RNP Regional Interoperability

Australian Government
Civil Aviation Safety Authority
www.casa.gov.au

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safe skies for all

Scope

- Purpose of PBN
- ICAO RNP framework
- Impediments to Interoperability
- Australia's approach to PBN implementation
- Proposed APAC Regional RNP framework
- Summary

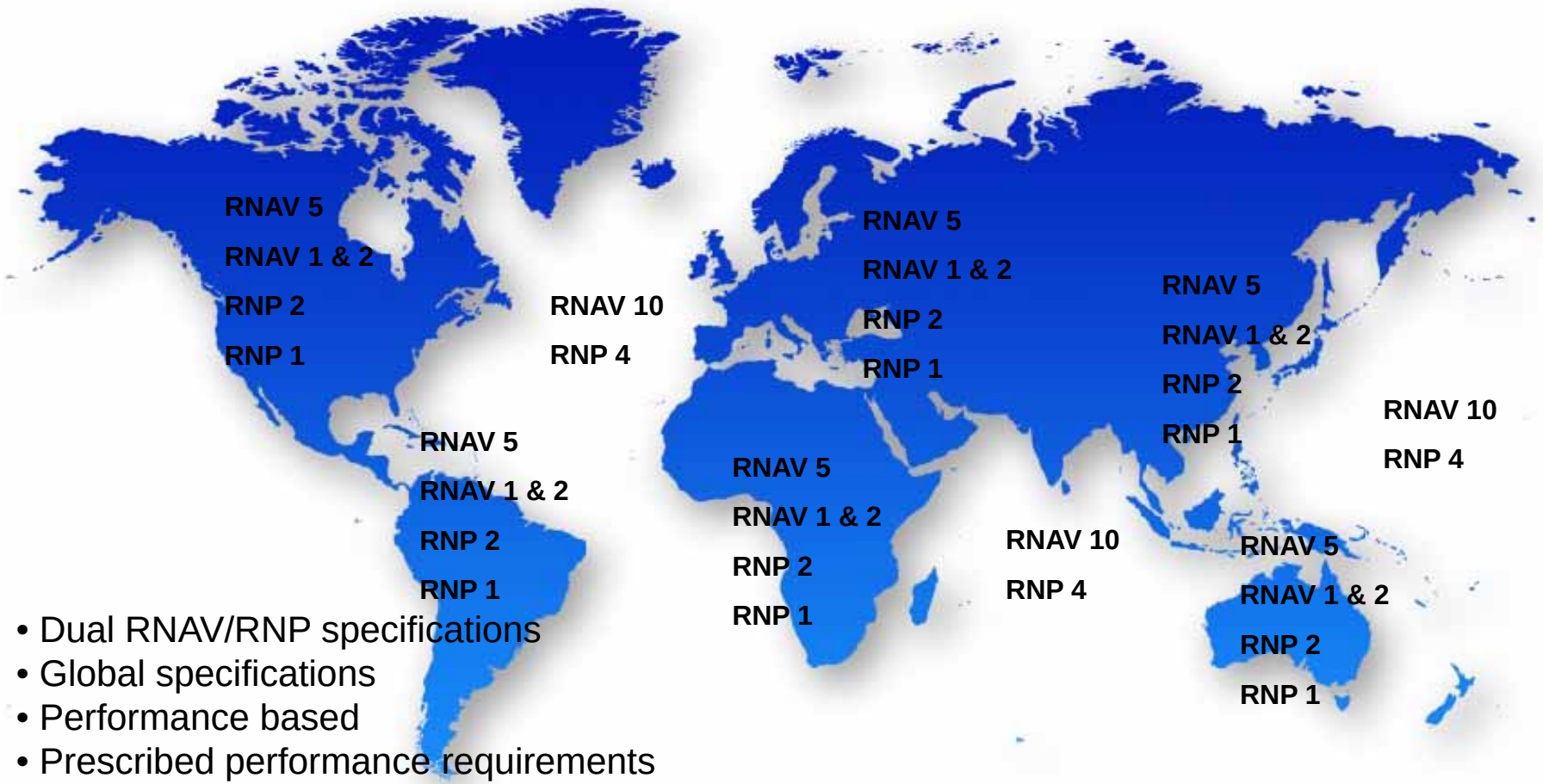
Purpose of PBN

- Global harmonisation of navigation specifications
  - Seamless global ATM – global interoperability
  - Seamless global regulatory requirement
  - RNAV specs harmonise legacy and current RNAV operations
  - RNP specs harmonise current and future RNP operations
  - Global application of operational approvals per Annex 6 Ch 4.2

PBN is the global harmonisation of IFR navigation specifications

- Multiple RNAV specifications
- Specifications by State or Region
- Prescribed equipment requirements
- Multiple approvals required from individual State authorities

ICAO global PBN navigation specifications



- Dual RNAV/RNP specifications
- Global specifications
- Performance based
- Prescribed performance requirements
- Single approval required – global recognition between regulators

ICAO RNP framework – value based, area navigation enabled

- Taxonomy
  - One dimension taxonomy “RNP value”
  - Numerically based but mathematically illogical
- Functionality
  - Non-hierarchal relationship between nav specs
  - Change in RNP value requires a new nav spec
- Performance varies as a function of the aircraft and ATM area navigation capability
  - Aircraft: DME/DME, DME/DME/IRU, GNSS/IRU or GNSS equipped
  - ATM: DME density and disposition

