International Civil Aviation Organization

SEVENTEENTH MEETING OF THE COMMUNICATIONS/NAVIGATION/SURVEILLANCE SUB-GROUP (CNS SG/17) OF APANPIRG

Bangkok, Thailand, 13 – 17 May 2013

Agenda Item 6.1: PBN Implementation

a) Review outcome of the Performance Based Navigation (PBN) Task Force/10 meeting

GNSS LANDING SYSTEM SEMINAR AND TENTH PBN TASK FORCE OUTCOMES

(Presented by the Secretariat)

SUMMARY

This paper presents the outcomes of the GLS Seminar, and PBN/TF/10 and Workshop for review by this meeting.

1. Introduction

1.1 The Ground-based Augmentation System (GBAS) Landing System (GLS) Seminar was held at Sydney, Australia from 6 to 7 December 2012. The Seminar was attended by 37 participants from Australia, Bangladesh, Fiji, Hong Kong China, India, Malaysia, New Zealand, Singapore, Thailand, Honeywell, IATA, ALPA (affiliated to IFALPA). The GLS Seminar was comprised of 16 technical presentations by experts from airlines, ATC, regulators, air navigation service providers and meteorological service providers.

1.2 The Tenth Meeting of the Performance Based Navigation Task Force (PBN/TF/10) was held in Nadi, Fiji from 11 to 13 December 2012 at Nadi, Fiji. The PBN Workshop was conducted prior to the PBN/TF/10 from 10-11 December 2012 which was attended by 63 participants from 21 administrations including nine from Pacific Island States.

1.3 The PBN/TF/10 meeting was attended by 62 participants from Australia, Bangladesh, Cambodia, Hong Kong China, Fiji, French Polynesia, Indonesia, India, Japan, Kiribati, New Caledonia, New Zealand, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Thailand, Tonga, Vanuatu, and IATA.

1.4 Four Draft Conclusions and one Draft Decision were developed by the PBN/TF/10.

2. DISCUSSION

GLS Seminar

2.1 The Twenty Third Meeting of APANPIRG/23 noted the updates from Australia to the PBNTF/9 meeting on the Australian installation of GLS at Sydney. IATA supported GLS technology but preferred an aggressive timeline and implementation plan to meet airline requirements. The meeting adopted Conclusion 23/26 invited ICAO to organize GNSS Landing System (GLS) seminar:

2.2 GLS was a proven ICAO standardized precision approach service providing a quality and flexible solution for the approach phase of flight. It was noted that at the 12th Air Navigation Conference PBN based on GNSS was flagged as the key enabler and that augmented GNSS was identified as the technology to provide precision approach guidance. Moreover, GLS/GBAS was the only standardized and certified augmentation system available to replace Category I ILS and Microwave Landing System (MLS).

2.3 GLS passed GNSS corrections for each satellite in view and associated integrity information to the aircraft equipment using VHF broadcasts twice a second (MT1). Message Types 2 and 4 provided the site data and approach path definition and were sent at 10 second intervals. The messages included a 32 bit Cyclical Redundancy Check (CRC) to ensure integrity.

2.4 A critical improvement that GLS provided was that there was no requirement for critical areas that had to be sanitized around the navigation aids, unlike ILS. Aircraft operators stressed that the capability of the aircraft, and in particular the inertial coasting that allowed a continuity of flight path in the short term, meant that the risks associated with loss of GNSS acquisition were minimal. It was noted that GBAS improved accuracy of position in the taxi and rollout, as well as airborne phases.

2.5 The Seminar noted that flight validation was essential for GLS, although an ILS ‘overlay’ that had been previously checked, but did not necessarily need a flight inspection if the required VDB coverage and power were already confirmed.

2.6 Dmax was a parameter that was set to determine the maximum distance that a GBAS signal can be operationally utilized, due to the effects of oblique geometry through the ionosphere. This was currently set at 23NM in Australia. The RTCA was considering the merits of what this value might be globally and what consequence this would have on for aircraft receivers. Within the 23NM service volume, it was possible to provide services to more than one aerodrome if they were both within this area.

2.7 Currently GLS was approved for CAT I operations, although there was planning for CAT II and III capability through the ICAO Navigation Panel. Honeywell was expecting CAT III certification about 2016. GLS allowed up to 26 types of approaches for an aerodrome, potentially providing customized solutions for different wake turbulence or aircraft classifications and even providing different arrival and departure flight paths to the same runway. GLS also had the capability of defining a curved path to allow segregation of aircraft types or an overlay of visual procedures without using RNP Authorization Required (AR) procedures.

2.8 In conducting maintenance on a GBAS, there was no need to take it out of service, unlike ILS. GLS had low maintenance requirements compared to ILS. In addition, GBAS had a ‘fail-soft’ capability that allowed a slow degradation in redundancy. The siting of GLS was not as vulnerable as ILS to aircraft excursions, as there was no need to be sited immediately adjacent to the runway. The flexible siting options also a freeing up of sterilized land for airport development.

