ICAO CAPACITY & EFFICIENCY

ICAO SARPs and Documentation on Navigation Infrastructure to Support PBN

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Workshop for the Implementation of Navigation Infrastructure to Support PBN and GNSS Precision Approach Operations in NAM/CAR/SAM regions, 15 -17 August 2016, Lima, Peru

Outline

- **Assembly Resolution 37-11**
- **Global Air Navigation Plan (GANP)**
- **PBN Documentation Framework**
- **NAV Infrastructure Specification Documentation to Support PBN**

Why PBN? A37-11

Approach procedures with vertical guidance (APV (Baro-VNAV) including LNAV-only minima for all instrument runway ends by **2016**

*Time is running out to meet the Performance-based Navigation (PBN) objectives of **A37-11***

Global Air Navigation Plan (GANP)

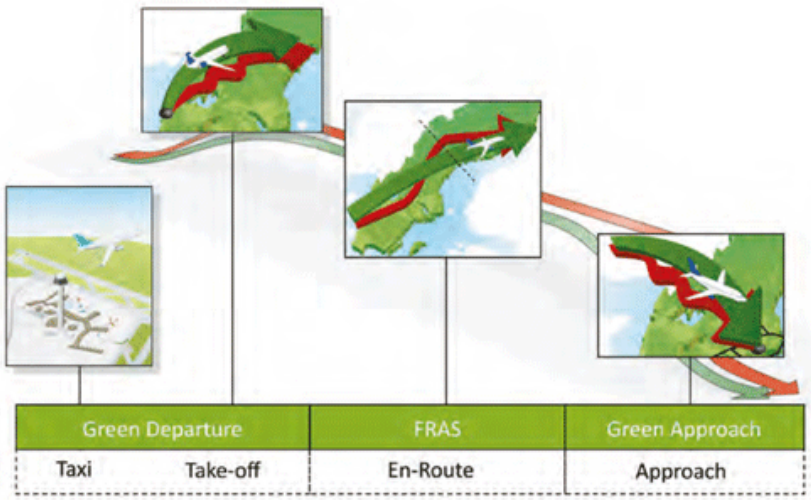
- ICAO focus is on development and implementation of:
  - PBN
  - CCO and CDO
  - ATFM (including runway sequencing capabilities (AMAN/DMAN)

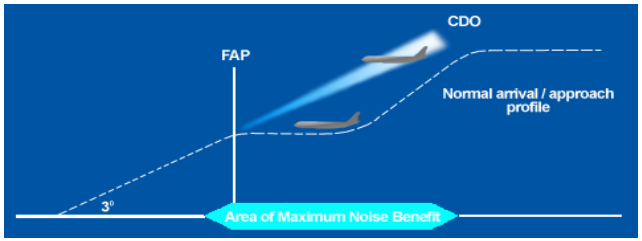
Our Priorities

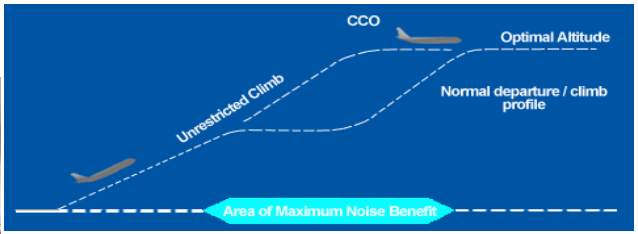
PBN: Our Highest Priority

Prior to the development of the ASBU Modules, ICAO focused its efforts on the development and implementation of Performance-based Navigation (PBN), Continuous Descent Operations (CDO), Continuous Climb Operations (CCO) and runway sequencing capabilities (AMAN/DMAN).

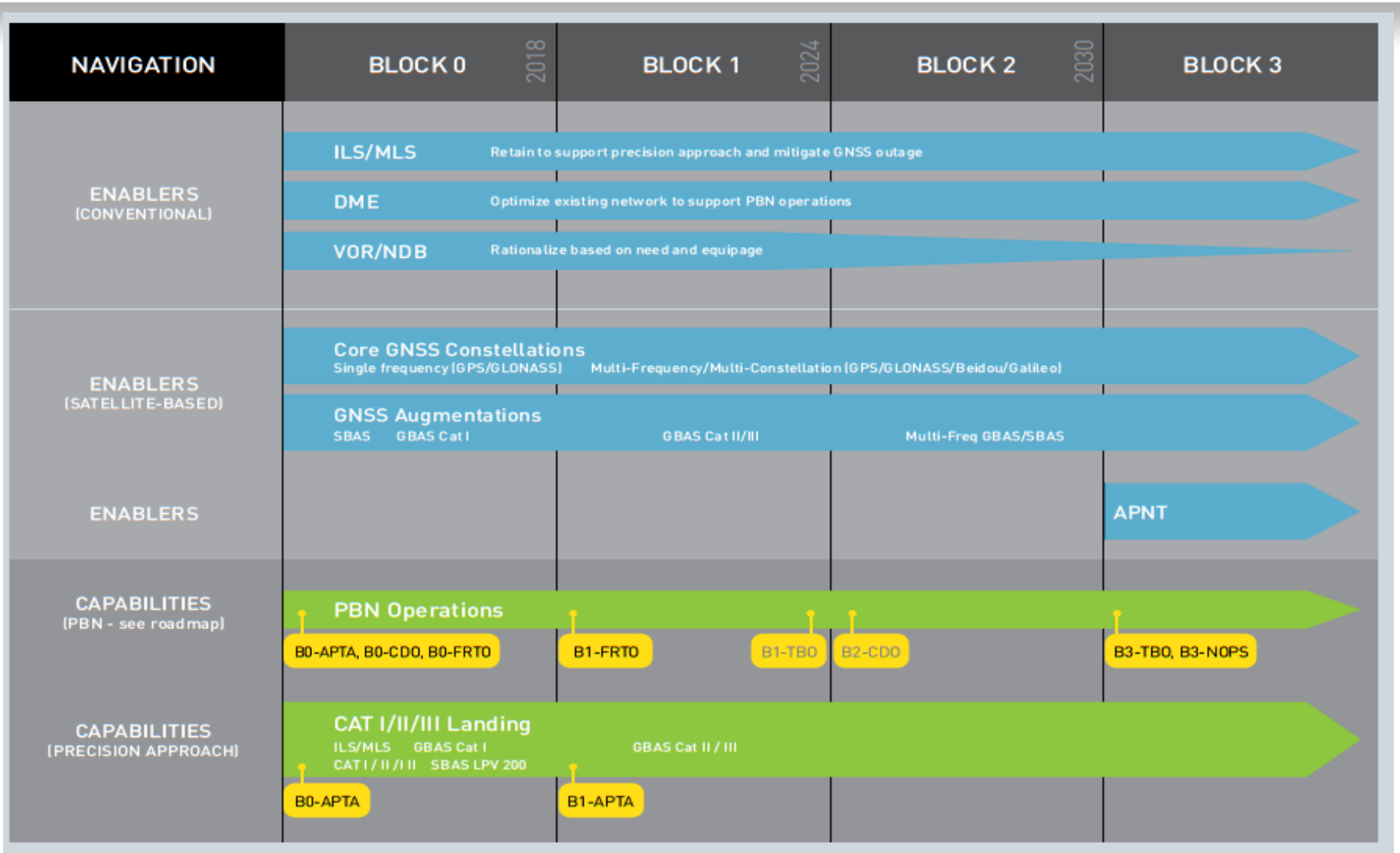
The introduction of PBN has met the expectations of the entire aviation community. Current implementation plans should help deliver additional benefits but remain contingent upon adequate training, expert support to States, continued maintenance and development of international Standards and Recommended Practices (SARPs), and closer coordination between States and aviation stakeholders.