ICAO value based, area navigation enabled RNP framework

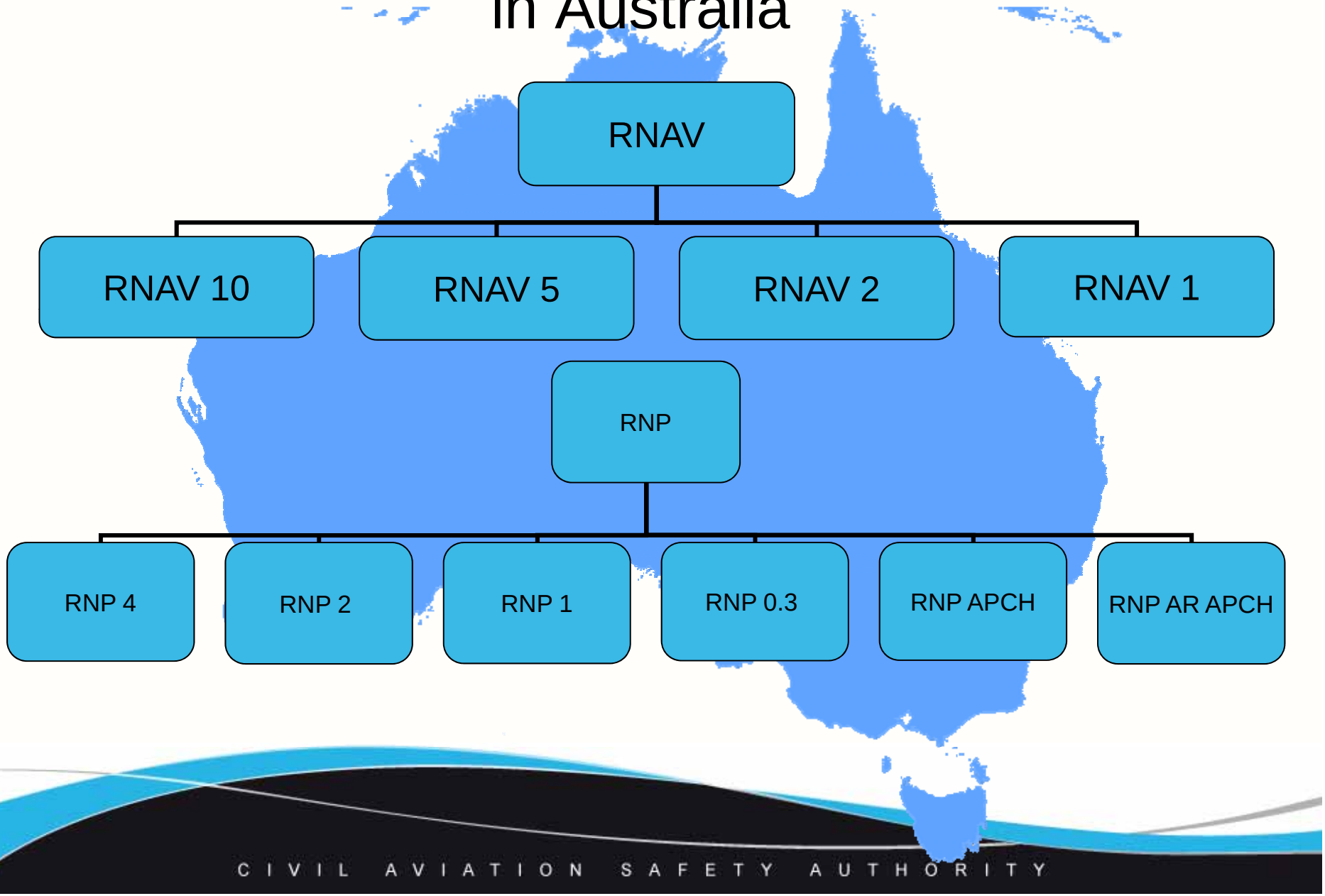
	Navigation Specification					
	RNP 4	RNP 2 (draft)	**RNP 0.3 (draft)**	Basic RNP 1	**RNP APCH/ AR APCH**	**RNP DEP (draft)**
Application	Oceanic / Remote Continental	Remote continental and continental enroute	Continental enroute	Terminal area	Terminal area	Terminal area
Nav System	2 x GNSS enabled LRNS	2 x GNSS enabled LRNS (remote) 1 x GNSS or DME/DME* (continental)	2 x GNSS (draft)	1 x GNSS or DME/DME*	1 x GNSS or 2 x GNSS and/or 1 x IRS * (RNP AR APCH)	2 x GNSS or 2 x GNSS and/or 1 x IRS

* While DME/DME-based RNAV systems are capable of RNP 2 and 1accuracy, the increased complexity in the DME infrastructure requirements and assessment necessary to support an RNP 2 or 1 application means it is not expected to be practical or cost-effective for widespread application of DME/DME based RNP 2 or RNP 1. For RNP AR APCH DME/DME may be used a reversionary capability for individual operators where the infrastructure supports the required RNP AR APCH performance.

