AFCAC/ICAO Joint Workshop

Walter White

ICAO PBN CONCEPTS , BENEFITS, AND OBJECTIVES

24 JUNE 2014

AIRBUS

PERFORMANCE-BASED NAVIGATION

The implementation of Performance-Based Navigation, or PBN, is presently the global aviation communityôs highest Air Navigation priority.

PERFORMANCE-BASED NAVIGATION

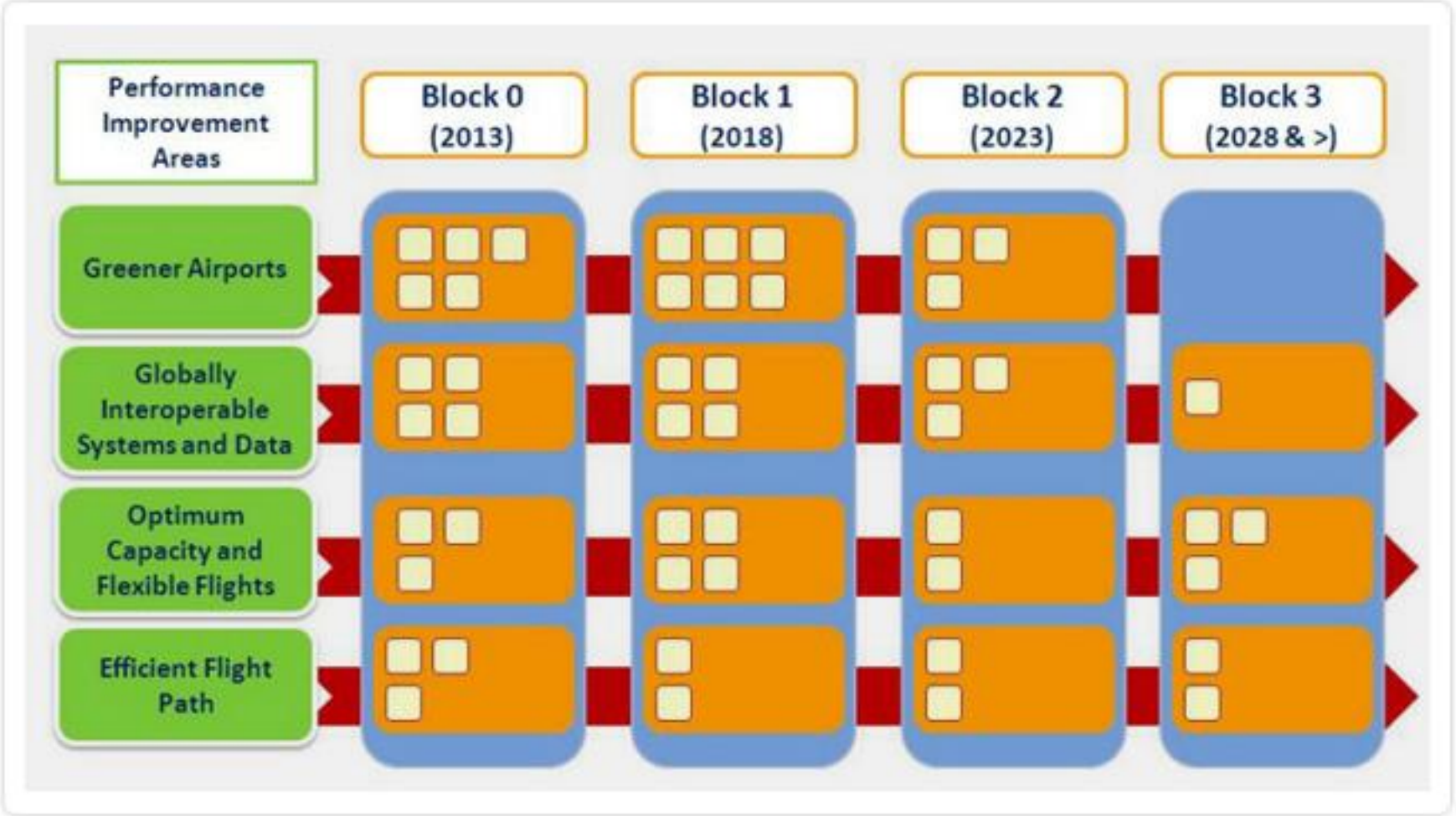
It is key to the implementation of ICAOôs Aviation System Block Upgrades (ASBU) and is an enabler for Continuous Descent and Continuous Climb operations.

ASBU Framework

Aviation System Block Upgrades - ASBUs (Edition March 2013)

http://www.icao.int/sustainability/Pages/ASBU-Framework.aspx

ASBU



ASBU

2013

Performance Improvement Area 1: Airport Operations			
Block 0	**Block 1**	**Block 2**	**Block 3**
B0-APTA **Optimization of Approach Procedures including vertical guidance** This is the first step toward universal implementation of GNSS-based approaches.	B1-APTA **Optimised Airport Accessibility** This is the next step in the universal implementation of GNSS-based approaches.		
B0-WAKE **Increased Runway Throughput through Optimized Wake Turbulence Separation** Improved throughput on departure and arrival runways through the revision of current ICAO wake vortex separation minima and procedures.	B1-WAKE **Increased Runway Throughput through Dynamic Wake Turbulence Separation** Improved throughput on departure and arrival runways through the dynamic management of wake vortex separation minima based on the real-time identification of wake vortex hazards.	B2-WAKE (*) **Advanced Wake Turbulence Separation (Time-based)** The application of time-based aircraft-to-aircraft wake separation minima and changes to the procedures the ANSP uses to apply the wake separation minima.	
B0-RSEQ **Improved Traffic Flow through Sequencing (AMAN/DMAN)** Time-based metering to sequence departing and arriving flights.	B1-RSEQ **Improved Airport operations through Departure, Surface and Arrival Management** Extended arrival metering, Integration of surface management with departure sequencing bring robustness to runways management and increase airport performances and flight efficiency.	B2-RSEQ **Linked AMAN/DMAN** Synchronised AMAN/DMAN will promote more agile and efficient en-route and terminal operations	B3-RSEQ **Integrated AMAN/DMAN/SMAN** Fully synchronized network management between departure airport and arrival airports for all aircraft in the air traffic system at any given point in time.
B0-SURF **Safety and Efficiency of Surface Operations (A-SMGCS Level 1-2)** Airport surface surveillance for ANSP.	B1-SURF **Enhanced Safety and Efficiency of Surface Operations- SURF, SURF IA and Enhanced Vision Systems (EVS)** Airport surface surveillance for ANSP and flight crews with safety logic, cockpit moving map displays and visual systems for taxi operations.	B2-SURF **Optimized Surface Routing and Safety Benefits (A-SMGCS Level 3-4 and SVS)** Taxi routing and guidance evolving to trajectory based with ground / cockpit monitoring and data link delivery of clearances and information. Cockpit synthetic visualisation systems.	
B0-ACDM **Improved Airport Operations through Airport-CDM** Airport operational improvements through the way operational partners at airports work together.	B1-ACDM **Optimized Airport Operations through Airport-CDM** Airport operational improvements through the way operational partners at airports work together.		
	B1-RATS **Remotely Operated Aerodrome Control** Remotely operated Aerodrome Control Tower contingency and remote provision of ATS to aerodromes through visualisation systems and tools.		

AIRBUS

ASBU

2013	Perf 2018 mprovement Area 4: Efficient Flight P: ıgh Trajectory-based O; 2023		
Block 0	**Block 1**	**Block 2**	**Block 3**
B0-CDO **Improved Flexibility and Efficiency in Descent Profiles (CDO)** Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with continuous descent operations (CDOs)	**B1-CDO** **Improved Flexibility and Efficiency in Descent Profiles (CDOs) using VNAV** Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with Optimised Profile Descents (OPDs).	**B2-CDO** **Improved Flexibility and Efficiency in Descent Profiles (CDOs) using VNAV, required speed and time at arrival** Deployment of performance based airspace and arrival procedures that optimise the aircraft profile taking account of airspace and traffic complexity including Optimised Profile Descents (OPDs), supported by Trajectory-Based Operations and self-separation.	**B3-TBO** **Full 4D Trajectory-based Operations** Trajectory-based operations deploys an accurate four-dimensional trajectory that is shared among all of the aviation system users at the cores of the system. This provides consistent and up-to-date information system-wide which is integrated into decision support tools facilitating global ATM decision-making.
B0-TBO **Improved Safety and Efficiency through the initial application of Data Link En-Route** Implementation of an initial set of data link applications for surveillance and communications in ATC.	**B1-TBO** **Improved Traffic Synchronization and Initial Trajectory-Based Operation.** Improve the synchronisation of traffic flows at en-route merging points and to optimize the approach sequence through the use of 4DTRAD capability and airport applications, e.g.; D-TAXI, via the air ground exchange of aircraft derived data related to a single controlled time of arrival (CTA).		
B0-CCO **Improved Flexibility and Efficiency in Departure Profiles - Continuous Climb Operations (CCO)** Deployment of departure procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with continuous climb operations (CCOs).			
	B1-RPAS **Initial Integration of Remotely Piloted Aircraft (RPA) Systems into non-segregated airspace** Implementation of basic procedures for operating RPA in non-segregated airspace including detect and avoid.	**B2-RPAS** **RPA Integration in Traffic** Implements refined operational procedures that cover lost link (including a unique squawk code for lost link) as well as enhanced detect and avoid technology.	**B3-RPAS** **RPA Transparent Management** RPA operate on the aerodrome surface and in non-segregated airspace just like any other aircraft.