2.9 Data collected from 131 days at Sydney indicated that the standard deviation from the GLS was 14cm laterally and 35cm vertically. Two very short term events (less than a second) had breached the limits due to insufficient constellation geometry being detected by the Remote Satellite Measurement Units (RSMU), although this was within the six second time to alert.

2.10 The Seminar recognized that the Asia/Pacific was leading the global implementation of GLS as part of the Aviation System Block Upgrade (ASBU) B0-65 (Number may be changed) module. In conclusion, the Seminar urged accelerated implementation programmes for ground and airborne components of GLS where there was an economic benefit.

PBN Workshop

2.11 There were three Group Sessions and 10 presentations made during the PBN Workshop, which included:

- Introduction to PBN – 'PBN 101';
- Introduction of New Navigation Specs / Functionalities;
- Procedure Design Criteria for the new navigation specs and GLS;
- Airspace Planning and Design;
- Instrument Flight Procedure Design;
- New Development – RNP to XLS;
- Navigation Aids;
- ATC Procedures and Training;
- Operator Training / Approvals;
- PBN Plan Requirements – the BPEs, etc.; and
- PBN Implementation Lessons Learned.

2.12 The value of this type of workshop was noted by the attendees with the recommendation that similar workshops on PBN and APV (Approach with Vertical Guidance) would be required to ensure the progress of implementation is maintained. A PBN Plan template was developed and States that had not yet developed a robust plan were urged to utilize the template.

PBN/TF/10

2.13 The PBN/TF meeting was apprised of the dialogue that had been on-going in Australia regarding the requirements of conventional procedure overlays. IATA stated that this was a complex area with possible legal implications for ATC. APANPIRG/23 noted the lack of guidance on this matter and discussed the draft Conclusion formulated by PBN/TF/9, asking ICAO to review and develop operational guidance materials for conventional instrument flight procedures flown using GNSS/RNP aircraft.

2.14 APANPIRG/23 did not adopt the draft PBN/TF Conclusion regarding conventional instrument flight procedures flown using GNSS/RNP aircraft, requesting further clarification of what was expected from the Draft Conclusion. During PBN/TF/10, Australia developed Flimsy 1, which provided more information on the issues that precipitated the overlay matter earlier.

2.15 In the United States, AC 90-108 allowed the substitution of approved RNAV aircraft to fly enroute, terminal and approach procedures based on conventional aids without the aids being either on the aircraft or in operation. However, the AC did not make any reference to either the flight planning requirements or the separation standards to be applied. The United States provided the ATS service the operator requested. Australia advised that they already used GNSS in lieu of conventional navigation aid information, as did other Asia/Pacific States. Moreover, most modern RNP capable aircraft had approval to conduct enroute, terminal and approach procedures based on using their RNP capabilities in their Aircraft Flight Manual (AFM).

2.16 Amendment 1 to Doc 4444 (Flight Plan 2012) still required that the flight plan contain the equipment that the aircraft carried rather than its capabilities. The outcome of this was that aircraft could not include capabilities to fly conventional enroute, terminal and approach procedures on the flight plan, and in turn, ATS could not technically apply conventional aid separation standards to these aircraft, imposing significant operational restrictions and costs on operators.

2.17 The issue of GNSS overlays of conventional navigation aids was considered by the ICAO Separation and Airspace Safety Panel (SASP), which had produced Draft Circular 322 in 2009. IATA accepted the use of GNSS overlays as an interim measure.

2.18 PBN/TF/10 agreed to the following Draft Conclusion, for consideration by the CNS Sub-Group and APANPIRG:

Draft Conclusion PBN/TF/10-1 - RNAV Substitution for Conventional Instrument Flight Procedures

That, considering the intent of US AC 90-108 and issues concerning the application of GNSS capability for aircraft flying conventional instrument flight procedures:

a) Asia/Pacific States should publish material that

   i) includes approval for authorized operators with the appropriate RNAV capability to include the listing of conventional navigation aids in flight plans, provided the operator has approval for navigation aid substitution and an appropriate, up-to-date database; and

   ii) includes acceptance of navigation substitution approvals of foreign States; and

   iii) supports ATC separation standards for navigation aid substitution; and

b) ICAO HQ should

   i) expedite development of global navigation aid substitution provisions; and

   ii) review the current Flight Plan contents to consider the listing of aircraft navigation capabilities rather than the listing of specific equipment carried (revisions should include the addition of Item 18 PBN codes for navigation specifications not currently included).

2.19 The Task Force agreed that the new navigation specifications in the advance Fourth Edition (unedited) version of the PBN Manual, particularly Advanced RNP, were still a 'work in progress'. However Advanced RNP elements could be applied where benefits could accrue. The limitation preventing early application was the lack of procedure design criteria in ICAO Doc 8168 PANS OPS, for the application of low RNP values for missed approach and departure applications.

2.20 Providing for low RNP values for departure and missed approach operations would, in many cases, remove the need to implement RNP-AR procedures with their high overhead costs for operators and regulators alike. Training material for Advanced RNP would be needed, particularly for the advanced ATM capabilities envisaged. However, the Advanced RNP applications needed more development before the training material could be produced.