Impediments to interoperability

- No common area navigation system results in uncertainty of performance
  - Inconsistent performance
    - Performance is conditional (aircraft and terrestrial infrastructure in combination)
    - Terrestrial ATM infrastructure varies by State or region
  - Unpredictable performance
    - Range/altitude considerations
- These limitations result in
  - Lack of technical, operational and regulatory interoperability
  - Inability to apply systems based ATM management regionally or globally
  - Complexity and difficulty in comprehending, educating and implementing PBN concepts

ICAO PBN navigation specifications applied in Australia



Europe, USA, Australia radionavigation aid density comparison

Country	Europe (ECAC)	USA	Australia
Size (million km^2)	6.6	9.6	7.7
Aircraft (> 5,700Kg)	3,754	3,712	603
NDBs	1130	750	279
VORs	733	1012	92
DME	949	1012	72
Total Nav Aids	2,812	2,774	443
Enroute Nav	BRNAV (RNAV 5)	US RNAV 5	GPS
TMA Nav	PRNAV (RNAV 1)	RNAV A (RNAV 2) RNAV B (RNAV 1)	GPS
Area (km^2)/Nav Aid	2,347	3,461	17,381

Europe, USA, Australia VOR/DME density comparison

Country	Europe (ECAC)	USA	Australia
Size (million km^2)	6.6	9.6	7.7
VORs	733	1012	92
DME	949	1012	72
Total DME/VOR	1682	2024	164
Area (km^2)/Nav Aid	3924	4743	46 951

Europe, USA, Australia DME density comparison

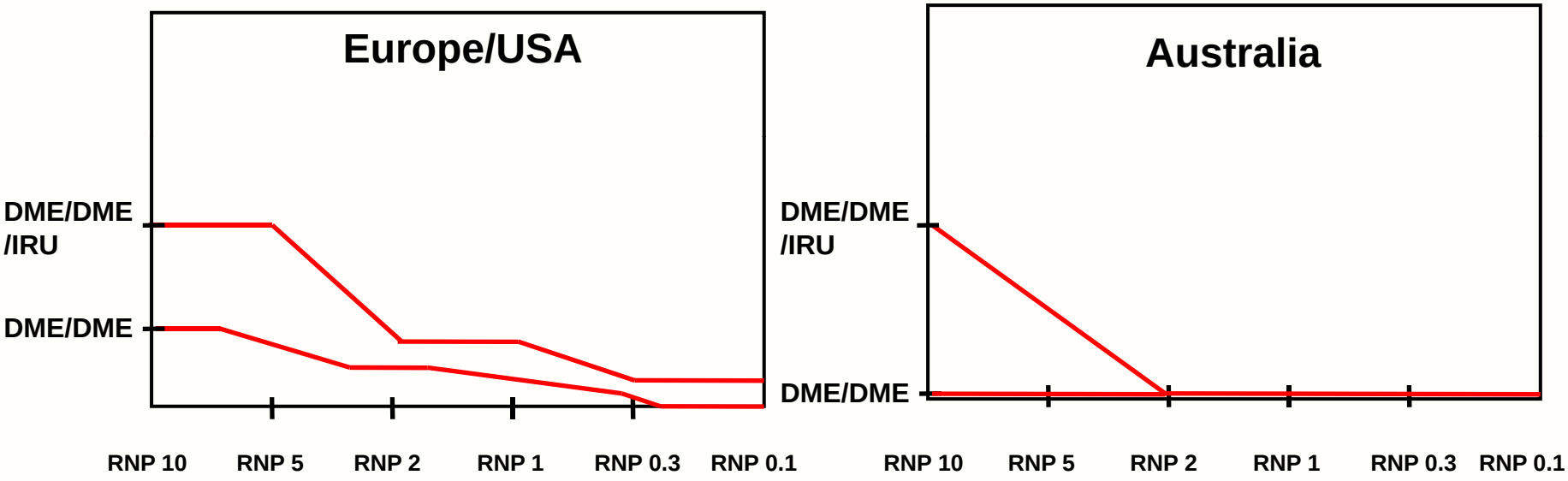
Country	Europe (ECAC)	USA	Australia
Size (million km^2)	6.6	9.6	7.7
DME	949	1012	72
Area (km^2)/Nav Aid	6954	9486	106 944

Disparity in global radionavigation aid density results in inconsistent and unpredictable navigation performance