AIRBUS

PERFORMANCE-BASED NAVIGATION

PBN implementation involves many different stakeholders and processes from airborne equipment to airspace infrastructure development.

PERFORMANCE-BASED NAVIGATION

PBN sets clear performance requirements for flight operations. PBN involves a major shift from conventional ground-based navigation and procedures to satellite-based navigation and area navigation procedures. PBN is more accurate and allows for shorter more direct routes, as well as more efficient take-offs and landings. This reduces fuel burn, airport and airspace congestion, and aircraft emissions.

PERFORMANCE-BASED NAVIGATION

PBN:

- Improves Safety
  - Reduces CFIT
  - Consistent predictable flight paths
  - Stabilized approach paths
- Improves Operating Returns
  - Reduces fuel costs
  - Reduces investment in ground based systems
  - Reduces time in flight through more direct routes
- Increases Airspace Capacity
  - More efficient direct routes
  - Reduces airspace conflicts
- Is Environmentally Friendly

PERFORMANCE-BASED NAVIGATION

Benefits in terms of ATC

- Å Safety culture
- Å Fewer radio transmissions
- Å Less chance of readback/hearback errors
- Å Greater predictability
- Å Airspace Containment
- Å Fewer go-arounds
- Å Less transit occupancy time in airspace
- Å Changing Roles and Responsibilities
- Å Best practices involving stakeholders in design

PERFORMANCE-BASED NAVIGATION

PBN Documents:

- Doc 9613 ï Performance-based Navigation Manual
- Doc 9931 ï Continuous Descent Operations (CDO) Manual
- *Doc 9992 ï Manual on the Use of Performance-based Navigation (PBN) in Airspace Design
- *Doc 9993 ï Continuous Climb Operations (CCO) Manual
- *Doc 9997 ï Performance-based Navigation (PBN) Operations Approval Manual

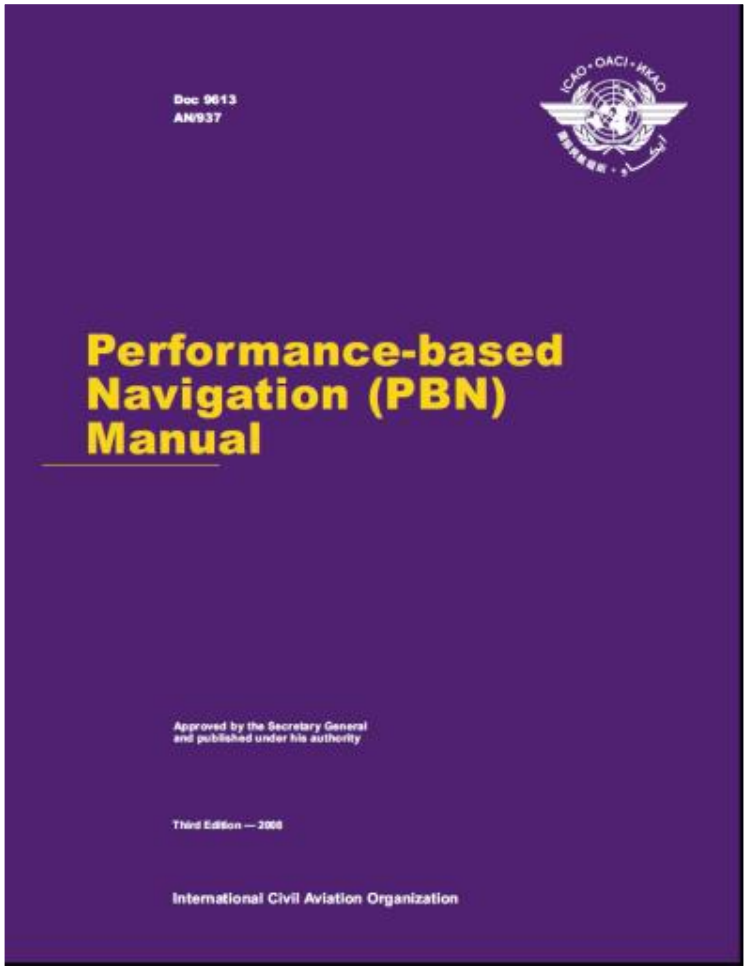
*advance copies restricted to States on ICAO-net

http://www.icao.int/safety/pbn/Pages/default.aspx

PBN Overview

PERFORMANCE-BASED NAVIGATION

- Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace. (ICAO Doc 9613)



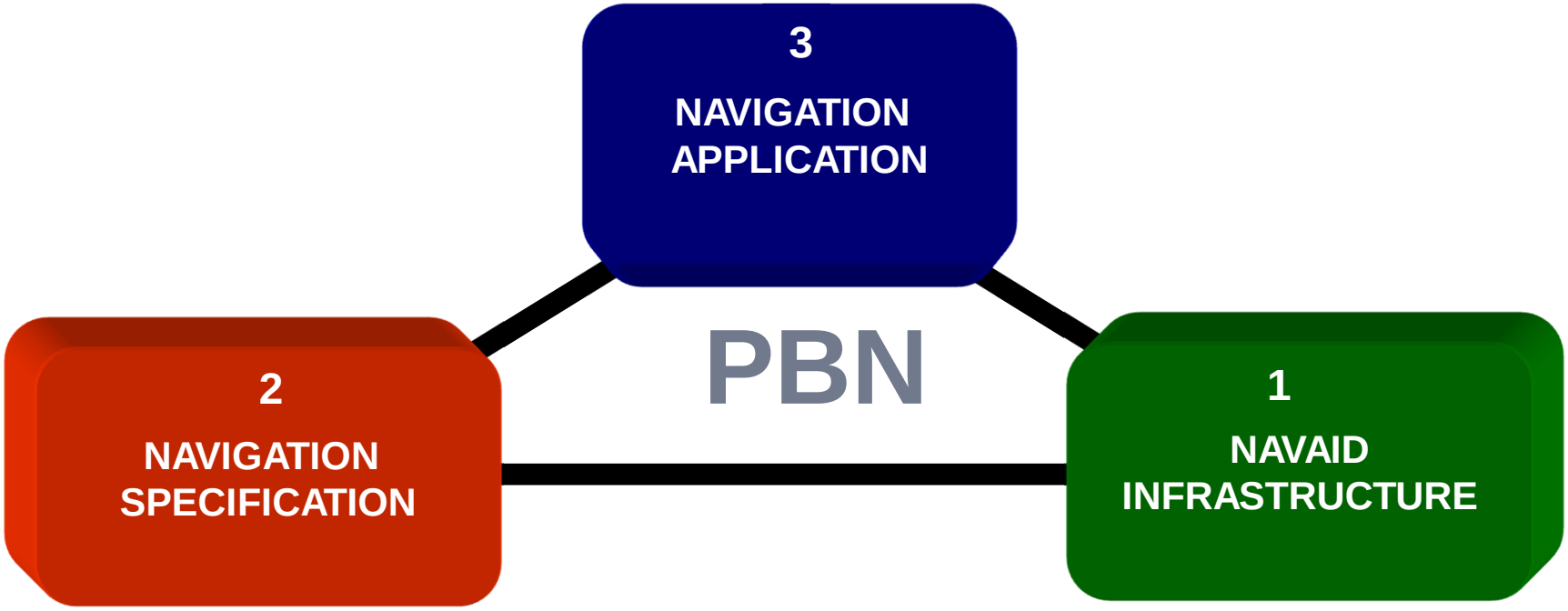
PERFORMANCE-BASED NAVIGATION CONCEPT

- PBN specifies ***SYSTEM PERFORMANCE REQUIREMENT*** for aircraft operating on air traffic routes or instrument approach procedures, in a designated airspace.