2.21 The meeting considered that the most practical way to undertake these tasks and update the PBN Manual Doc 9613 was through the reconvening of the ICAO PBN Study Group. The meeting agreed to the following Draft Conclusion for consideration by the CNS Sub-Group and APANPIRG:

Draft Conclusion PBN/TF/10-2 - New PBN Navigation Specifications

Considering that the RNP2, RNP0.3 and Advanced RNP Navigation Specifications were to be significantly valuable for future planning, ICAO was urged to:

a) expedite standards and guidance associated with these navigation specifications; and

b) provide adequate training material and courses to enable effective implementation; and

c) expedite the development of procedure design standards in Doc 8168 for low RNP value missed approach and departure operations.

2.22 In accordance with APANPIRG Conclusion 21/32 – *Develop State PBN Implementation Plan* and DGCA Action Item 47/4, Asia/Pacific PBN State Plans had been categorized into three categories based on quality:

- Robust – when 8 to 10 basic plan elements (BPE) were satisfied;
- Marginal – when 5 to 7 BPE were satisfied; and
- Incomplete – when 4 or less BPE were satisfied.

2.23 **Table 1** indicates the results of the 2012 PBN State Plan assessments.

State	# of BPEs Addressed (Robust/Needs Improvement / Non Existent)	Status	Submitted
Tonga	8/2/1	Robust	26 June 2012
Bangladesh	9/2/0	Robust	30 July 2012
French Polynesia	6/1/4	Marginal	12 October 2012
Malaysia	9/1/0	Robust	20 November 2012
Maldives	9/2/0	Robust	10 December 2012

Table 1: 2012 PBN State Plan Assessments

2.24 There were 42 administrations which include New Caledonia and French Polynesia separately; or 43 if the US was included in regards to its territories (American Samoa, Guam, Johnston, Kingman, Midway, Mariana, Palmyra, and Wake Islands). **Table 2** provides an overall summary of the status of Asia/Pacific PBN Plans.

Asia/Pacific PBN Plan Status	2011 (PBN/TF/8)	2012 (PBN/TF/9)	2012 (PBN/TF/10)
Robust	9 (21%)	14 (33%)	18 (43%)
Marginal	4 (10%)	5 (12%)	3 (7%)
Incomplete	8 (19%)	5 (12%)	4 (10%)
Total Plans (of 42)	**21 (50%)**	**24 (57%)**	**25 (60%)**
Administrations with no plan	21 (50%)	18 (43%)	17 (40%)

Table 2: Asia/Pacific PBN Plan Overall Status

2.25 There had been a significant improvement in the number of administrations with a 'Robust' plan since PBN/TF/9. Bangladesh, Maldives, Malaysia and Tonga had successfully transitioned to 'Robust' category. The number of administrations with satisfactory PBN planning had more than doubled in less than two years.

2.26 A number of States remained with either 'Marginal' or 'Incomplete' status plans, or had no plan. Administrations with significant aviation activity in this category were Afghanistan (no plan), Indonesia ('Incomplete'), Pakistan ('Marginal'), and Viet Nam ('Incomplete'). Of concern was the proportion of Pacific Island administrations (three quarters of the 40%) that had not provided a PBN Plan to ICAO; however six of these administrations attended the PBN Workshop. **Figure 1** provided an overall view of the Asia/Pacific PBN Plan Status.