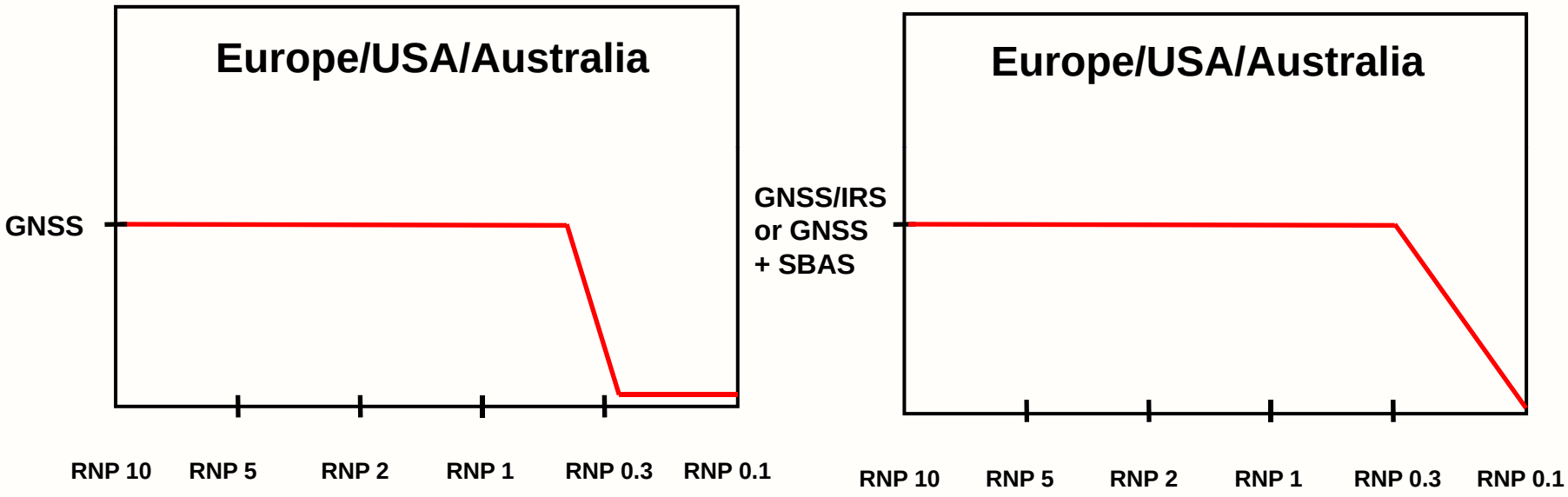
Aircraft Nav System	System Performance		
	Europe (ECAC)	**USA**	**Australia**
DME/DME/IRU	• RNAV 5 assured • RNAV 2 and 1 conditional • RNP 2 and 1 conditional • RNP 0.3 not supported	• RNAV 5 assured • RNAV 2 and 1 conditional • RNP 2 and 1 conditional • RNP 0.3 not supported	• RNAV 5 conditional • RNAV 2 and 1 not supported • RNP 2, 1 and 0.3 not supported
GNSS	• RNP 1 assured • RNP 0.3 conditional	• RNP 1 assured • RNP 0.3 conditional	• RNP 1 assured • RNP 0.3 conditional
GNSS/IRS or GNSS + SBAS	• RNP 0.3 assured*	• RNP 0.3 assured*	• RNP 0.3 assured*

* Based on tightly coupled GNSS/IRS or GNSS + SBAS and minimum of 24 satellites

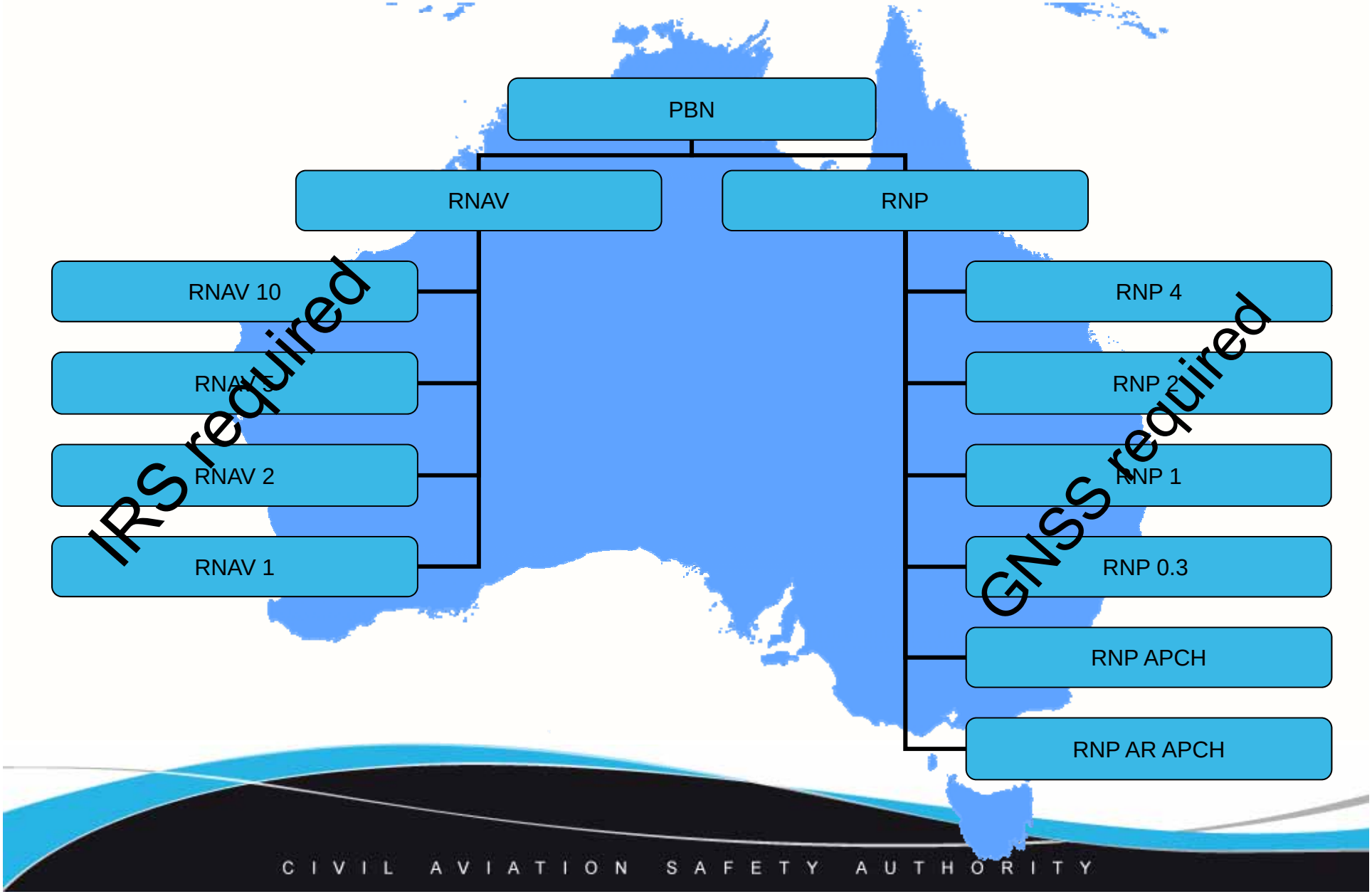
Disparity in global radionavigation aid density results in inconsistent and unpredictable navigation performance