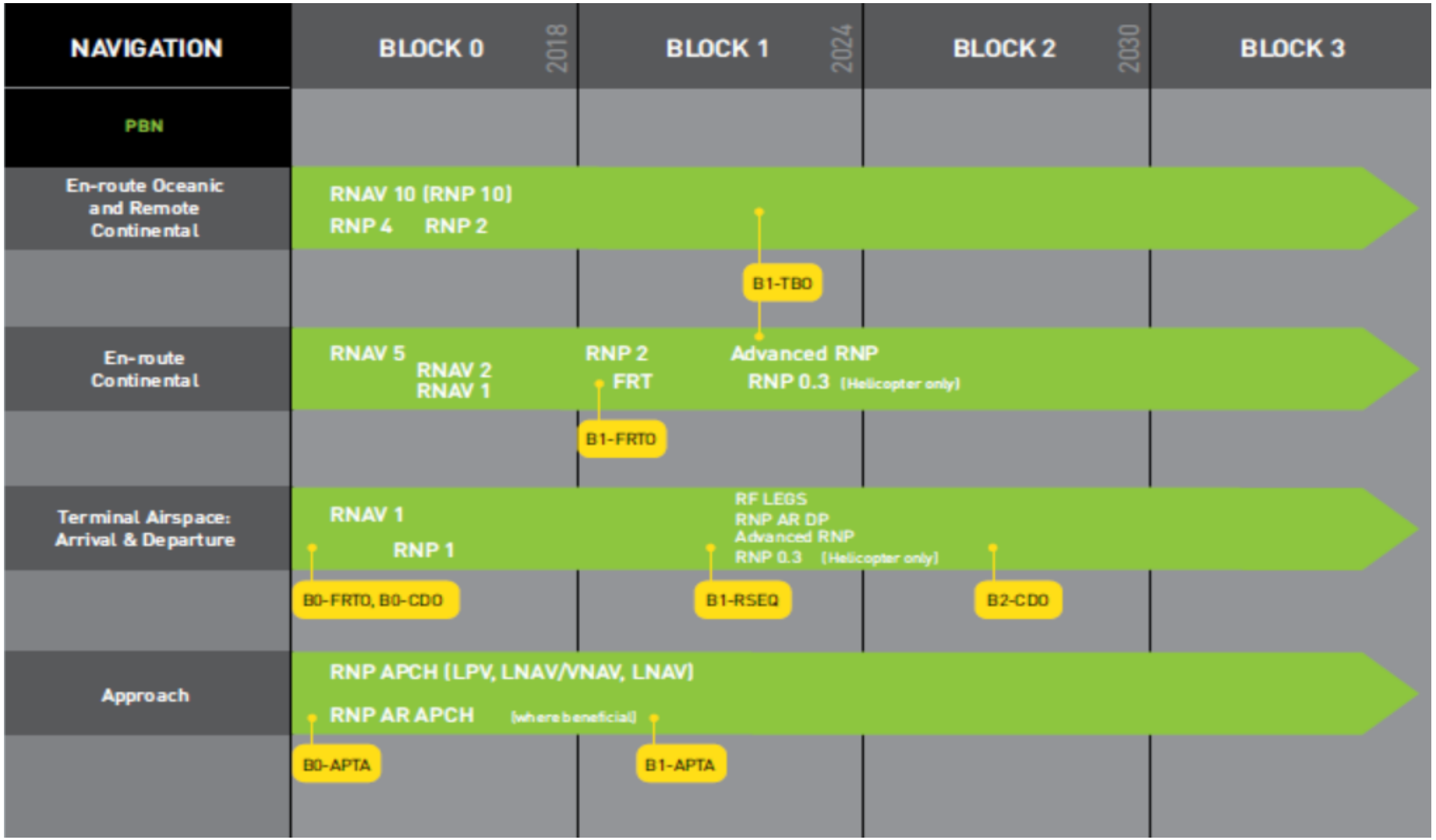




Navigation Roadmap



PBN Roadmap


NAVIGATION
BLOCK 0
2018
BLOCK 1
2024
BLOCK 2
2030
BLOCK 3
PBN
En-route Oceanic and Remote Continental
RNAV 10 (RNP 10)
RNP 4
RNP 2
B1-TBO
En-route Continental
RNAV 5
RNAV 2
RNAV 1
RNP 2
FRT
Advanced RNP
RNP 0.3 (Helicopter only)
B1-FRTO
Terminal Airspace: Arrival & Departure
RNAV 1
RNP 1
RF LEGS
RNP AR DP
Advanced RNP
RNP 0.3 (Helicopter only)
B0-FRTO, B0-CDO
B1-RSEQ
B2-CDO
Approach