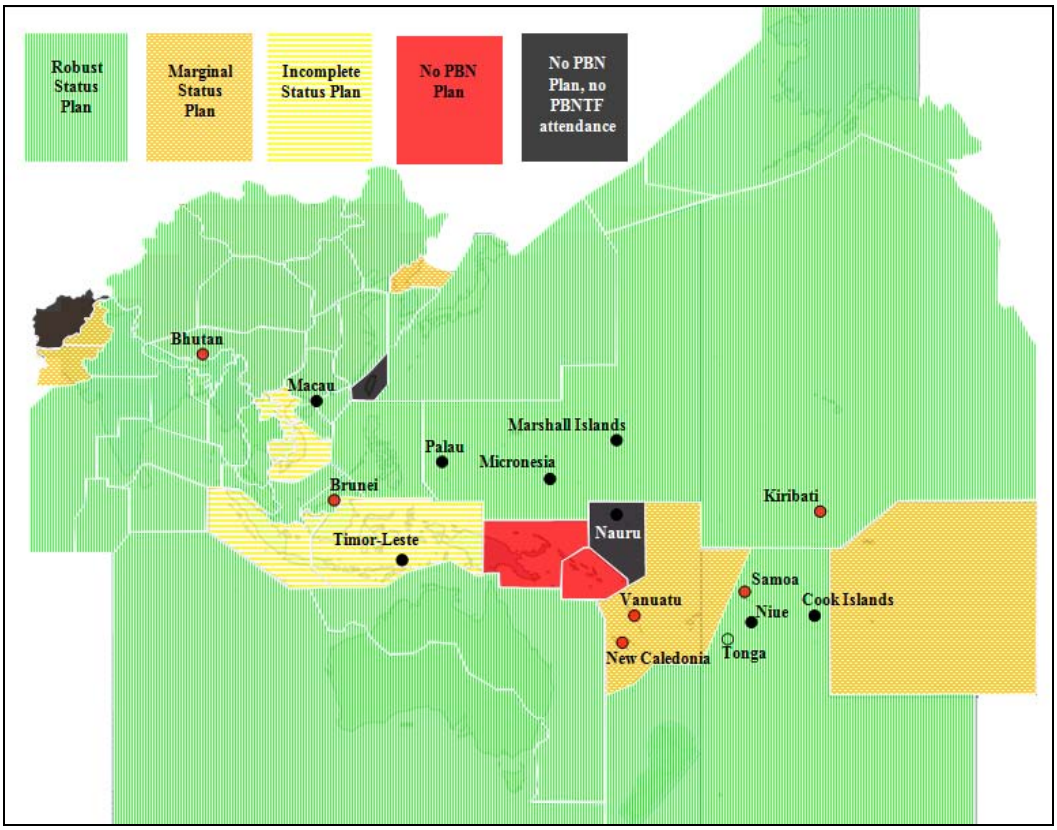


Figure 1: Asia/Pacific State PBN Plan Status

2.27 New Zealand suggested that the PBN Workshop deliverables could be fashioned into a template for the States that had difficulty in creating a PBN Plan. With the assistance of IATA, a template was developed.

2.28 Tonga stated that many small Pacific Island States did not have a CNS infrastructure such as adequate communications and ATS surveillance that supported PBN. The Chairman acknowledged this, but suggested that even simple GNSS procedures alone would derive great benefits.

2.29 Australia stated that they would not meet the timeline of Assembly Resolution A37-11, due to insufficient Baro-VNAV capability within their fleet, and lack of a Space Based Augmentation System (SBAS). The meeting noted that there were a number of domestic operations (such as twin turboprop aircraft) that were not Baro-VNAV capable. Australia noted that even some of the airlines had difficulty in determining if their aircraft were Baro-VNAV capable.

2.30 New Zealand assessed its aerodromes using the A37-11 criteria, noting that they used Baro-VNAV where aircraft were capable of using this procedure. IATA agreed that A37-11 had to be implemented on a needs basis. They noted that many airports were still served only by a conventional approach such as a Non-Directional Beacon (NDB) procedure.

2.31 The meeting discussed the implementation targets for APV approaches in accordance with Assembly Resolution 37-11. The conclusion was that the wording of the resolution 37-11 is not clear enough and that it may lead to States setting unrealistic implementation targets, or misdirecting scarce IFP design resources.

2.32 The meeting suggested the following additional guidelines for the States to use in their planning for implementation of APV approaches in accordance with Assembly Resolution A37-11:

- planning for APV implementation should be carried out at those instrument runways where the configuration of terrain allows for a runway-aligned approach;
- the primary focus should be on those runways served by scheduled air-transport operations by APV-capable aircraft with a maximum certificated take-off mass of 5 700 kg or more; and
- priority should be given to those aerodromes with the best operational and safety benefit-to-cost of implementation ratio.

2.33 The meeting noted that Asia/Pacific would not achieve compliance with Resolution A37-11 even if the timeline was amended, so the following Draft Conclusion was agreed for consideration by the CNS Sub-Group and APANPIRG:

Draft Conclusion PBN/TF/10-3 - PBN Procedures with Vertical Guidance

That, given the difficulties that some States had with insufficient fleet capability for Baro-VNAV and no Space Based Augmentation System (SBAS), ICAO was urged to consider alternative requirements or means of achieving the highest possible conformance with the intent of Assembly Resolution A37-11 where practicable.

2.34 Japan stated that the IFPP had simplified the Baro-VNAV design criteria to improve consistency and these were expected to be published in 2014. The Chairman noted that the Baro-VNAV design criteria needed to be improved as the procedure often did not derive lower minima than a standard GNSS approach. Moreover, Baro-VNAV did not cater for slightly offset approaches, even though the definition of a straight-in approach included procedures up to 15 degrees off centreline.

2.35 The Secretariat provided an update of the progress and accomplishments of the ICAO Flight Procedure Programme (FPP) in 2012. The paper also presented the strategy for FPP Phase 2 covering 2013 to 2017. The FPP in co-operation with its partner organizations conducted a total of fourteen courses and workshops in 2012, with nearly 400 students from eighteen administrations in the Asia/Pacific Region. The training and workshops were focused on support in the areas of procedure design, quality assurance process and PBN implementation.

2.36 The Regional Navigation Strategy for the Asia/Pacific Region was a list of high-level navigation policies that had been developed by the CNS-MET Sub-Group of APANPIRG. Under the recent re-organization of APANPIRG, the Strategy fell under the responsibility of the CNS Sub-Group, which the PBN/TF reported to. The latest version of the Regional PBN Implementation Plan (Version 3.0, September 2011) provided detailed guidance for administrations in the field of PBN. APSAPG had been tasked by APANPIRG with the development of an Asia/Pacific Seamless ATM Plan, which incorporated the Aviation System Block Upgrade (ASBU) modules, including those related to PBN.