- The performance requirements are defined in term of accuracy, integrity, continuity and availability

- and ***ALSO*** In term of ***FUNCTIONALITIES***
  - Display
  - ARINC 424 legé

COMPONENTS OF PBN CONCEPT



NAVIGATION APPLICATION

- A *NAVIGATION APPLICATION* is the application of a *NAVIGATION SPECIFICATION* and associated *NAVAID INFRASTRUCTURE* to ATS routes, instrument approach procedures and/or defined airspace volume in accordance with the Airspace Concept.

- Example in Terminal area
  - **Navigation Specification : RNAV1 (1 Nm of accuracy)**
  - **Navaid infrastructure: GNSS or DME/DME**

Reference : PBN Manual vol I § 1.4

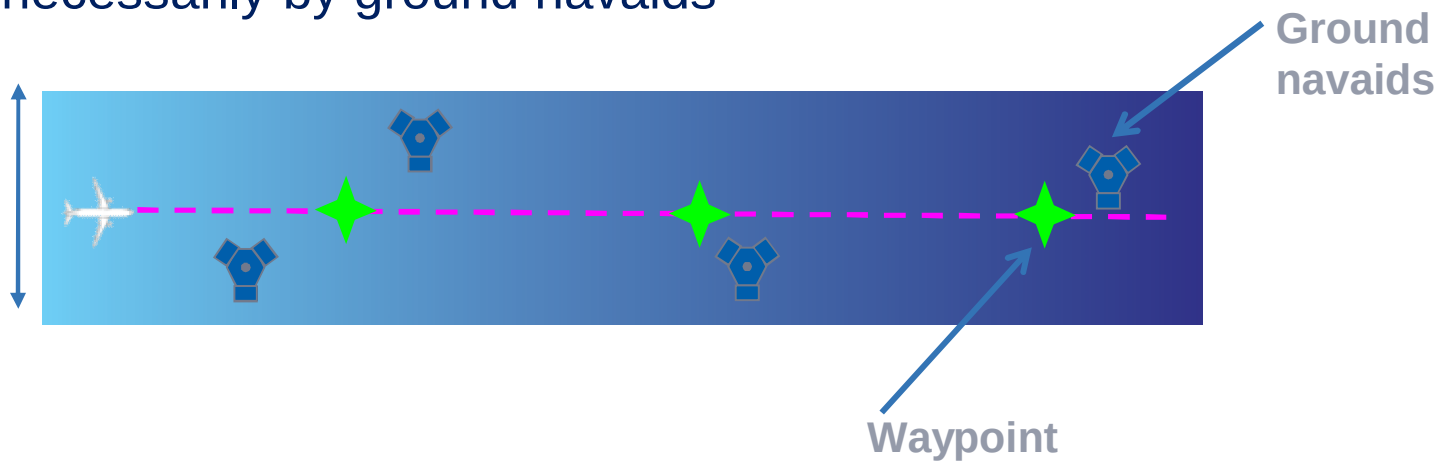
FLIGHT MANAGEMENT SYSTEM

- FMS capabilities are integral part of PBN
- Enables aircraft to fly RNAV or RNP procedures

RNAV DEFINITION

RNAV stands for Area Navigation

RNAV : Capability to fly any desired flight path, defined by waypoints such as geographic fixes (LAT/LONG) and not necessarily by ground navaids



RNAV capability is linked to aircraft on-board equipments (RNAV systems)

RNAV is a method of navigation allowing for the definition of more direct routes

AIRBUS

RNAV-SOME CLARIFICATIONS

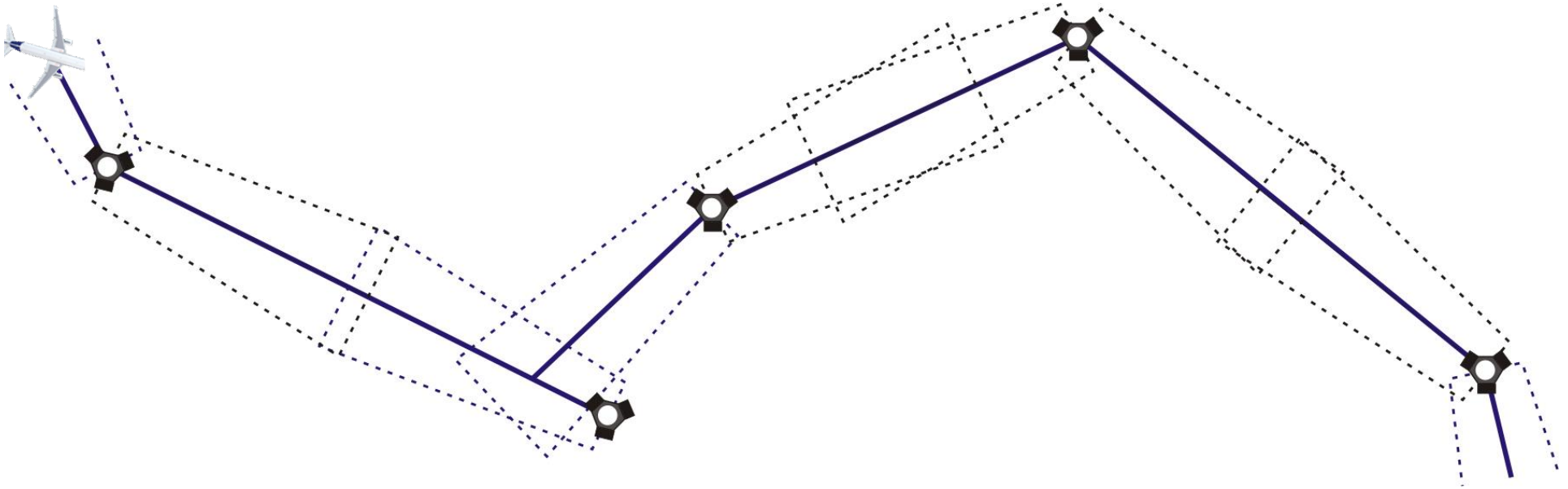
- The RNAV navigation concept is not new
  - This method of navigation has been in use for many years
  - **Most of the aircraft are RNAV capable**

- An RNAV route **can be flown using different navigation sensors**:
  - IRS
  - VOR-DME
  - DME-DME
  - GNSS (GPS)