RNP APCH (LPV, LNAV/VNAV, LNAV)
RNP AR APCH (where beneficial)
B0-APTA
B1-APTA

Global Air Safety Plan (GASP)

- Identifies **PBN Products and Services** as one of the main implementation activities available to States (*No Country Left Behind*)

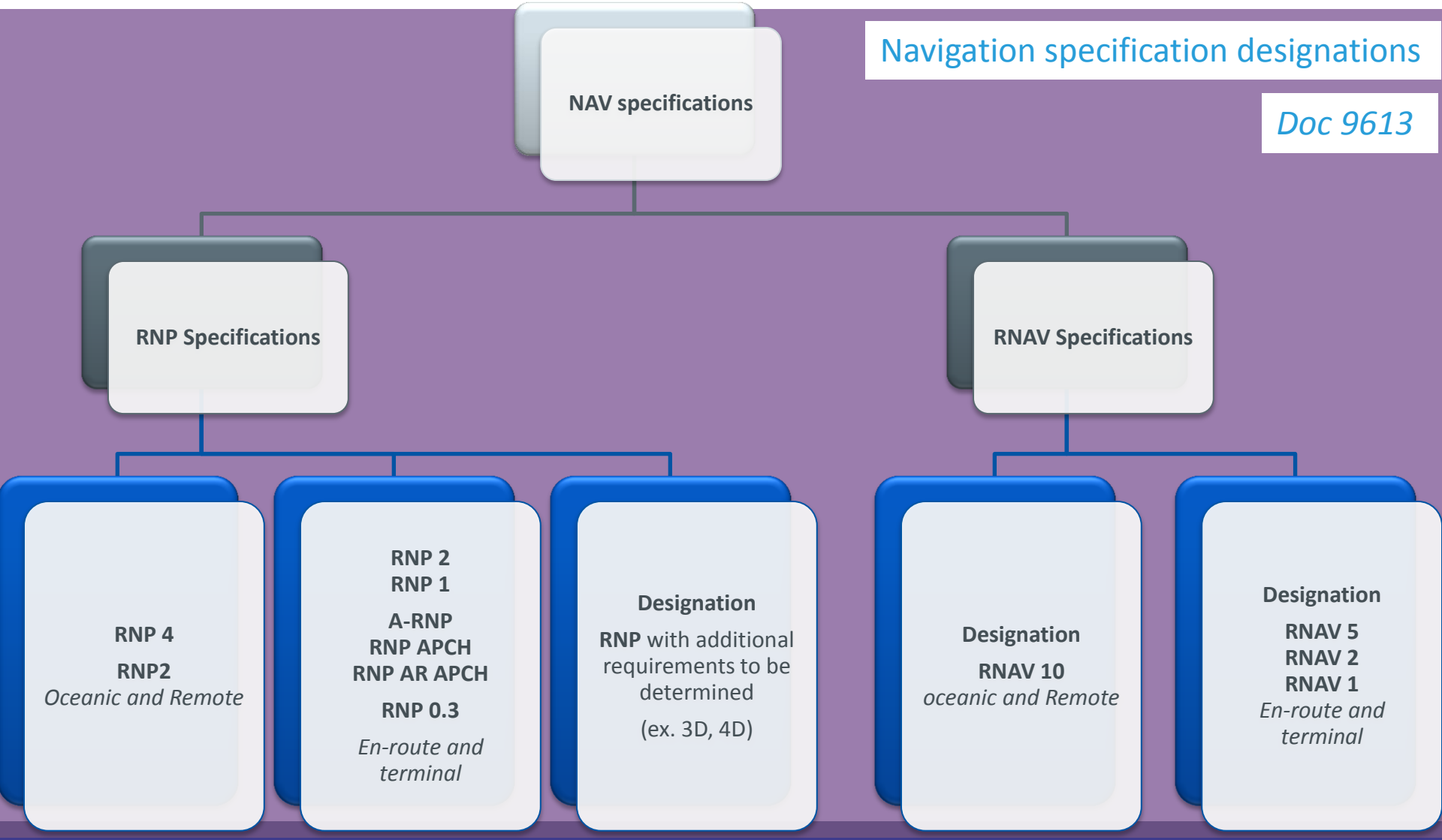
- "*Many safety benefits can be gained from PBN implementation*"
  - PBN instrument approaches with vertical guidance (APV) can help reduce probability of runway excursions and CFIT