Use of GNSS enables constant and predictable navigation performance



Australia’s approach to PBN implementation



Hierarchical based GNSS enabled RNP framework – a basis for regulatory development

RNP Value	Phase of Flight			
	Oceanic (and remote continental)	Enroute (continental enroute and terminal)	Approach	Departure
4	2 x GNSS	N/A	N/A	N/A
2	2 x GNSS	1 x GNSS	N/A	N/A
1	N/A	1 x GNSS	1 x GNSS	1 x GNSS
0.3	N/A	2 x GNSS	1 x GNSS	2 x GNSS
Below 0.3	N/A	N/A	2 x GNSS	2 x GNSS

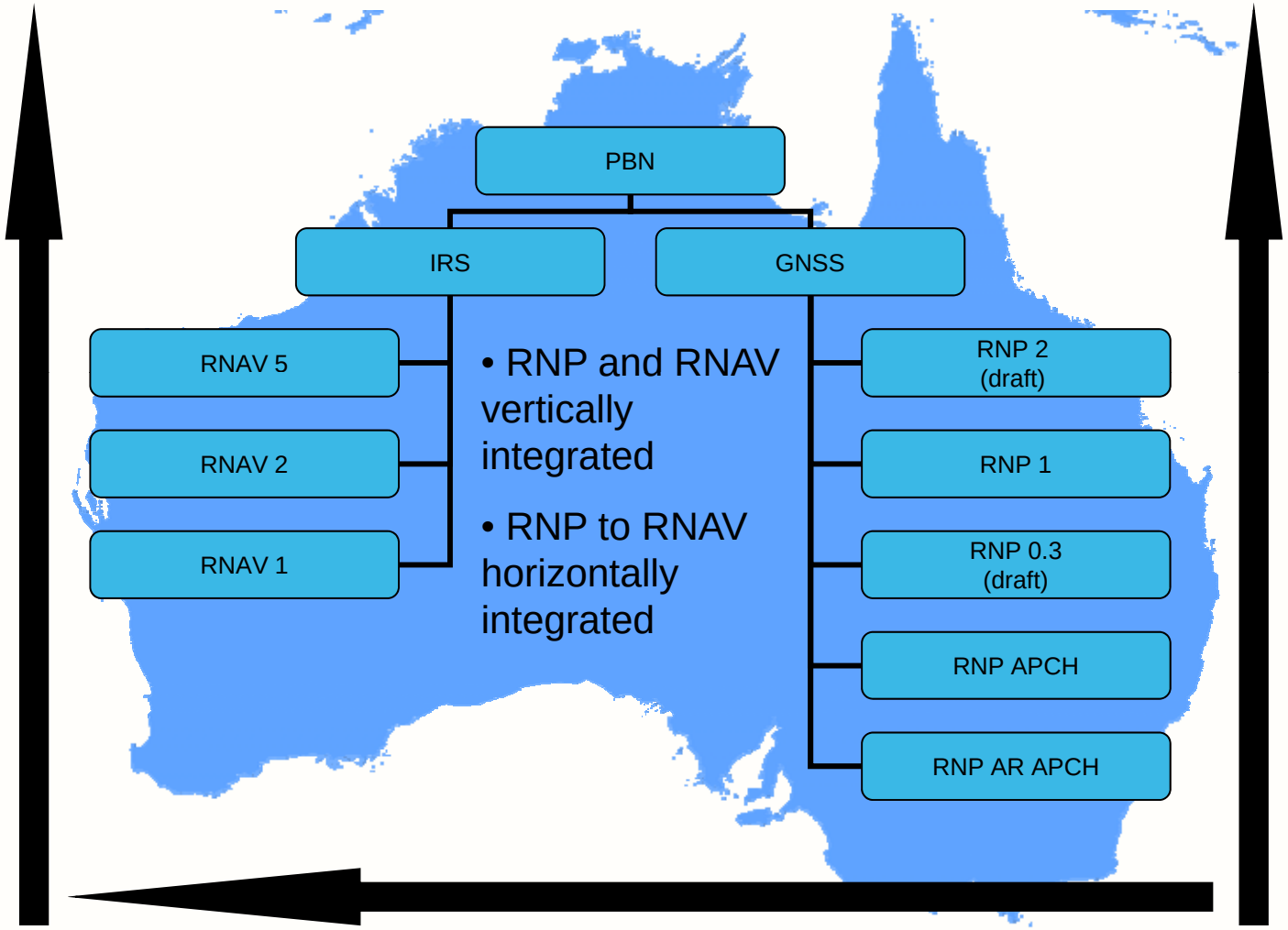
PBN regulatory structure - Australia

- Navigation Authorisations are hierarchical eg:
  - RNP AR APCH qualifies for RNP APCH – LNAV and LNAV/VNAV
  - RNP 1 qualifies for RNAV 1, 2 and 5
  - RNAV 1 qualifies for RNAV 2 and 5
- Requirements for RNAV 10 and RNP 4 unchanged
- RNP 2 and RNP 0.3 will “require” GNSS and will be hierarchical