All Performance Based Navigation (PBN) is based on RNAV

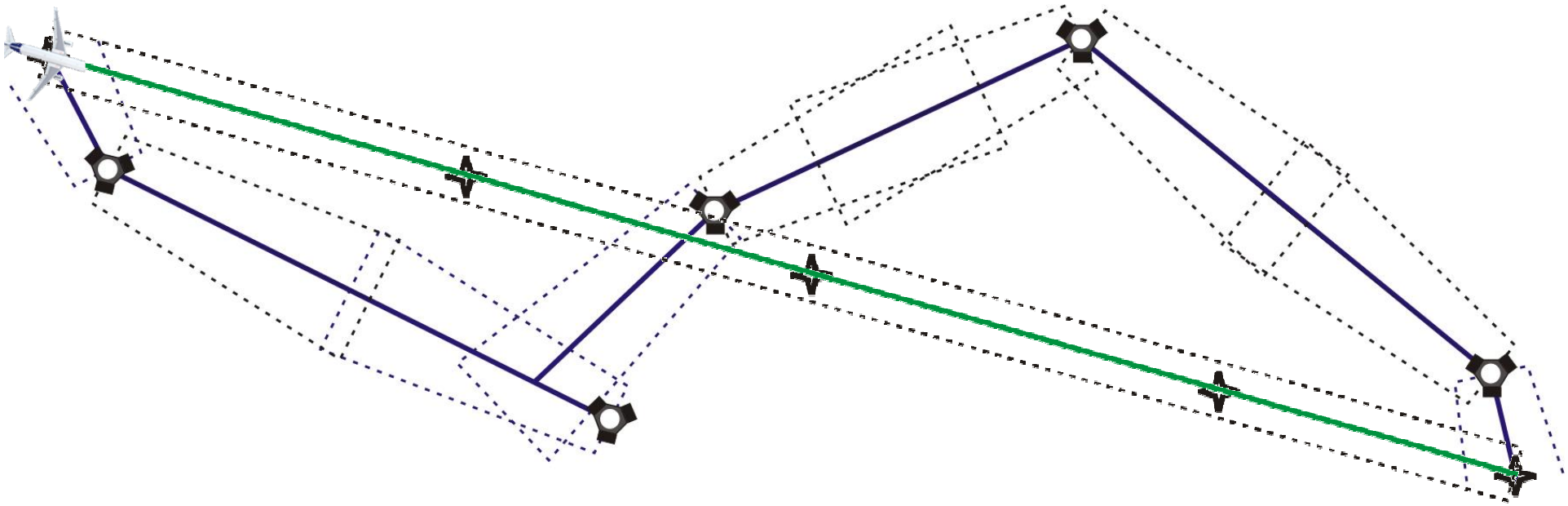
AIRBUS

WHY PBN



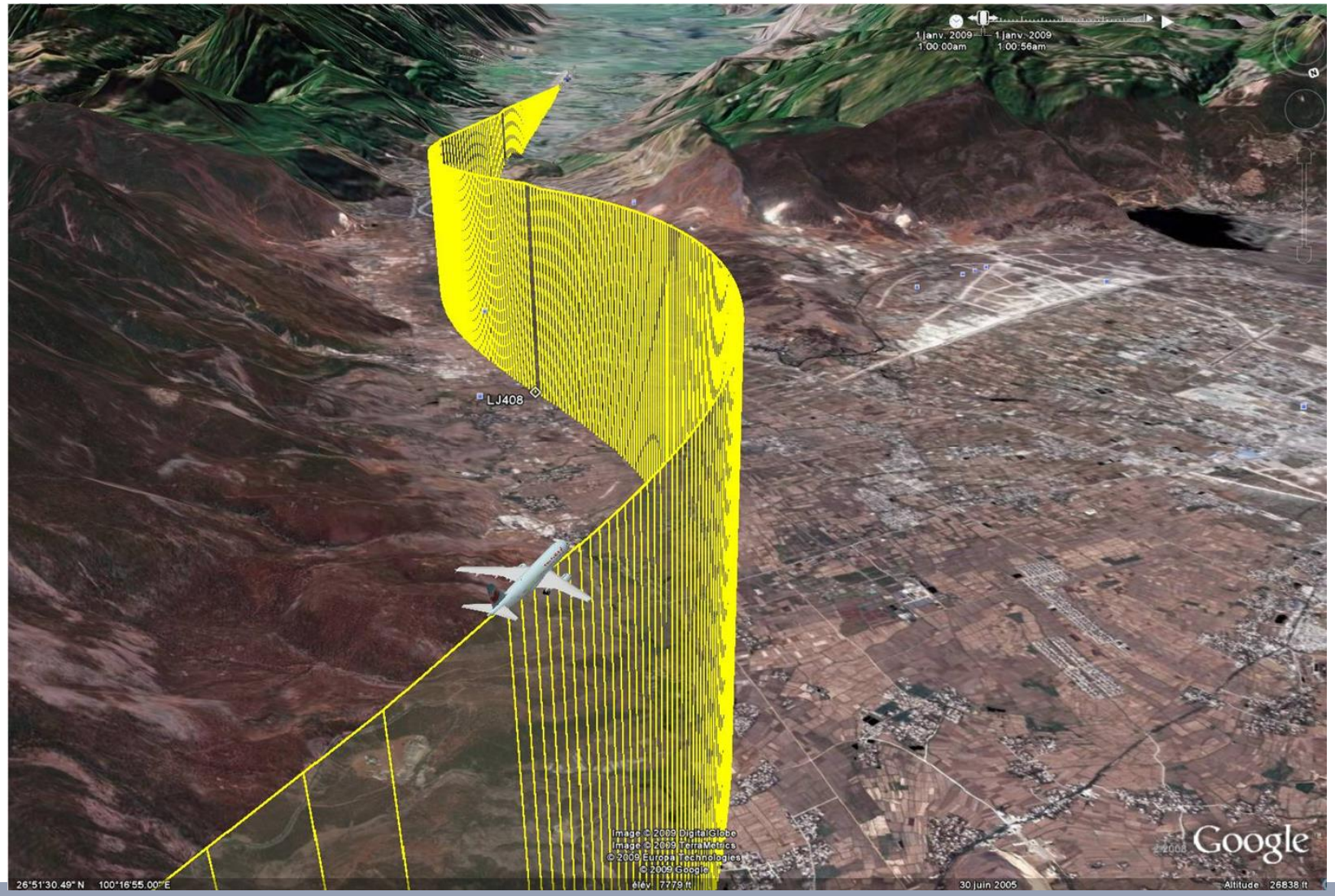
Conventional Route Following VORs

WHY PBN

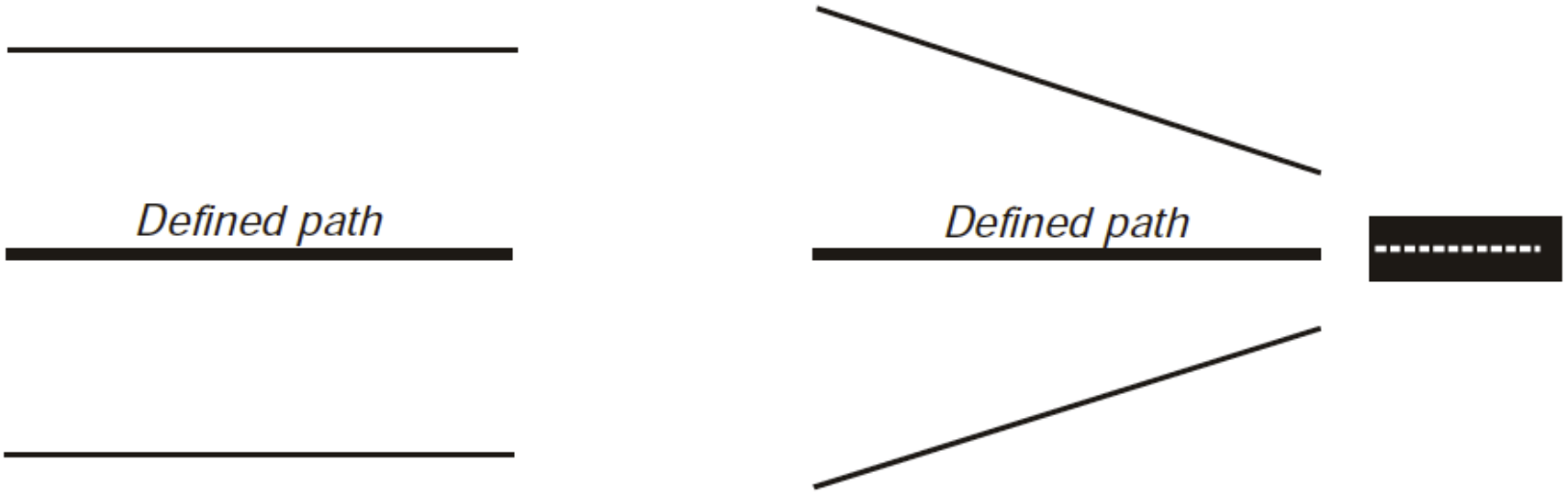


PBN Route Using Waypoints

PBN APPROACH - FLEXIBILITY IN DESIGN



NAVIGATION SPECIFICATION



a) PBN: linear lateral performance requirements, e.g. RNP and RNAV specifications

b) non-PBN: angular lateral performance requirements, e.g. APV I and APV II

ICAO 9613 figure I-A-1-2

PERFORMANCE

Performance described in terms of accuracy value.

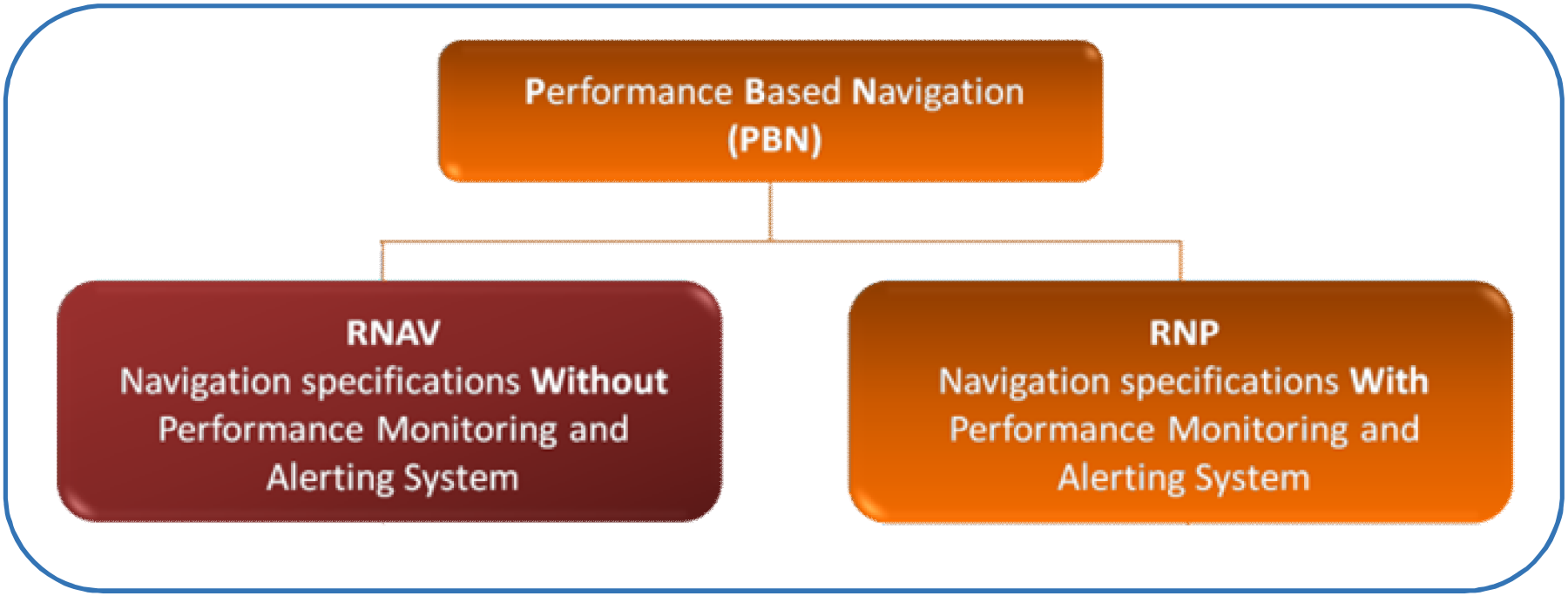
RNAV[x] or RNP[x] where [x] is the accuracy value in nm.