PBN Documentation Framework

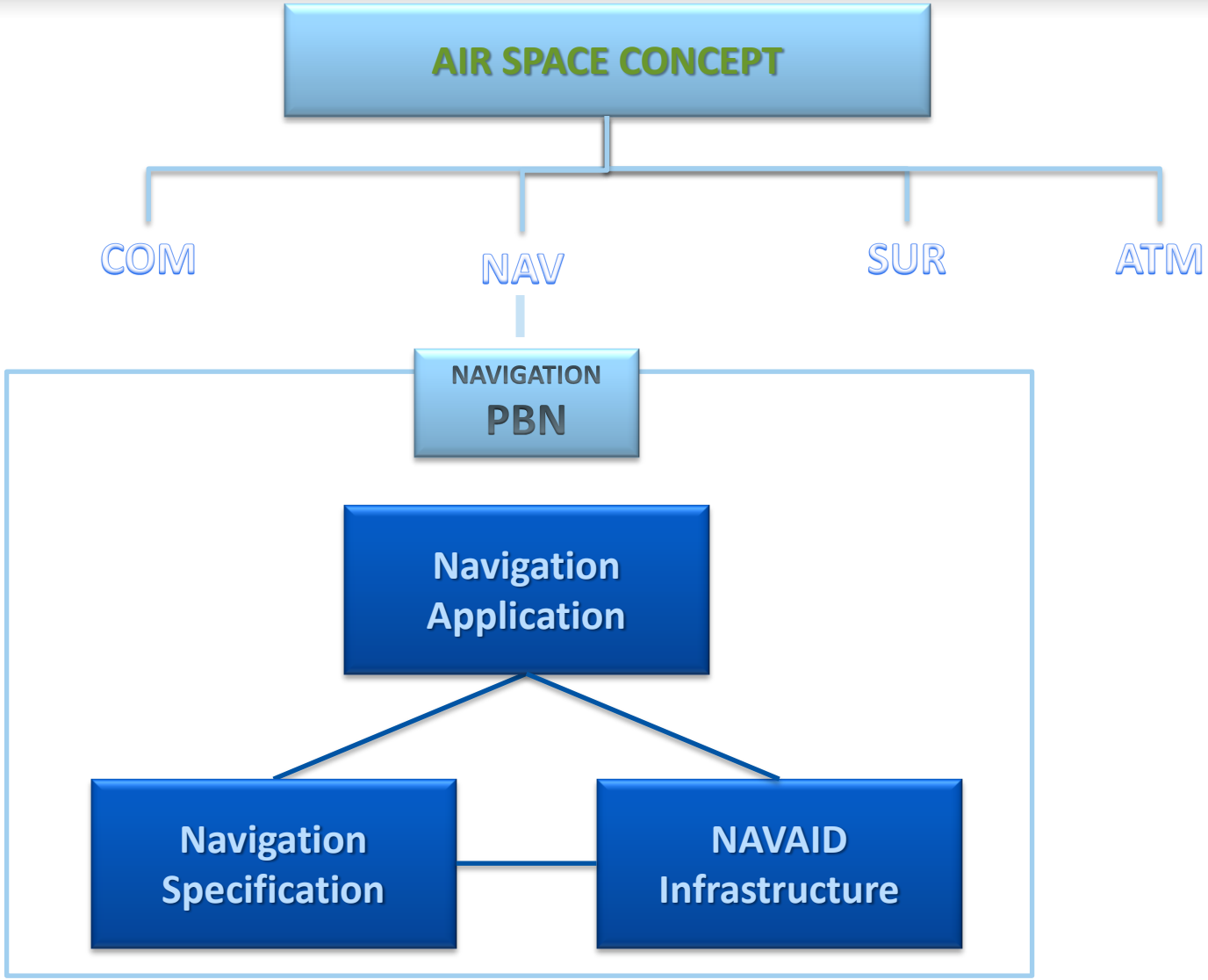
- PBN Manual (Doc 9613) 4th Edition
- PBN Ops Approval Manual (Doc 9997)
- Manual on PBN Use in Airspace Design (Doc 9992)
- RNP AR Procedure Design Manual (Doc 9905)
- PANS Ops Volume I & II
- CDO Manual (Doc 9931)
- CCO Manual (Doc 9993)
- Procedure QA Manual (Vol 1 to Vol 6) (Doc 9906)