2.37 It was important that there was alignment and an appropriate hierarchy between the Regional Navigation Strategy for the Asia/Pacific Region and documents that provided implementation guidance regarding PBN. The Regional Navigation Strategy for the Asia/Pacific Region contained a prescriptive statement of PBN specifications, which means that it was not confined to overall objectives, as might be expected in a high-level policy statement.

2.38 The Regional PBN Implementation Plan included Short-Term (2008-2012) strategies and a Medium-Term Implementation Plan (2013-2016). With the passage of time, these strategy timeframes had become out-of-date.

2.39 The PBN/TF/10 meeting extensively discussed proposed amendments to the Regional Navigation Strategy for the Asia/Pacific Region and the Regional PBN Implementation Plan, and also took the opportunity to provide feedback on the early draft excerpt of the Asia/Pacific Seamless ATM Plan related to PBN.

2.40 The draft Asia/Pacific Seamless ATM Plan excerpt included a passage that required the establishment of a PBN specification for all ATS routes. During discussion at the PBN Workshop, Australia had advised that it intended to re-designate PBN specifications for all domestic RNAV routes. RNAV5 was being used as the baseline in order to confirm the area semi-widths and minimum safe altitudes for routes. Australia advised that the RNAV specification was being supported by GNSS, and that this would be confirmed in the Australian AIP, as the RNAV5 specification allowed use of other navigation aids such as VOR and DME.

2.41 It was recognized that while the original intention of PBN was to create a harmonized world-wide navigation scheme, unfortunately there was no hierarchy between specifications; thus an aircraft with a higher performing capability such as RNP2 was not able to utilize a route with a lower specification such as RNAV5. Australia had deemed higher performing navigation specifications as being able to be used on RNAV5 routes, in effect creating a hierarchy between specifications.

2.42 The following Draft Conclusion was agreed by the PBN/TF/10 for consideration by the CNS Sub-Group and APANPIRG:

Draft Conclusion PBN/TF/10-4: PBN Implementation Guidance Updates

That, recognizing the need for alignment of PBN Strategies and Guidance Material, as well as development of the Asia/Pacific Seamless ATM Plan, the following documents be updated with regard to PBN:

a) Regional Navigation Strategy for the Asia/Pacific Region, appended as **Appendix B** *(Note: Attachment to WP09);* and

b) Asia/Pacific Regional PBN Implementation Plan Version 4.0, appended as **Appendix C** *(in the Attachment to this WP).*

2.43 The Secretariat presented information related to future planning of the PBN/TF. The meeting recalled that the PBN Task Force had been formed in 2007 under APANPIRG Conclusion 18/52. PBN/TF/8 and PBN/TF/9 had both discussed the future of the Task Force.

2.44 It was noted by APANPIRG that the new CNS Sub-Group could oversee PBN development, and that the proposed Regional Sub-Office (RSO) could also play an important part in day-to-day PBN implementation assistance, along with the Asia/Pacific Flight Procedures Programme (FPP).

2.45 Apart from the future updating of PBN material, IATA asked for reassurance that there be a continued focus on PBN implementation. The Task Force recognized the need for continuing PBN and APV activity in the region, particularly supporting smaller States with PBN implementation.

2.46 The meeting agreed to the following Draft Conclusion for consideration by the CNS Sub-Group and APANPIRG:

Draft Decision PBN/TF/10-5 - Dissolution of the PBN Task Force

That, subject to:

a) the establishment of suitable oversight of PBN implementation within the Asia/Pacific Region; and

b) endorsement by APANPIRG/24 of the –

(i) Asia/Pacific Regional PBN Implementation Plan Version 4.0 amendment; and

(ii) PBN components within the Asia/Pacific Seamless ATM Plan;

the Performance-based Task Force (PBN/TF) be dissolved and any on-going tasks be delegated to the CNS Sub-Group or as directed by APANPIRG.

3. Action by the Meeting

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) endorse Draft Conclusion PBN/TF/10-1: RNAV Substitution for Conventional Instrument Flight Procedures (paragraph 2.18);

c) endorse Draft Conclusion PBN/TF/10-2: New PBN Navigation Specifications (paragraph 2.21);

d) endorse Draft Conclusion PBN/TF/10-3: PBN Procedures with Vertical Guidance (paragraph 2.33);

e) endorse Draft Conclusion PBN/TF/10-4: PBN Implementation Guidance Updates (paragraph 2.42);

f) endorse Draft Decision PBN/TF/10-5: Dissolution of the PBN Task Force (paragraph 2.46); and

g) discuss any relevant matters as appropriate.