Examples:

- RNAV 5 = 5nm either side of centerline
- RNP 1 = 1nm either side of centerline
- RNP 0.3 = 0.3nm either side of centerline

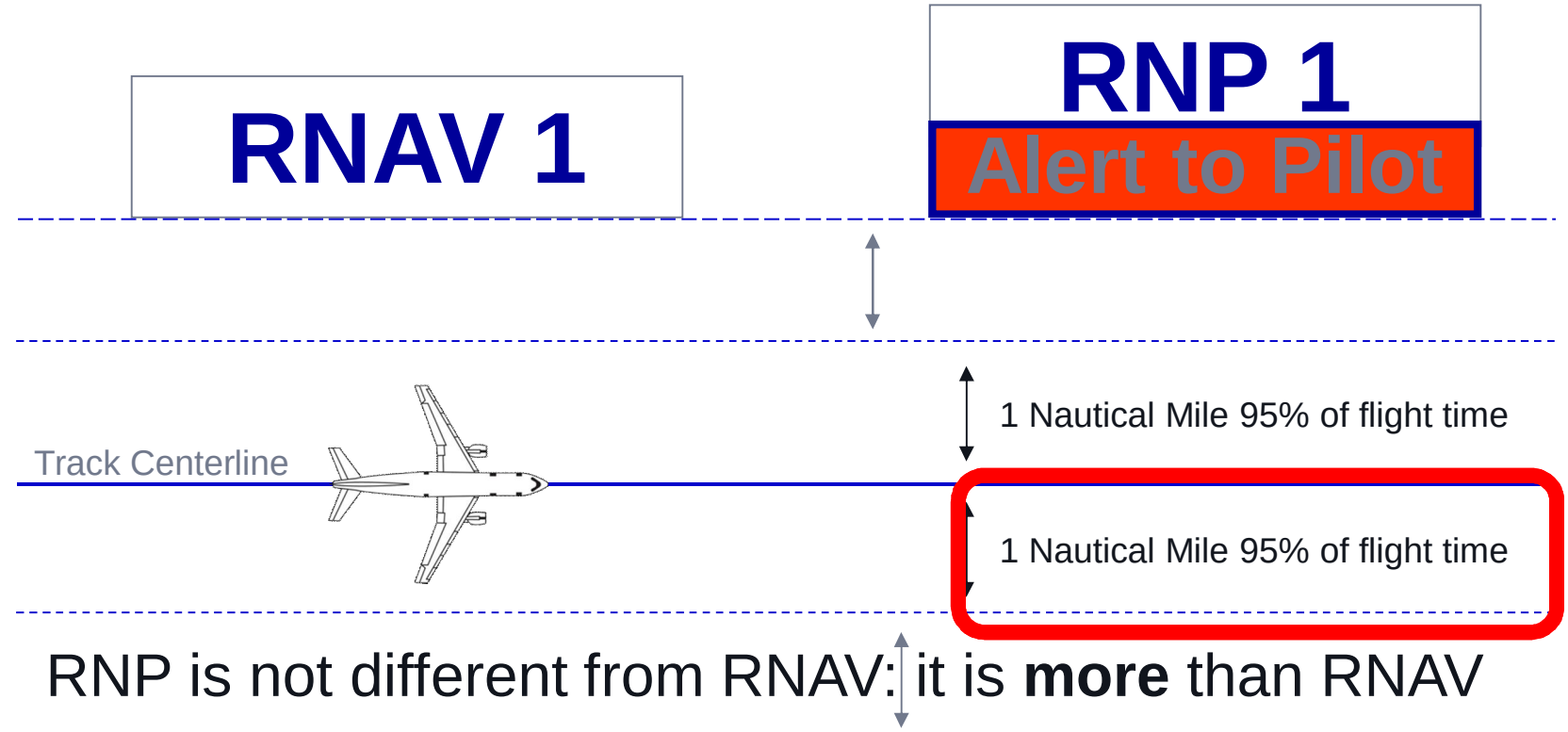
NAVIGATION SPECIFICATION

Two types of navigation specifications exist



RNP = RNAV + OPMA (On-board Performance Monitoring and Alerting)

RNAV and RNP



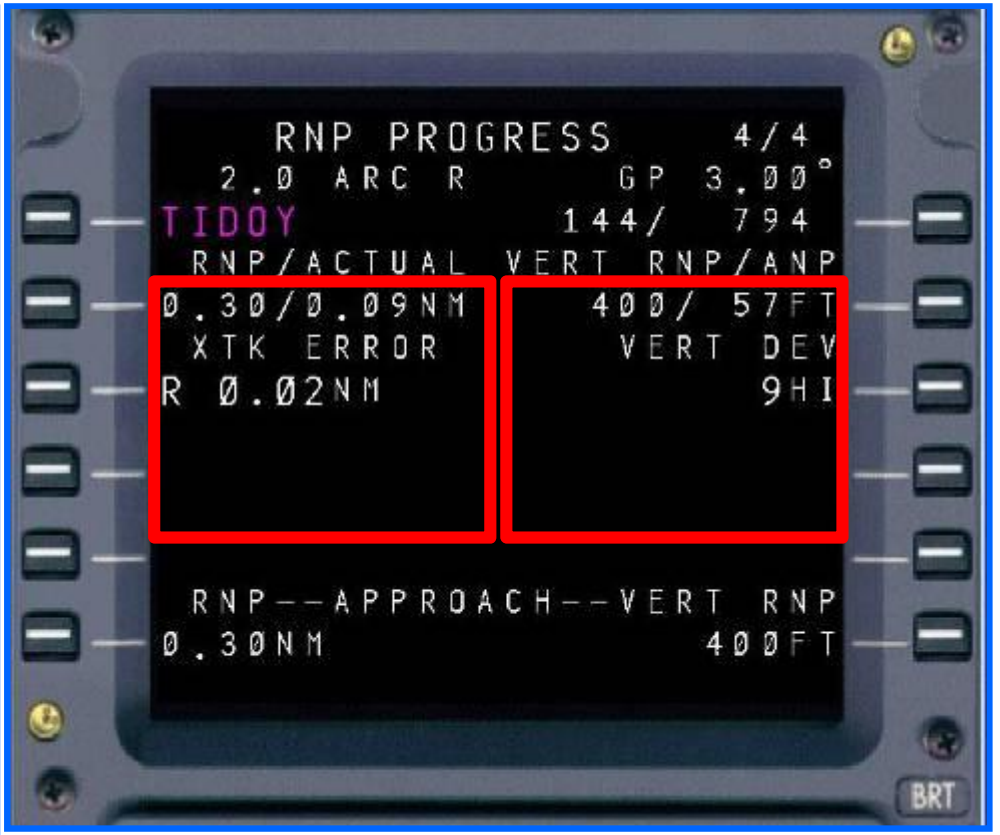
The Key Extra Ingredient:
On-Board Performance Monitoring and Alerting

ROLE OF OPMA

- Allows flight crew to determine whether the airborne system meets the navigation performance required.
- Relates to lateral and longitudinal performance but not vertical.
- Provides greater assurance of lateral track keeping.

