Performance Monitoring
  - of individual modules
  - Air Navigation Report Form
- Annual Global Air Navigation Report
- Compare progress across regions
- Adjust ICAO work programme



# What`s next?



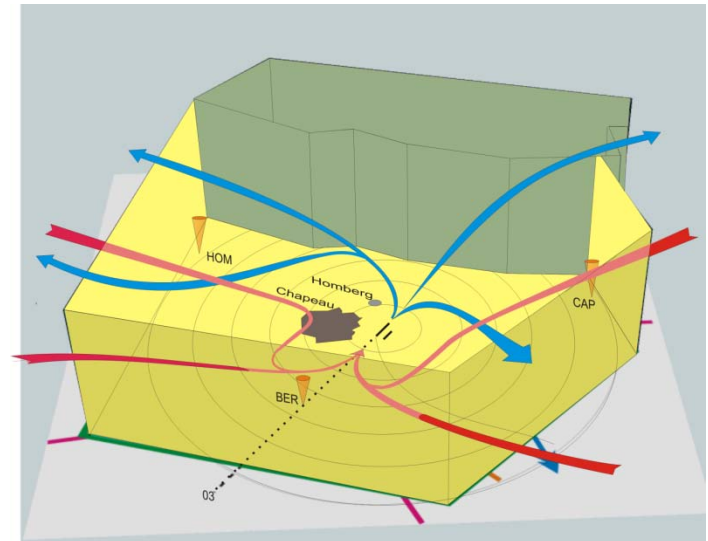
## PBN Airspace Design

PLAN

DESIGN

VALIDATE

IMPLEMENT



### 7 Projects

- Costa Rica, El Salvador, Honduras, Jamaica, Mexico, Trinidad and Tobago, Turks & Caicos, COCESNA

# PBN Multidisciplinary Team



✈️ Lead by ATM / airspace specialist

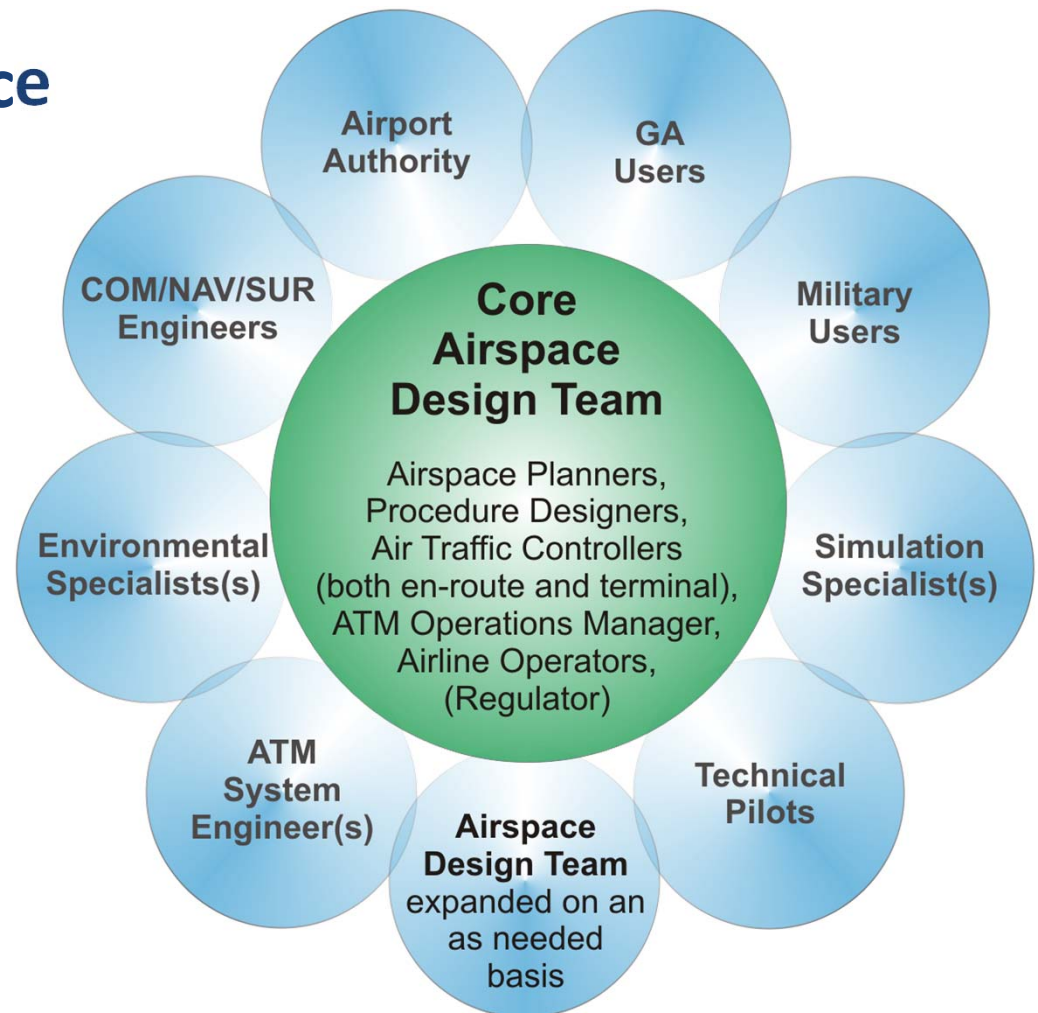
✈️ ATCOs (Air Traffic controllers)

✈️ ATM & CNS specialist

✈️ Procedure designers

✈️ Technical pilots

✈️ .....





North American  
Central American  
and Caribbean  
(NACC) Office  
Mexico City

South American  
(SAM) Office  
Lima

**ICAO  
Headquarters  
Montreal**

Western and  
Central African  
(WACAF) Office  
Dakar

European and  
North Atlantic  
(EUR/NAT) Office  
Paris

Middle East  
(MID) Office  
Cairo

Eastern and  
Southern African  
(ESAF) Office  
Nairobi

Asia and Pacific  
(APAC) Office  
Bangkok

**Thank You**