– – – – – – – – – – – – –

INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

ASIA/PACIFIC REGIONAL PERFORMANCE-BASED NAVIGATION IMPLEMENTATION PLAN

DRAFT
VERSION 4.0

June 2013 (Effective until 12 November 2015)

RECORD OF AMENDMENT

Version	Activity	Date
0	Adopted by APANPIRG/19 as Interim Edition	September 2008
0.1	RASMAG Proposal	December 2008
0.2	Amended/Finalized by PBN/TF/4	March 2009
0.3	Amended/Finalized by PBN/TF/5	July 2009
1.0	Adopted by APANPIRG/20	September 2009
2.0	Adopted by APANPIRG/21	September 2010
3.0	Adopted by APANPIRG/22	September 2011
4.0	Adopted by APANPIRG/24	June 2013

TABLE OF CONTENTS

1. Executive Summary 5
2. Explanation of Terms 5
2.1 Asia/Pacific Regional PBN Implementation Plan
2.2 Performance Based Navigation
2.3 Performance requirements
3. Acronyms 5
4. Introduction 6
Need for the Regional PBN Implementation Plan 6
Roles of Navigation in supporting ATM operations 6
Benefits of Performance-Based Navigation 7
Goals & Objectives of PBN Implementation 8
Planning Principles 9
5. PBN Operational Requirements & Implementation Strategy 9
Route Operations 9
TMA Operations 10
Instrument Approaches 10
6. Current Status & Forecast 10
APAC Traffic Forecast 10
Aircraft fleet readiness status 11
Global Navigation Satellite System (GNSS) 11
Other PBN Navigation Infrastructure 11
Surveillance Infrastructure 12
Communication Infrastructure 12
7. Implementation Road Map of Performance Based Navigation 12
ATM Operational Requirements 12
Short Term Implementation Plan 13
- Route Operations 13
- TMA Operations 13
- Instrument Approaches 14
- Summary Table & Implementation Targets 14
Medium Term Implementation Plan 15
- Route Operations 15
- TMA Operations 15
- Instrument Approaches 15
- Summary Table & Implementation Targets 16
Long Term Implementation Strategies (2016 and beyond) 17
8. Transitional Strategies 17

TO BE UPDATED

9. Safety Assessment & Monitoring Requirements 17
Need for a safety assessment 17
En-route safety assessment and monitoring 17
Undertaking a safety assessment 18
APPENDIX A: Changes to the PBN Regional Plan 20
APPENDIX B: IATA Traffic Forecast 25
APPENDIX C: Reference documentation for developing operational and airworthiness approval 27
APPENDIX D: Practical Example 29
APPENDIX E: Basic Planning Elements (BPEs) Table 30

Attachment A: RNP Project BRISBANE GREEN
Attachment B: Brisbane Efficiency Analysis of simulated RNP Approaches versus ILS with fixed reference
Attachment C: Tangible Benefits of PBN Implementation in Thai Terminal Airspace

– – – – – – – – – – – –

ASIA/PACIFIC REGIONAL PERFORMANCE-BASED NAVIGATION IMPLEMENTATION PLAN

1. Executive Summary

1.1 This Asia/Pacific Regional PBN Implementation Plan has been produced in line with Resolution A 36/23 adopted by ICAO Assembly in its 36th Session held in September 2007 and Conclusion 18/52 adopted by APANPIRG/18. ADD REFERENCE TO A37 The Regional PBN Plan addresses the strategic objectives for PBN implementation based on clearly established operational requirements, avoiding equipage of multiple on-board or ground based equipment, avoidance of multiple airworthiness and operational approvals and explains in detail contents relating to potential navigation applications. The Plan envisages the conduct of pre- and post-implementation safety assessments and continued availability of conventional air navigation procedures during transition. The Plan also discusses issues related to implementation which include traffic forecasts, aircraft fleet readiness, adequacy of ground-based CNS infrastructure etc. Implementation targets for ~~various categories of airspace for the short term (2008 – 2012) and for the medium term (2013 – 2016) have been projected in tabular forms to facilitate easy reference~~ the period 2008-2016 were initially developed for Versions 1-3 of this Plan. However, these PBN implementation expectations have now been placed in the Asia/Pacific Seamless ATM Plan, which has a planning horizon until 2028. For the ~~long term~~ ~~(~~ period 2016 and beyond~~)~~ it ~~has been~~ was envisaged that GNSS ~~will~~ would be the primary navigation infrastructure. It ~~is~~ was also expected that precision approach capability using GNSS and its augmentation systems ~~will~~ would become available in the long term.

2. Explanation of Terms

2.1 The drafting and explanation of this document is based on the understanding of some particular terms and expressions that are described below:

2.1.1 **Asia/Pacific Regional PBN Implementation Plan.** A document adopted by APANPIRG, often referred to as the "Regional PBN Plan", offering appropriate guidance for air navigation service providers, airspace operators and users, regulating agencies, and international organizations–on the evolution of navigation capabilities as one of the key systems supporting air traffic management, and which describes the RNAV and RNP navigation applications that should be implemented in the short, medium and long term in the APAC Region.

2.1.2 **Performance Based Navigation** Performance based navigation specifies RNAV and RNP system performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in an airspace.