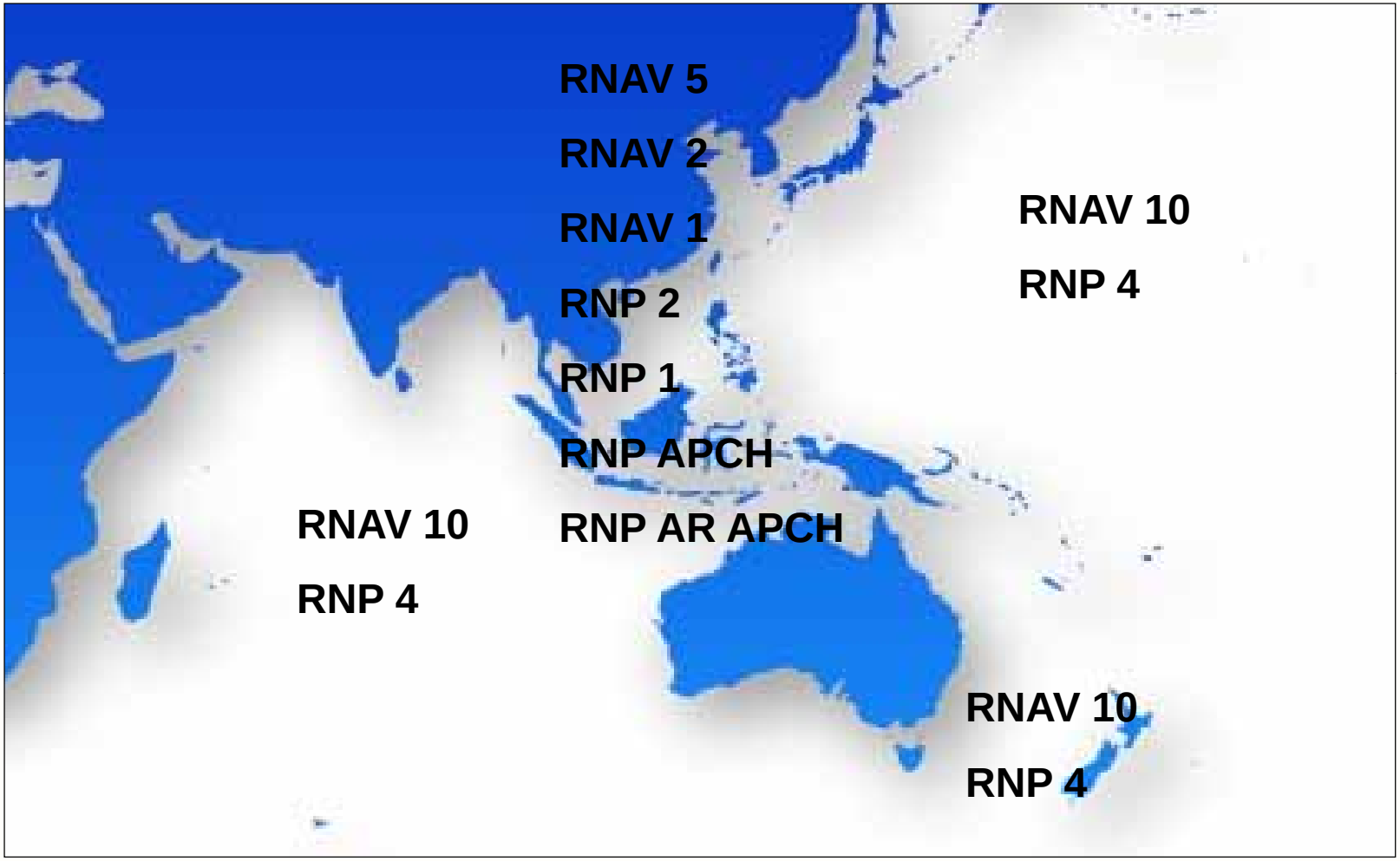
PBN regulatory structure - Australia

- Draft CAO 20.91 Navigation Authorisations “deeming” provisions
  - Stand alone navigator TSO-129 () and TSO-C146 () or ETSO-C146()
    - RNAV 5, 2 and 1
    - RNP 1
  - Stand alone navigator TSO-C129a and ETSO-C129a
    - RNAV 5, 2 and 1
    - RNP1
    - RNP APCH – LNAV
  - Stand alone navigator TSO-C146 () and ETSO-C146 ()
    - RNAV 5, 2 and 1
    - RNP1
    - RNP APCH – LNAV, LP and LPV
  - FMS equipped aircraft to be assessed (but many expected to “equivalent” to TSO-129a or certified TSO-C145/146)

PBN regulatory structure in Australia
(continental enroute and terminal)