RNP

RNP *is* RNAV with the additional requirement of On Board Performance Monitoring and Alerting

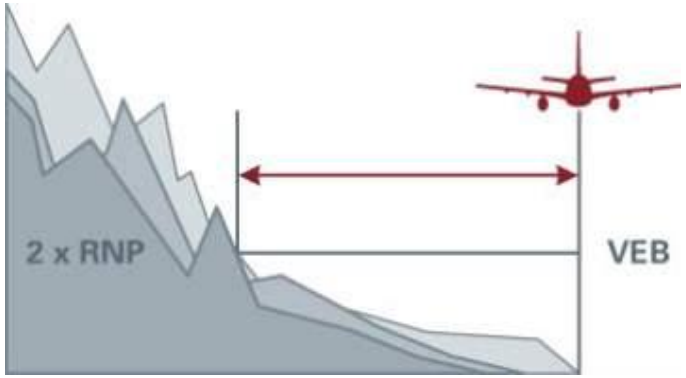


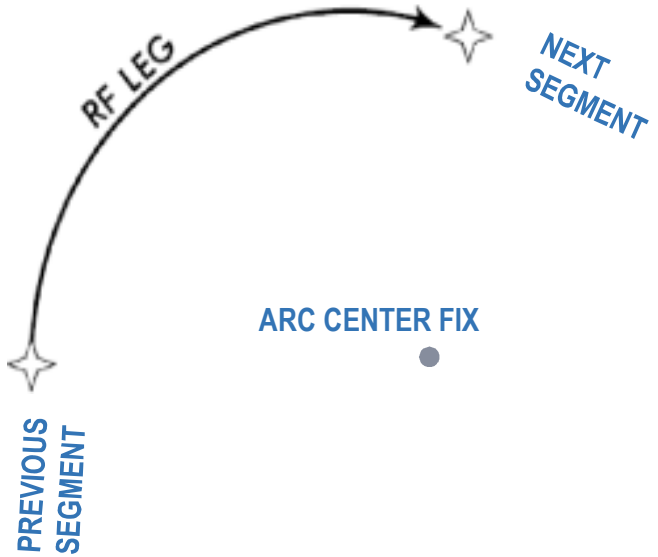
RNP AR DEFINITION

RNP AR stands for Authorization Required (ICAO wording), equivalent to RNP SAAAR (ex-FAA wording)

An RNP AR procedure has one of the following characteristics:

- Reduced RNP values lower than 0.3 in approach (down to 0.1 NM) or lower than 1 NM in missed approach and/or departure;
- Curved flight path after FAF (RF legs);
- Reduced obstacle protections, at 2xRNP, without buffers





PBN REQUIREMENTS: *LEVELS OF QUALIFICATION*

EQUIPMENT LEVEL APPROVAL

NAVIGATOR BOX
e.g. GPS of type ABC

- GPS could be a sensor in multi-sensor system or a self-contained and stand-alone navigator;

AIRCRAFT LEVEL APPROVAL

- Installation approval on aircraft against an EASA AMC or FAA AC which includes an operational context e.g. RNAV 5;

OPERATOR LEVEL APPROVAL

+

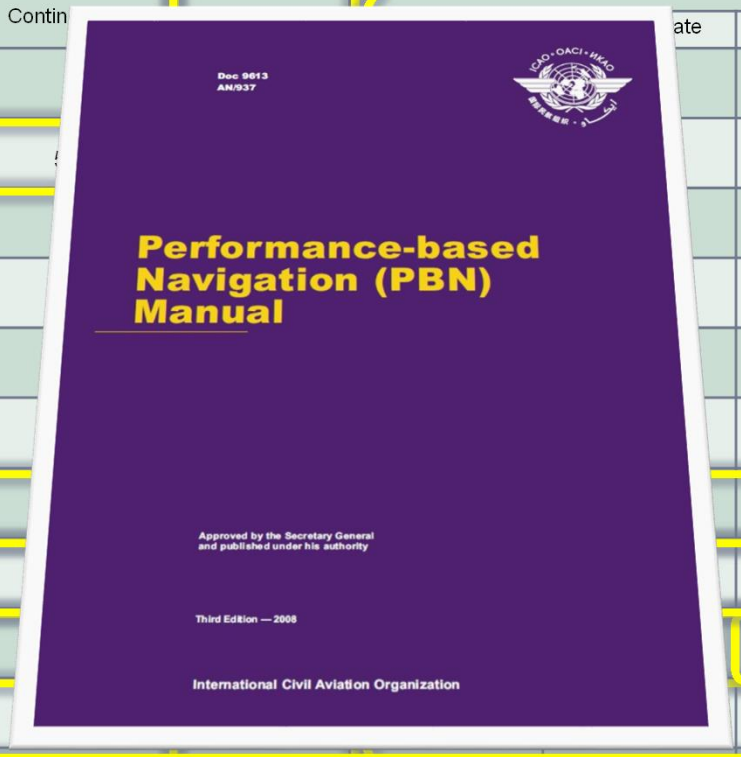
- For the aircraft installation to be used by pilot, operational approval needed.
- Operational Approval is concerned with training, flight crew procedures, quality, database management, etc.

AIRBUS

NAVIGATION SPECIFICATION BY FLIGHT PHASE

8. The RNP 0.3 specification is primarily intended for helicopter operations.

Navigation Specification	Flight phase							
	En-route oceanic/remote	En-route Contin	Arrival			Approach Final	Approach Missed [1]	Departure
RNAV 10	10							
RNAV 5 [2]								
RNAV 2								2
RNAV 1							1	1
RNP 4	4							
RNP 2	2							
RNP 1 [3]							1	1
Advanced RNP [4]	2 [5]					0.3	1	1
RNP APCH [6]						0.3 [7]	1	
RNP AR APCH						0.3-0.1	1-0.1	
RNP 0.3 [8]		0.3	0.3	0.3	0.3		0.3	0.3



AIRBUS

PBN ï ADVANCED RNP

ICAO State Letter SP 65/4-13/24

Proposes amendments to:

- PANS-OPS, Volume I
- PAN-OPS Volume II
- Annex 4
- Annex 6, Parts I, II and III
- Annex 14, Volume II
- Annex 15
- PANS-ABC

Applicable on 13 November 2014

International Civil Aviation Organization | Organisation de l'aviation civile internationale | Organización de Aviación Civil Internacional | Международная организация гражданской авиации | منظمة الطيران المدني الدولي | 国际民用航空组织

Tel.: +1 (514) 954-8219 ext. 6718

Ref.: SP 65/4-13/24 — 14 June 2013

Subject: Proposal for the amendment of PANS-OPS, Volumes I and II regarding procedure design criteria and charting requirements to support performance-based navigation (PBN) as well as helicopter point-in-space (PinS) approach and departure operations with consequential amendments to Annexes 4; 6, Parts I, II and III; 14, Volume II; 15 and the PANS-ABC

Action required: Comments to reach Montréal by 30 September 2013

Sir/Madam,

1. I have the honour to inform you that the Air Navigation Commission, at the tenth meeting of its 192nd Session on 7 March 2013 and the twelfth meeting of its 193rd Session on 4 June 2013, considered proposals developed by the Instrument Flight Procedures Panel (IFPP) seventh, eighth, ninth, tenth and eleventh working group of the whole meetings to amend the *Procedures for Air Navigation Services — Aircraft Operations*, Volume I — *Flight Procedures* and Volume II — *Construction of Visual and Instrument Flight Procedures* (PANS-OPS, Doc 8168) with consequential amendments to Annex 4 — *Aeronautical Charts*; Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*, Part II — *International General Aviation — Aeroplanes* and Part III — *International Operations — Helicopters*; Annex 14 — *Aerodromes*, Volume II — *Heliports*; Annex 15 — *Aeronautical Information Services*; *Procedures for Air Navigation Services — ICAO Abbreviations and Codes* (PANS-ABC, Doc 8400) regarding flight procedure design criteria and associated charting requirements for performance-based navigation (PBN), in particular for the new navigation specifications as well as for helicopter point-in-space (PinS) approach and departure operations.

2. The proposed amendment to PANS-OPS, Volumes I and II are in Attachments B and C, respectively. Consequential amendments to Annexes 4; 6, Parts I, II and III; 14, Volume II; 15 and the PANS-ABC are in Attachments D to H, respectively.