2.1.3 **Performance requirements.** Performance requirements are defined in terms of accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept. Performance requirements are identified in navigation specifications which also identify which navigation sensors and equipment may be used to meet the performance requirement.

3. Acronyms

3.1 The acronyms used in this document along with their expansions are given in the following list:

ABAS	Aircraft-Based Augmentation System
AIS	Aeronautical Information Services
APAC	Asia and Pacific
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APCH	Approach
APV	Approach Procedures with Vertical Guidance
ATC	Air Traffic Control
Baro VNAV	Barometric Vertical Navigation
CNS/ATM	Communication Navigation Surveillance/Air Traffic Management
CPDLC	Controller Pilot Data Link Communications
DME	Distance Measuring Equipment
EMA	En-route Monitoring Agency
FASID	Facilities and Services Implementation Document
FIR	Flight Information Region
FMS	Flight Management System
GBAS	Ground-Based Augmentation System
GNSS	Global Navigation Satellite System
GRAS	Ground-based Regional Augmentation System
IATA	International Air Transport Association
IFALPA	International Federation of Air Line Pilots' Associations
INS	Inertial Navigation System
IRU	Inertial Reference Unit
PANS	Procedures for Air Navigation Services
PBN	Performance Based Navigation
PIRG	Planning and Implementation Regional Group
RASMAG	Regional Airspace Safety Monitoring Advisory Group
RCP	Required Communication Performance
RNAV	Area Navigation
RNP	Required Navigation Performance
SARP	Standards and Recommended Practices
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
STAR	Standard Instrument Arrival
TMA	Terminal Control Area
VOR	VHF Omni-directional Radio-range
WGS	World Geodetic System

4. Introduction

Need for the regional PBN Implementation Plan

4.1 The Thirty-sixth Session of the ICAO Assembly held in Montreal in September 2007 adopted a Resolution to resolve that States and PIRGs complete a regional PBN implementation plan by 2009.

4.2 Recognizing that the PBN concept is now established, States should ensure that all RNAV and RNP operations and procedures are in accordance with the PBN concept as detailed in State letter AN 11/45-07/22 and the ICAO Doc 9613: PBN Manual for ensuring a globally harmonized and coordinated transition of PBN.

4.3 In view of the need for detailed navigation planning, it is advisable to develop a Regional PBN Plan to provide proper guidance to air navigation service providers, airspace operators and users, regulating agencies, and international organizations, on the evolution of navigation capabilities as one of the key systems supporting air traffic management, and which describes the RNAV and RNP navigation applications that should be implemented in the short and medium term in the APAC Region.

4.4 Furthermore, the Asia/Pacific Regional PBN Implementation Plan will contain the basic material serving as guidance for regional projects for the implementation of air navigation infrastructure, such as ABAS, SBAS, GBAS, GRAS, etc., as well as for the development of national implementation plans.

Roles of Navigation in supporting ATM operations

4.5 An “airspace concept” may be viewed as a general vision or master plan for a particular airspace. Based on particular principles, an airspace concept is geared towards specific objectives. Strategic objectives drive the general vision of the airspace concept. These objectives are usually identified by airspace users, air traffic management (ATM), airports as well as environmental and government policy. It is the function of the airspace concept and the concept of operations to respond to these requirements. The strategic objectives which most commonly drive airspace concept are safety, capacity, efficiency, access, and the environment.

4.6 Navigation is one of several enablers of an airspace concept. Communications, ATS Surveillance and ATM are also essential elements of an airspace concept.

4.7 The PBN concept specifies RNAV and RNP system performance requirements in terms of accuracy, integrity, availability, continuity and functionality needed for the proposed operations in the context of a particular Airspace Concept, when supported by the appropriate navigation infrastructure. In that context, the PBN concept represents a shift from sensor-based to performance-based navigation. Performance requirements are identified in navigation specifications which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements. These navigation specifications are defined at a sufficient level of detail to facilitate global harmonization by providing specific implementation guidance for States and operators.

4.8 Under the PBN concept, the generic navigation requirements are defined based on operational requirements. Thus, users may evaluate the available options. To ensure synchronization of investment and interoperability of the airborne and ground systems, the selection of the solution should be in consultation with aviation stakeholders, including international and domestic airline operators, air navigation service providers, and regulators. The solution selected should also be the most cost-effective one.

4.9 The development of the PBN concept recognized that advanced aircraft RNAV systems are achieving an enhanced and predictable level of navigation performance accuracy which, together with an appropriate level of functionality, allows a more efficient use of available airspace to be realized. It also takes account of the fact that RNAV systems have developed over a 40-year period and as a result there were a large variety of differing implementations globally. Identifying navigation requirements rather than on the means of meeting the requirements will allow use of all RNAV systems meeting these requirements irrespective of the means by which these are met.