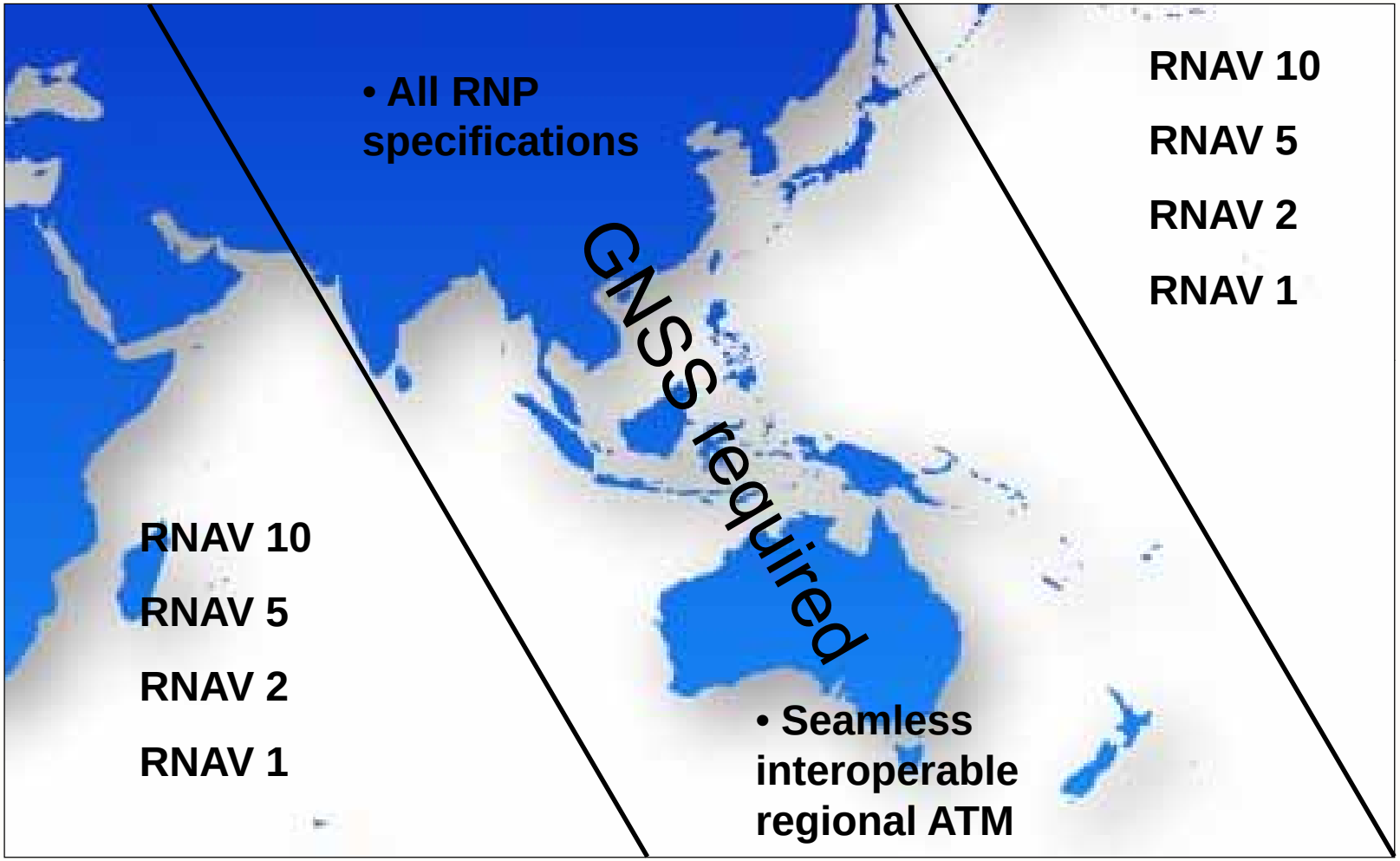


PBN navigation specifications planned for APAC*

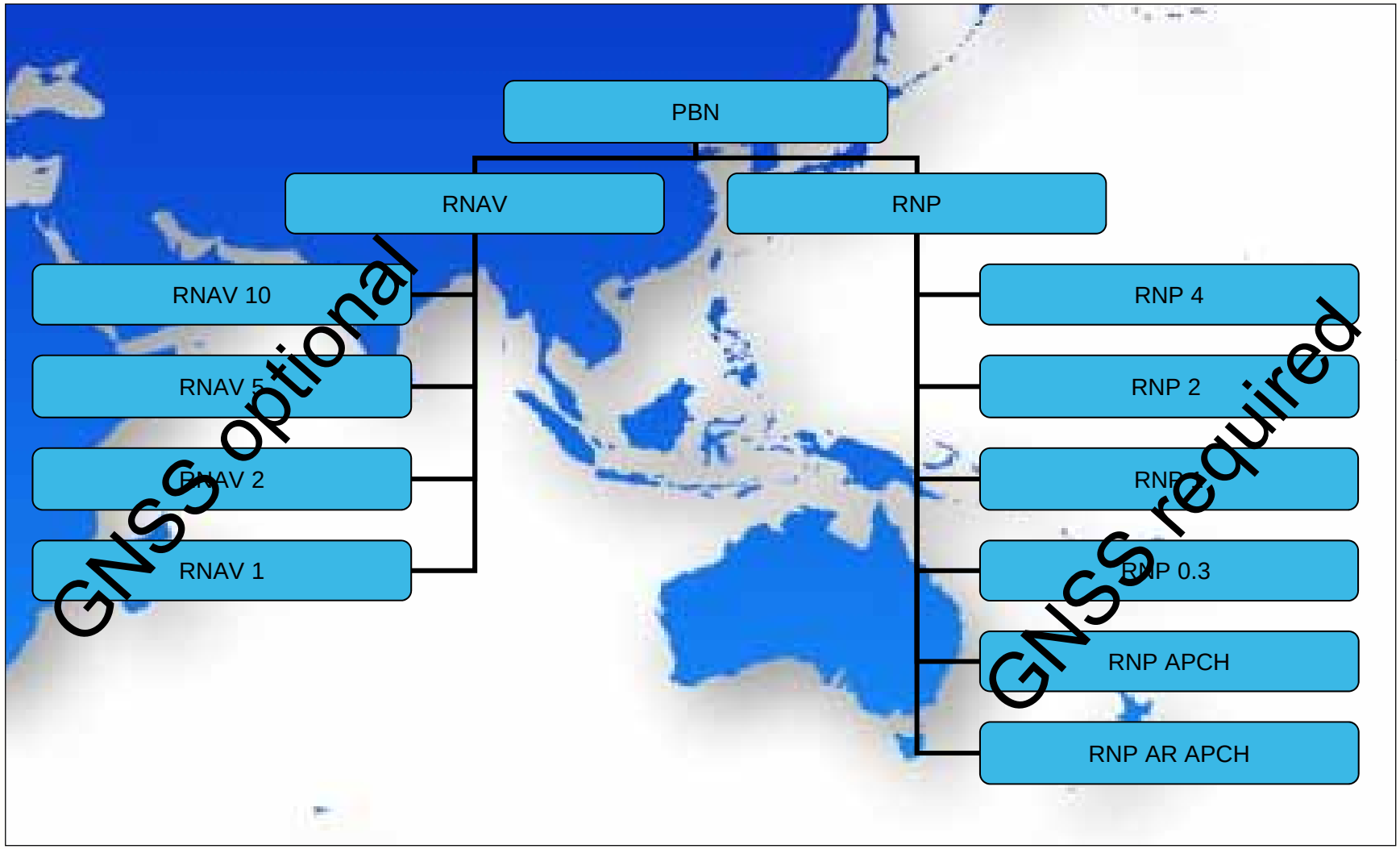


*Based on PBN TF7 review of State plans

GNSS enabled RNP navigation specifications



Proposed APAC regional RNP framework



Benefits of APAC regional RNP framework

Example – RNP Oceanic/Remote Continental					
RNP Value (RNP values can be any value between 4 and 2 to two decimal places eg: RNP 3.5	Equipment	Op Approval	Recognition Of Op Approval	Sep Std	LSALT
4	2 x GNSS enabled LRNS	"RNP 4 Oceanic"	All APAC States	30/30* oceanic to 7 CEP continental	Grid, route or PANS OPS semi width
2	2 x GNSS enabled LRNS	"RNP 2 Oceanic/ Remote"	All APAC States	20/20* oceanic to 7nm CEP continental	As above

Note: Oceanic separation standards are mainly limited by communication and surveillance requirements. Improved oceanic communication and surveillance technology will reduce these separation standards accordingly

Benefits of APAC regional RNP framework

Example – RNP Continental Enroute					
RNP Value (RNP values can be any value between 2 and 0.3 to 2 decimal places eg: RNP 1.5)	Equipment	Op Approval	Recognition Of Op Approval	Sep Std	LSALT (PANS-OPS semi-width)
2	1 x GNSS	"RNP 2 Enroute"	All APAC States	GNSS based CEP Eg: 7nm CEP	4 nm H 5 nm A
1	1 x GNSS	"RNP 1 Enroute"	All APAC States	PANS-ATM 7nm between tracks	2.5 nm H 3.5 nm A
0.3	2 x GNSS	"RNP 0.3 Enroute"	All APAC States	PANS-ATM 7nm between tracks	1.45 nm H 2.45 nm A

Benefits of APAC regional RNP framework