Navigation specification designations

Doc 9613

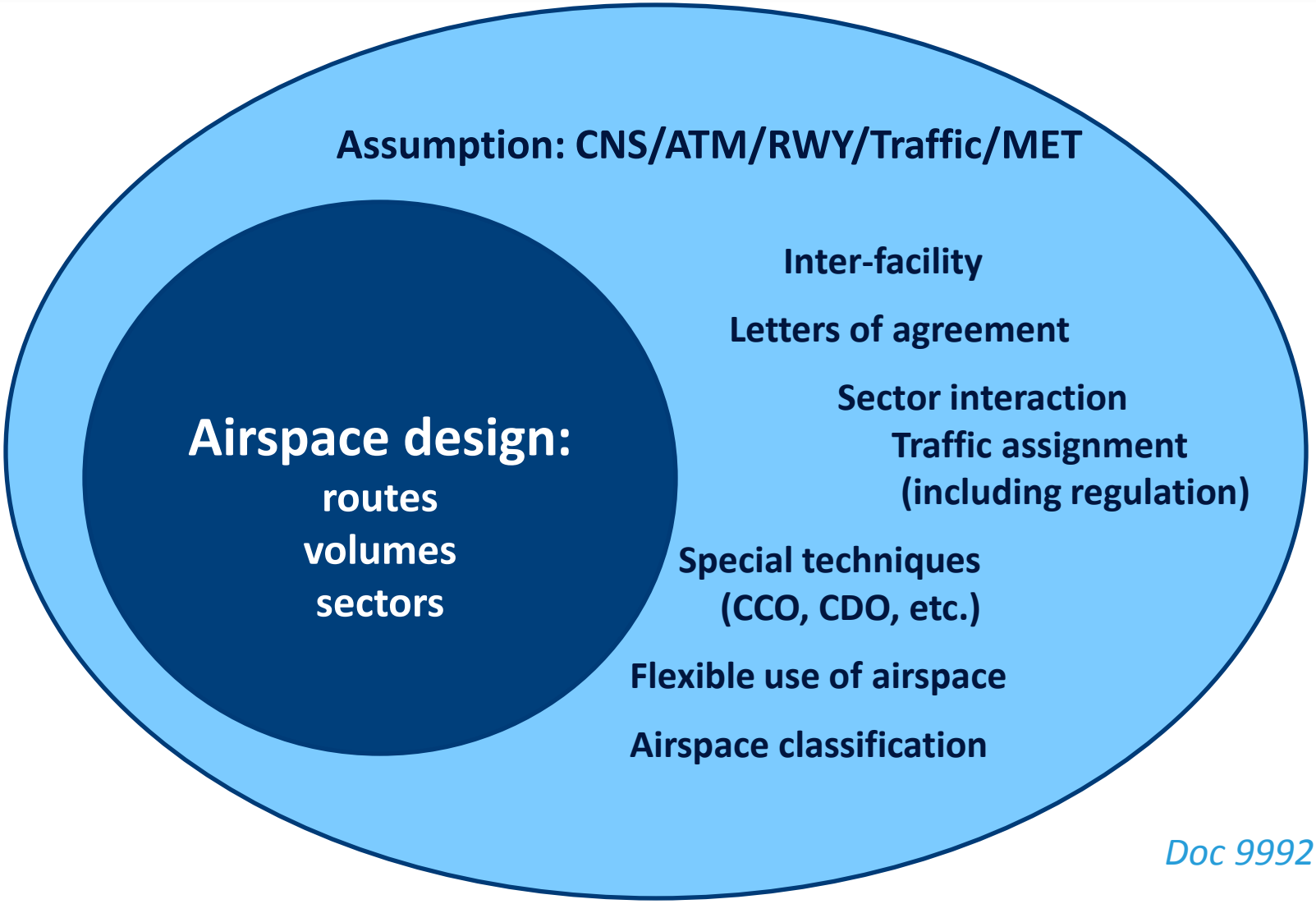


Airspace concept and PBN



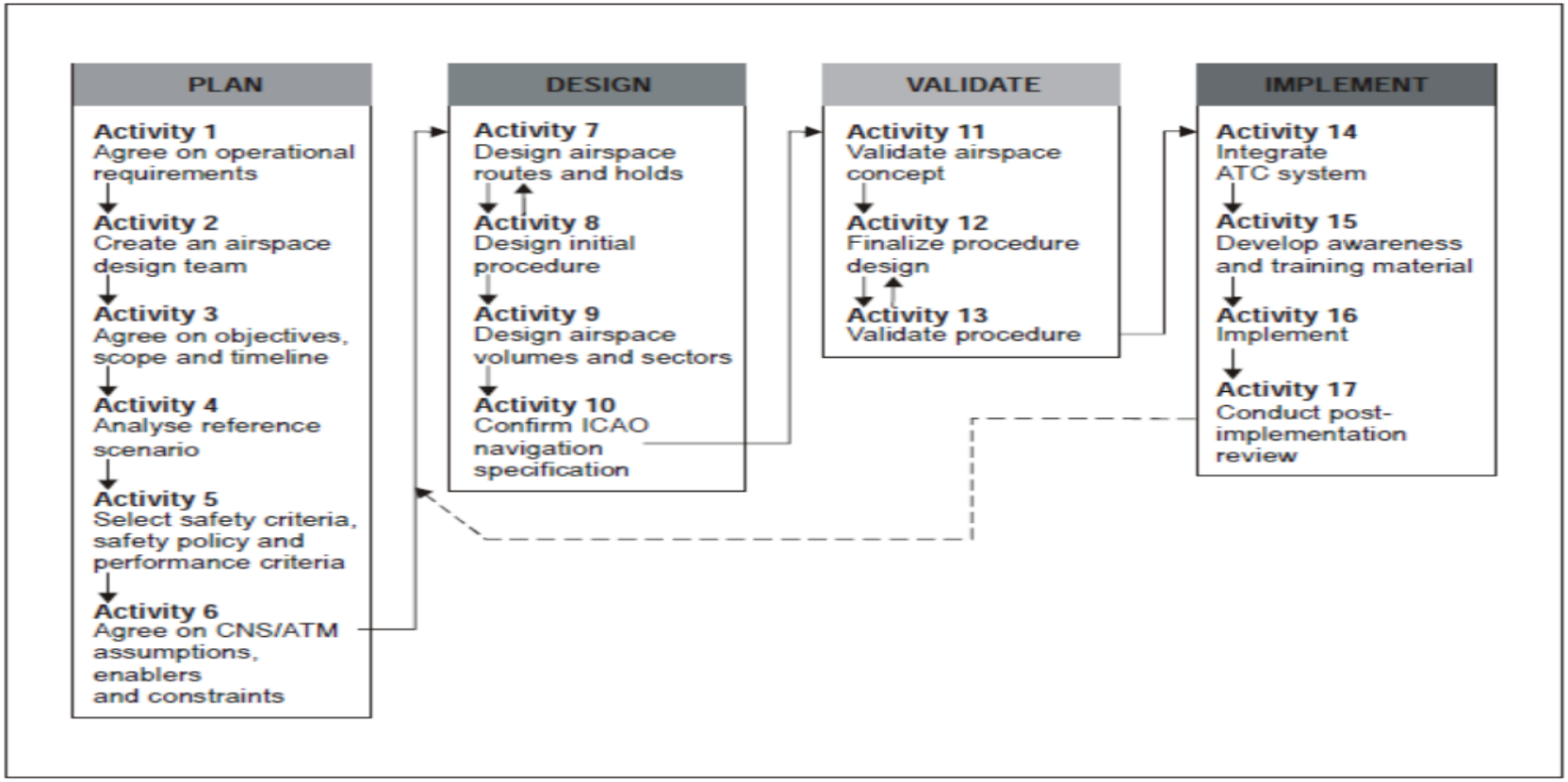
Doc 9992

Airspace concept constituents



Doc 9992

Airspace Concept Development and Implementation Process



Doc 9992

PBN IMPLEMENTATION PROCESS

PROCESS 1: IDENTIFYING AN ICAO NAVIGATION SPECIFICATION FOR IMPLEMENTATION

Activity 6: Agree on CNS/ATM assumptions (allowing for identification of potential navigation specification)

- The airspace concept to be developed is based upon certain CNS/ATM assumptions.
- These assumptions must take account of the environment that is expected to exist at the time when the new airspace operation is intended to be implemented (e.g. in 20XX).