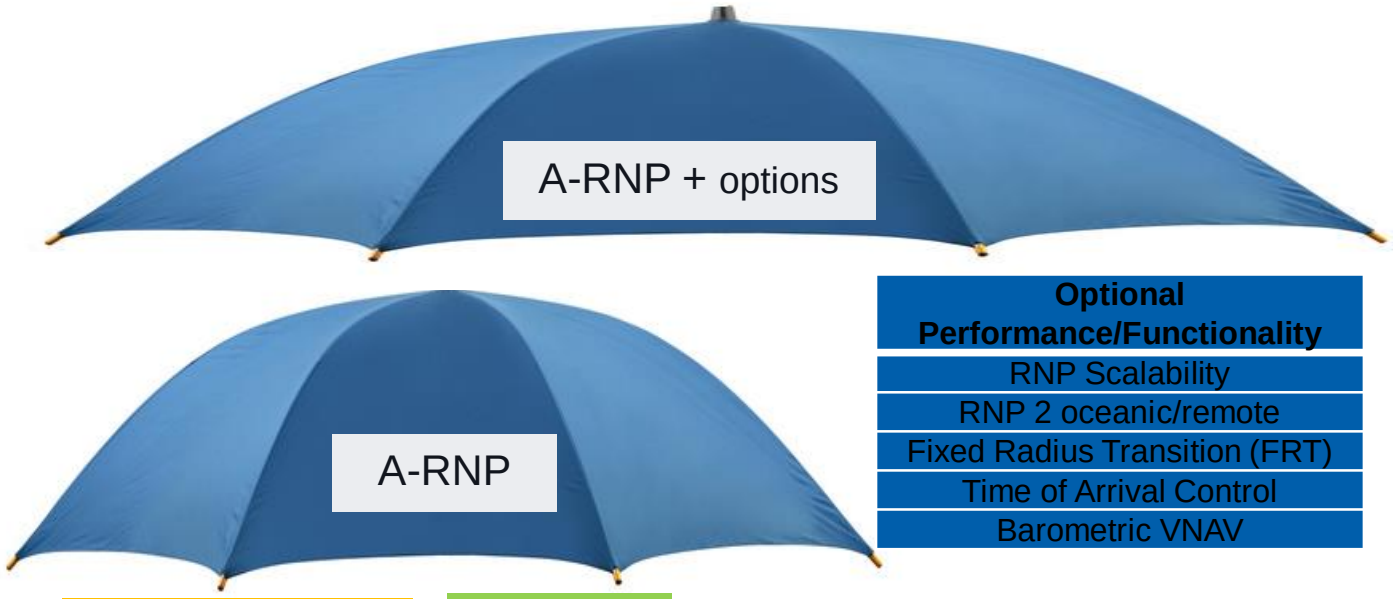
3. The amendment proposals address specific areas as listed and explained in Attachment A.

4. To facilitate your review of the proposed amendments, the rationale for each proposal has been provided in the text boxes immediately following the proposals throughout Attachments B, C, D, E, F, G and H.

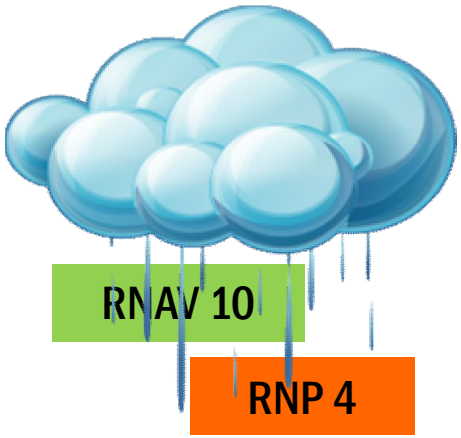
999 University Street, Montréal, Quebec, Canada H3C 5H7 — Tel.: +1 514-954-8219, Fax: +1 514-954-6077 — E-mail: icaohq@icao.int, www.icao.int

AIRBUS

PBN ï ADVANCED RNP

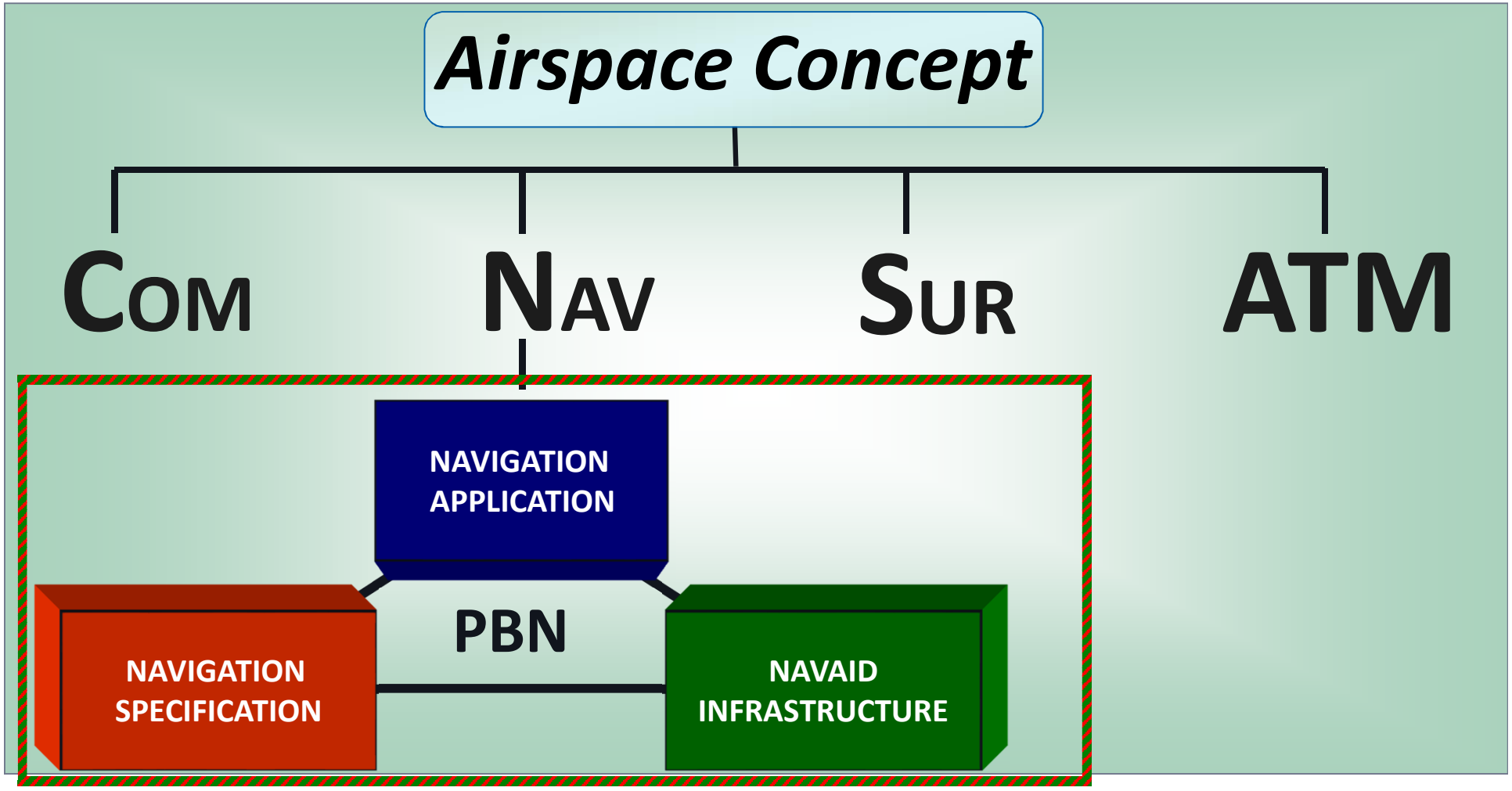


Optional Performance/Functionality
RNP Scalability
RNP 2 oceanic/remote
Fixed Radius Transition (FRT)
Time of Arrival Control
Barometric VNAV