Example - RNP Approach				
Line of Minima (RNP values can be to 2 decimal places eg: 0.15)	Equipment	Sep Std	Op Approval (RNP values can be to 2 decimal places eg: 0.18)	Charting
LNAV	1 x GNSS	Dependant on surveillance capability eg: ▪ GNSS based no surveillance 7nm CEP ▪RNP route based ▪7nm ▪GNSS based ADS-B 5nm ▪Radar based 3nm	“RNP APCH LNAV”	RNP APCH RWY 05 LNAV line of minima
LNAV/VNAV	1 x GNSS enabled FMS		“RNP APCH LNAV/VNAV”	RNP APCH RWY 05 LNAV/VNAV line of minima
LP	1 x GNSS		“RNP APCH LP”	RNP APCH RWY 05 LP line of minima
LPV	1 x GNSS		“RNP APCH LPV”	RNP APCH RWY 05 LPV line of minima
0.3-0.1	2 x GNSS enabled FMS		“RNP APCH RNP 0.X”	RNP APCH RWY 05 0.3-0.1 line of minima

Benefits of APAC regional RNP framework

Example - RNP Departure					
RNP for DEP (RNP values can be to 2 decimal places eg: 0.25)	Equipment	Sep Std	Obstacle Clearance	Charting	Op Approval (RNP values can be to 2 decimal places eg: 0.18)
0.3-0.1	2 x GNSS enabled FMS	▪Procedure based (2 x RNP) ▪Radar based 3nm ▪ADS-B based 5nm ▪GNSS based no surveillance 7nm CEP	Parallel containment 2 x RNP AEO 1 x RNP Annex 6 OEI req'ts	RNPDEP RWY 05 RNP 0.3	"RNP DEP 0.3" or "RNP DEP 0.3 to 0.15"

Summary

- The value based, area navigation enabled RNP development framework is limited by
  - inconsistent performance
  - unpredictable performance
- An hierarchical based, GNSS enabled RNP framework provides
  - Consistent performance
  - Predictable performance
- APAC, as a region, should consider moving to a hierarchical based, GNSS enabled RNP framework