Doc 9613 and Doc 9992

CNS/ATM assumptions

Traffic analysis
- Representative traffic sample
- Distribution — time/geography
- Cross-check adjacent facility traffic
- Instrument flight rules (IFR) visual flight
- rules (VFR) mix
- Civil/military mix
- Aircraft performance mix (jet/turboprop/helicopter)

Navigation
- Aircraft navigation equipage
- NAV infrastructure and coverage
- PBN conventional mix

Runway in use (primary/secondary)
- Available runways/length
- Meteorological conditions
- Landing aids
- Greenfield site? Orientation choice?
- Runway usage statistics

ATC system
- Sectors/personnel/equipment
- Traffic sequencing and management

Surveillance means/coverage
- Radar/ADS-B/MLAT/none

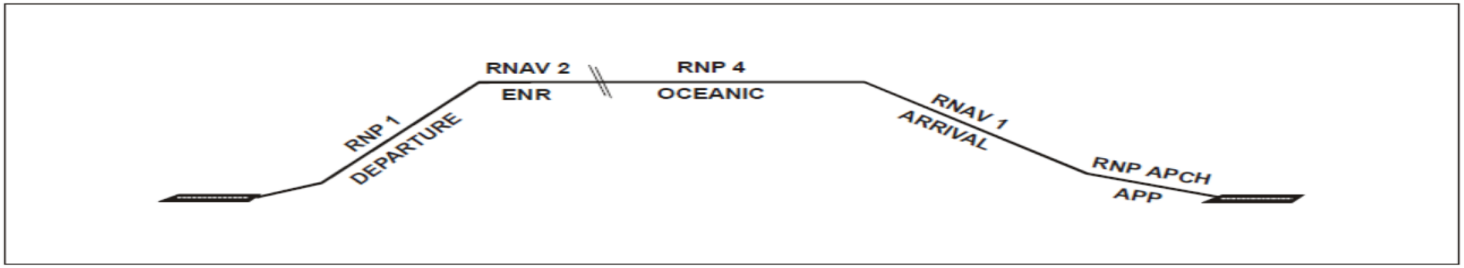
Communications means/coverage
- Voice/datalink

Doc 9992

Application of navigation specification by flight phase

NAVEGATION SPECIFICATION	FLIGHT PHASE							
	En-route Oceanic/ Remote	En-Route Continental	Arrival	Approach				DEP
				Initial	Interm.	Final	Miss	
RNAV 10	10							
RNAV 5		5						
RNAV 2		2	5					2
RNAV 1		1	2	1	1		1	1
RNP 4	4		1					
RNP 2	2	2						
RNP 1			1	1[a]	1[a]		1[ab]	1[a,c]
Advanced RNP	2	2 or 1	1	1	1	0.3	1	1
RNP APCH				1	1	0.3	1	
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1	
RNP 0.3		0.3	0.3	0.3	0.3		0.3	0.3

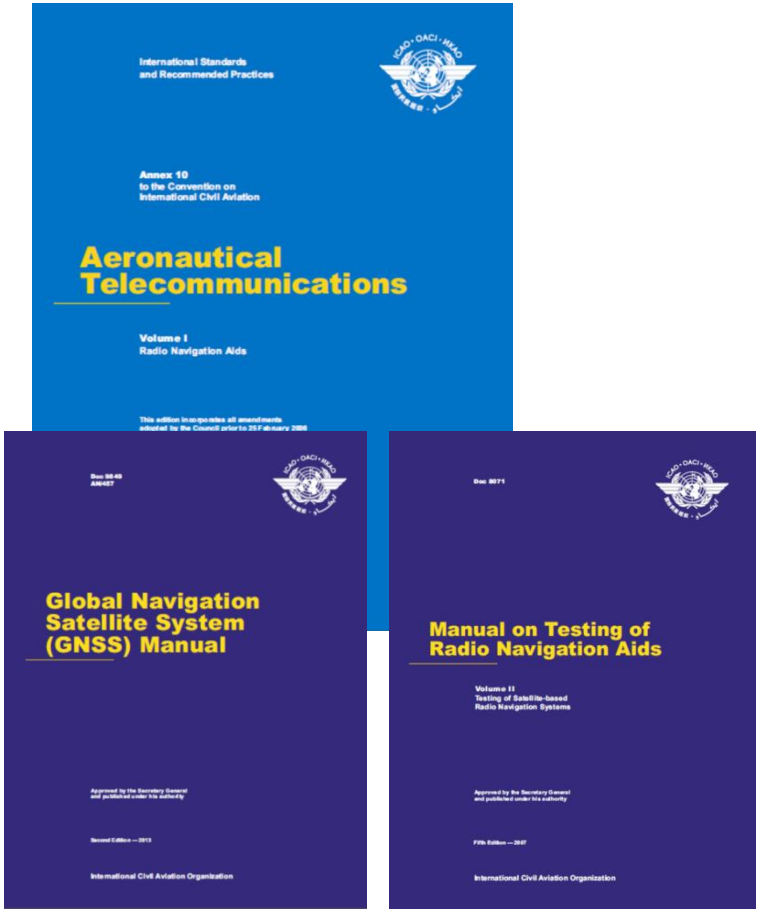
Example of an application of RNAV and RNP specifications to ATS routes and instrument procedures