AIRBUS

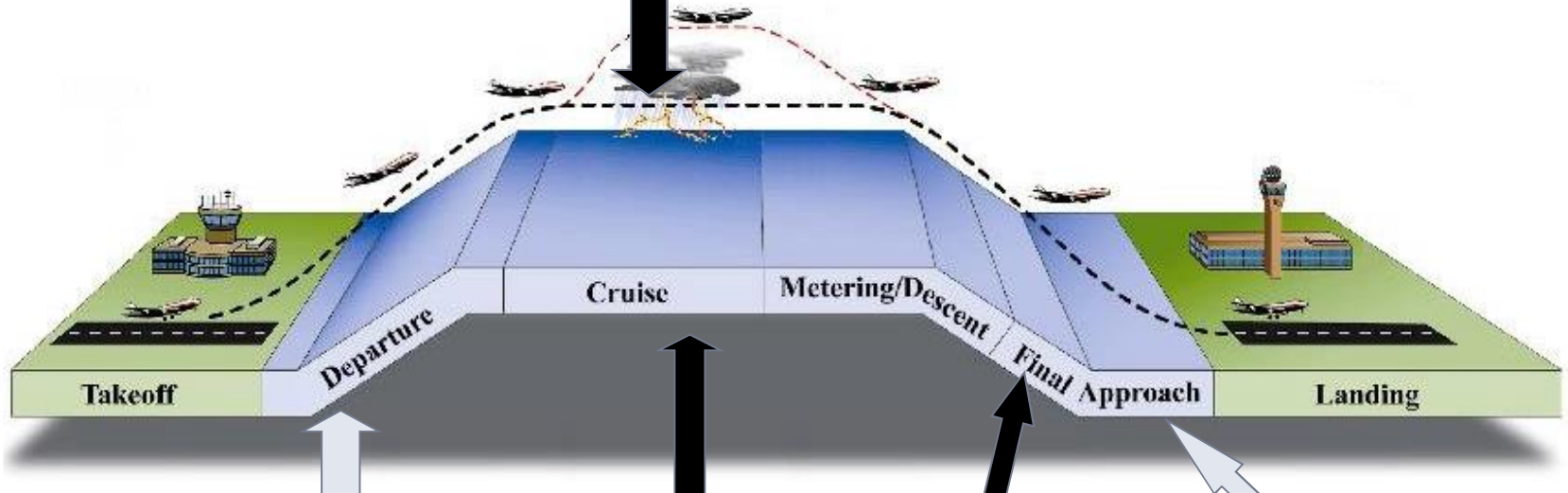
PBN ENABLES THE AIRSPACE CONCEPT



AIRBUS

NAVIGATION SPECIFICATION BY FLIGHT PHASE

OCEANIC / Enroute Remote (nonSUR)
RNAV 10, RNP 4, RNP 2, Advanced RNP 2



RNAV 1/2 &
RNP 1 SIDs
ARNP 1 SIDs

RNAV 5/2/1
RNP 2
Advanced RNP 2 or 1
Enroute Continental

RNAV 1/2 &
RNP 1 STARs
ARNP 1 STARs

RNP Approach
RNP-AR Approach

AIRBUS

Performance-based Navigation

2007 - ASSEMBLY RESOLUTION A36-23: PBN GLOBAL GOALS

The Assembly:

1. Urges 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 PBN Manual (Doc 9613).
2. *Resolves* that:
   a) States and planning implementation regional groups (PIRGs) ***complete a PBN implementation plan by 2009*** 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) for all instrument runway ends; either as a primary approach or as a back-up for precision approaches ***by 2016*** with intermediate milestones as follows: ***30 percent by 2010***, ***70 percent by 2014***; and
   b) ICAO develop a coordinated action plan to assist states in implementation of PBN...

2010 ï ASSEMBLY RESOLUTION A37-11: PBN GLOBAL GOALS

**Supersedes A36-23*

The Assembly:

1.Urges 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 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;
   2) Implementation of Approach Procedures with Vertical guidance (**APV)** (Baro-VNAV and/or augmented GNSS)**, including LNAV** (Lateral Navigation) **only minima**, for all instrument runway ends; either as a primary approach or as a back-up for precision approaches ***by 2016*** with intermediate milestones as follows: ***30 percent by 2010, 70 percent 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

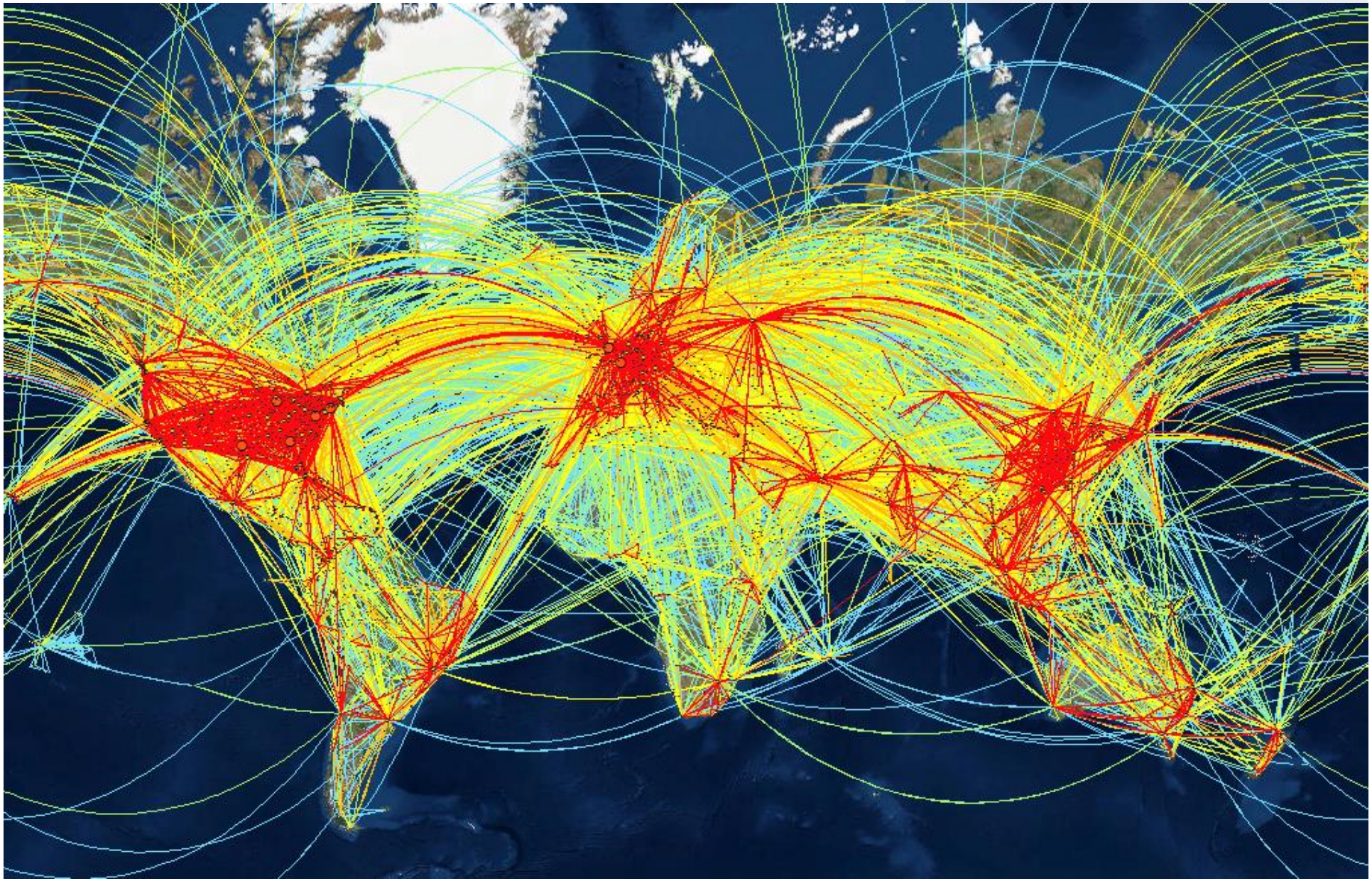
b) ICAO develop a coordinated action plan to assist states in implementation of PBN..

ICAO STRATEGIC OBJECTIVES 2014-2016

ICAO has established five Strategic Objectives for 2014-2016:

1. SAFETY
2. AIR NAVIGATION CAPACITY AND EFFICIENCY
3. SECURITY AND FACILITATION
4. ECONOMIC DEVELOPMENT OF AIR TRANSPORT
5. ENVIRONMENTAL PROTECTION

WORLDWIDE FLIGHT ROUTES



WHY A PBN PLAN

Why is the PBN Implementation Plan or Roadmap needed?

- To implement the regional PBN plans at the State level and address PBN implementation strategy at the national level

- To provide proper guidance and direction to the domestic air navigation service provider(s), airspace operators and users, regulating agency, as well as foreign operators who operate or plan to operate in the State
  - Assist the main stakeholders plan a gradual transition to the RNAV and RNP concepts
  - Assist the stakeholders in planning their investment strategies during the future transition

- ***The benefits of PBN only come with implementation***

HOW TO PBN PLAN

This PBN Implementation Workshop is intended to assist States/Administrations in enhancing their PBN Implementation Plans and move forward with actual PBN executions.

The Workshop will also provide updated information regarding global PBN activities and how PBN can be an enabler for enhancing ATM operations.

END

Advanced RNP

- A-RNP is based upon GNSS
  - ANSPs should ensure operators relying on GNSS are required to have the means to predict the availability of GNSS fault detection (e.g. ABAS RAIM)
- Operator procedures, maintenance, dispatch and other operations processes that satisfy the A-RNP criteria will be considered acceptable for RNAV 1, RNAV 2, RNAV 5, RNP 2, RNP 1 and RNP APCH Part A.
- An A-RNP aircraft qualification can be more broadly applicable to multiple navigation specifications without the need for re-examination of aircraft eligibility. This enables an operator's approved procedures, training, etc to be common to multiple navigation applications.
- The RNP system should provide the ability to intercept the final approach at or before the final approach fix. This functional capability must provide the pilot with the ability to rejoin the published final approach track following a period when the aircraft has been flown manually, or in AFCS Heading mode, following ATC vectors to support Final Approach Sequencing.