Doc 9613

Area of Application	Navigation Accuracy (NM)	Navigation Specification	Requirement onboard monitoring and alerting	Navaid Sensors
Oceanic/Remote	10	RNAV 10 / (RNP 10)	No	GNSS / INS-IRU
	4	RNP 4	Yes	GNSS
En route – Continental	5	RNAV 5	No	GNSS / INS-IRU / DME-DME / DME-DME-IRU / DME-VOR
En route – Continental and Terminal	2	RNAV 2	No	GNSS / DME–DME / DME-DME-IRU
	2	RNP 2 (TBD)	Yes	GNSS
Terminal	1	RNAV 1	No	GNSS / DME–DME / DME-DME-IRU
	1	Basic RNP 1	Yes	GNSS
Approach	0.3	RNP APCH	Yes	GNSS
	0.3-0.1	RNP AR	Yes	GNSS

NAV Infrastructure Specification Documentation to Support PBN (especially related to GNSS)



- Annex 10 Aeronautical Telecommunications Volume I, Radio Navigation Aids,
  CHAPTER 3. Specifications for radio navigation aids
  Appendix B Technical specifications for the Global Navigation Satellite System (GNSS)
  And other attachments includes:
  Attachment B, Strategy for Introduction and Application of Non-visual Aids to Approach and Landing and Attachment D Information and material for guidance in the application of the GNSS Standards and Recommended Practices
- DOC 9849 Global Navigation Satellite System (GNSS) Manual
- Doc 8071 Manual on Testing of Radio Navigation Aids, Volume II, Testing of Satellite-based Radio Navigation Systems

Operational references and considerations

Navigation Specification and CNS Infrastructure		
NAV specification	**Communication and Surveillance**	**Navigation**
RNAV 10 (RNP 10)	Determined in the implementation process in accordance to local and regional characteristics	No ground-based Navaids required
RNAV 5 (B RNAV)	• Direct pilot to ATC Communications • Radar monitoring by ATS	• VOR/DME • DME/DME • INS/IRS • GNSS
RNAV 2/ RNAV 1	• Direct pilot to ATC Communications • Radar surveillance by ATS	• GNSS • DME/DME • DME/DME/IRU • DME/VOR
RNP 4	Determined in the implementation process in accordance to local and regional characteristics (CPDLC, ADS-C, …)	GNSS
RNP 2	Determined based on operational considerations (route spacing, traffic density, etc.)	GNSS
RNP 1 (Basic)	• Direct pilot to ATC Communications	GNSS
RNP APCH	No specific requirements. Obstacle clearance required	• GNSS down to LNAV or LNAV/VNAV minima (SBAS, etc.) • MIssed approach segment (conventional navaids)
RNP AR APCH	No specific requirements.	GNSS DME/DME as alternative
RNP 0.3	No specific requirements.	GNSS

PBN Validation

Guidance

- PBN Manual (DOC 9613)
- Quality Assurance Manual for Flight Procedure Design (Doc 9906),
  - Volume 5 - Validation of Instrument Flight Procedures.
  - Volume 6 - Flight Validation Pilot Training and Evaluation
- Manual on Testing of Radio Navigation Aids, Volume II, Testing of Satellite-based Radio Navigation Systems (Doc 8071)

PBN Validation

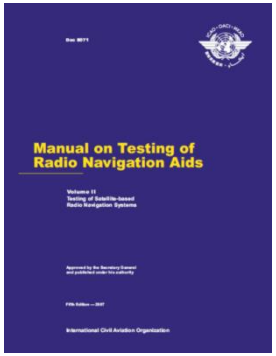
PBN Manual (DOC 9613)
Implementation Guidance
PROCESS 2 PHASE 3: VALIDATION

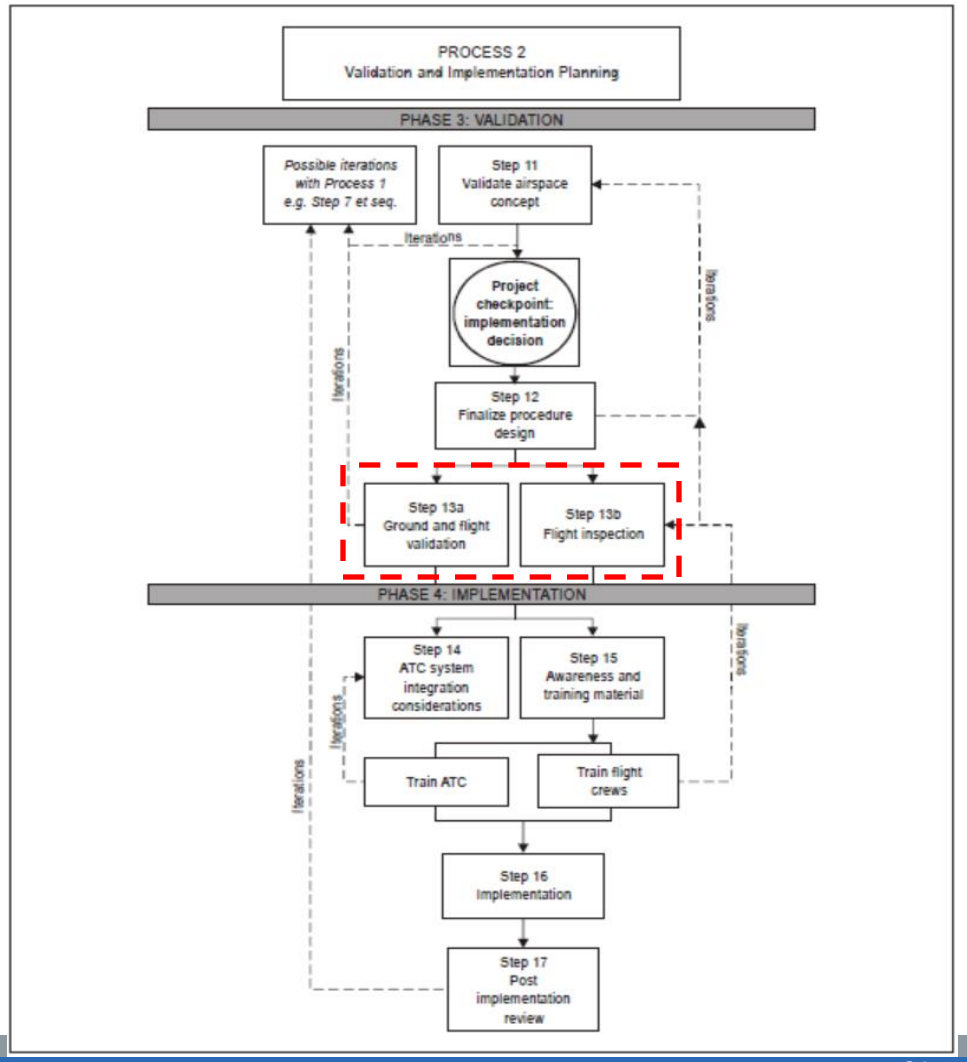
Step 13a — Instrument Flight Procedure (IFP) validation

Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5 — Validation of Instrument Flight Procedures.

Step 13b Flight inspection

Manual on Testing of Radio Navigation Aids (Doc 8071)

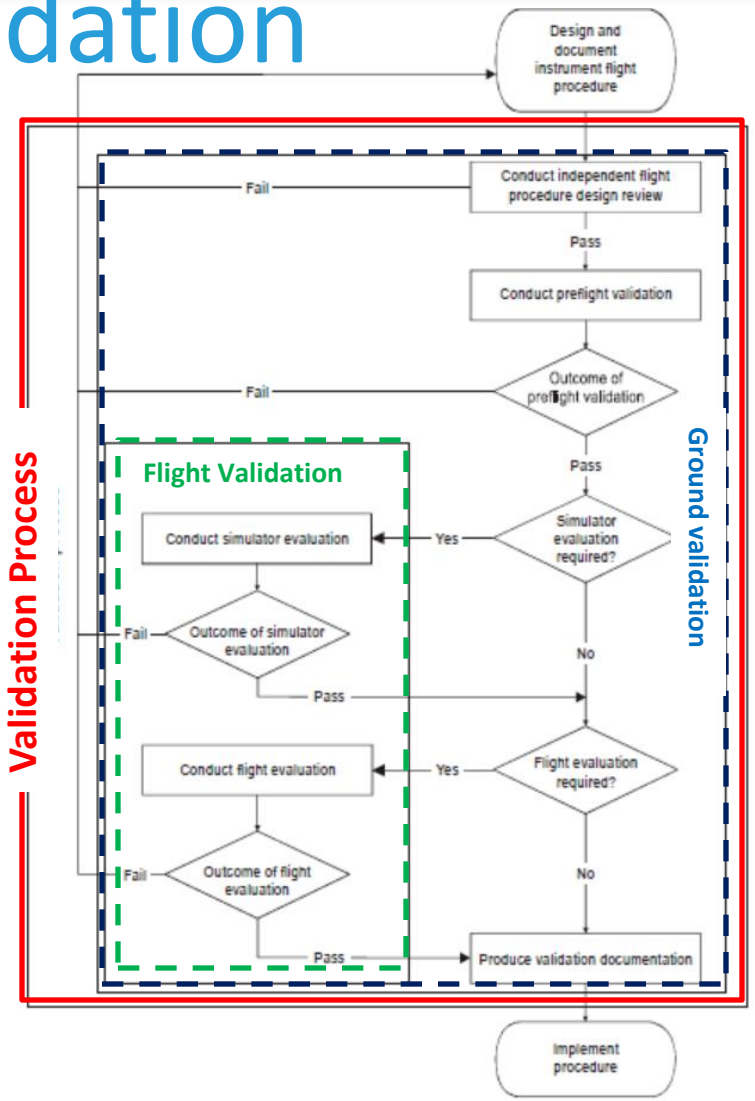




PBN Validation

THE VALIDATION PROCESS

Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5 — Validation of Instrument Flight Procedures.



Requirements for the Global Navigation Satellite System (GNSS)
Signal-in-space performance requirements

Typical operation	Accuracy horizontal 95% (Notes 1 and 3)	Accuracy vertical 95% (Notes 1 and 3)	Integrity (Note 2)	Time-to-alert (Note 3)	Continuity (Note 4)	Availability (Note 5)
En-route	3.7 km (2.0 NM)	N/A	$1 - 1 \times 10^{-7}$/h	5 min	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
En-route, Terminal	0.74 km (0.4 NM)	N/A	$1 - 1 \times 10^{-7}$/h	15 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Initial approach, Intermediate approach, Non-precision approach (NPA), Departure	220 m (720 ft)	N/A	$1 - 1 \times 10^{-7}$/h	10 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Approach operations with vertical guidance (APV-I)	16.0 m (52 ft)	20 m (66 ft)	$1 - 2 \times 10^{-7}$ in any approach	10 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Approach operations with vertical guidance (APV-II)	16.0 m (52 ft)	8.0 m (26 ft)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Category I precision approach (Note 7)	16.0 m (52 ft)	6.0 m to 4.0 m (20 ft to 13 ft) (Note 6)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999

Section 3.7 Annex 10 Volume I

Other Standards and Guidance Material to support PBN

- ATM Operational Concept, Doc 9735, RPB/ANIP
- ATM system requirements
- PANS-ATM for ATS use based on radar, ADS-B, GNSS for lateral & longitudinal separation
- Safety assessment
- PBN airspace concept: Regional performance framework and training (pilots, ATCOs) for En-route (Oceanic/Domestic), TMA and RNP approach procedures Doc 7030 & Doc 8733; develop a PFA, as required (ANI/WG/3, WP xx)
- Update LOAs
- Development of transition strategies (pre-tactical)

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