Benefits of Performance-Based Navigation

4.10 The main benefits derived from the implementation of PBN are:

a) Increased airspace safety through the implementation of continuous and stabilized descent procedures using vertical guidance;

b) Reduced aircraft flight time due to the implementation of optimal flight paths, with the resulting savings in fuel, noise reduction, and enhanced environmental protection;

c) Use of the RNAV and/or RNP capabilities that already exist in a significant percentage of the aircraft fleet flying in APAC airspace;

d) Improved airport and airspace arrival paths in all weather conditions, and the possibility of meeting critical obstacle clearance and environmental requirements through the application of optimized RNAV or RNP paths;

e) Implementation of more precise approach, departure, and arrival paths that will reduce dispersion and will foster smoother traffic flows;

f) Reduced delays in high-density airspaces and airports through the implementation of additional parallel routes and additional arrival and departure points in terminal areas;

g) Reduction of lateral and longitudinal separation between aircraft to accommodate more traffic;

h) Decrease ATC and pilot workload by utilizing RNAV/RNP procedures and airborne capability and reduce the needs for ATC-Pilot communications and radar vectoring;

i) Increase of predictability of the flight path.

Goals & Objectives of PBN Implementation

4.11 APANPIRG, in its Eighteenth meeting (September 2007), discussed various issues related to an early implementation of PBN in the region. To facilitate coordination between States, a PBN Task Force was formed under Conclusion 18/52 and tasked to develop a harmonized regional PBN implementation plan.

4.12 The Asia/Pacific Regional PBN Implementation Plan has the following strategic objectives:

a) To ensure that the implementation of the navigation item of the CNS/ATM system is based on clearly established operational requirements.

b) To avoid undue equipage of multiple on board equipment and/or ground-based systems.

c) To avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations.

d) To explain in detail the contents of the Regional Air Navigation Plan, relating to potential navigation applications.

4.13 Furthermore, the Asia/Pacific Regional PBN Implementation Plan will provide a high-level strategy for the evolution of the navigation applications to be implemented in the APAC Region in the short term (2008-2012) and medium term (2013-2016). This strategy is based on the concepts of Area Navigation (RNAV) and Required Navigation Performance (RNP) in accordance with ICAO Doc. 9613: *Performance Based Navigation Manual*, and will be applied to aircraft operations involving instrument approaches, standard departure (SID) routes, standard arrival (STAR) routes, and ATS routes in oceanic and continental areas.

4.14 The Regional PBN Plan was developed by the APAC States together with the international organizations concerned (including IATA and IFALPA)~~,~~ and is intended to assist the main stakeholders of the aviation community plan a gradual transition to the RNAV and RNP concepts. The main stakeholders of the aviation community that benefit from this Regional Plan are:

- Airspace operators and users.
- Air navigation service providers.
- Regulating agencies.
- International organizations.

4.15 The Regional PBN Plan is intended to assist the main stakeholders of the aviation community plan the future transition and their investment strategies. For example, airlines and operators can use this Plan to derive future equipage and additional navigation capability investments; air navigation service providers can plan a gradual transition for the evolving ground infrastructure. Regulating agencies will be able to anticipate and plan for the criteria that will be needed in the future.

4.16 Recognizing the safety benefits of PBN, the thirty-sixth session of the ICAO Assembly held in Montreal, September 2007 adopted a Resolution to resolve that States and PIRGs prepare ~~a~~ PBN implementation plans by 2009 to achieve:

a) Implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones; and

b) Implementation of APV (Baro-VNAV and/or augmented GNSS) 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.

The ICAO Assembly also urges that States include in their PBN implementation plan provisions for implementation of APV to all runway ends serving aircraft with a maximum certificated take-off mass of 5700 kg or more, according to established timelines and intermediate milestones.

Planning Principles

4.17 Planning for the implementation of PBN in the APAC Region shall be based on the following principles:

a) Pre- and post-implementation safety assessments will be conducted in accordance with ICAO provisions to ensure the application and maintenance of the established target levels of safety.

b) Continued application of conventional air navigation procedures during the transition period, to guarantee the operations by users that are not RNAV and/or RNP equipped.

c) The first regional PBN implementation plan should address the short term (2008-2012) and medium term (2013-2016) and take into account long term global planning issues.

d) Target date for preparation of the first regional PBN implementation plan is APANPIRG/19 (September 2007).

5. PBN Operational Requirements & Implementation Strategy

5.1 Introduction of PBN should be consistent with the Global Air Navigation Plan. Moreover, PBN implementation shall be in full compliance with ICAO SARPs and PANS and support relevant ICAO Global Plan Initiatives.

5.2 The ICAO Council accepted the second amendment to the Global Air Navigation Plan for the CNS/ATM System in November 2006. The approved plan has been renamed as Global Air Navigation Plan (Doc 9750). The relevant Global Plan Initiatives including implementation of performance based navigation (PBN) and navigation system have been included in the Global Plan. The introduction of PBN must be supported by an appropriate navigation infrastructure consisting of an appropriate combination of Global Navigation Satellite System (GNSS), self-contained navigation system (inertial navigation system) and conventional ground-based navigation aids.

5.3 The consolidated *Navigation Strategy for the Asia/Pacific Region was* reviewed and updated by the Thirteenth meeting of CNS/MET Sub Group of APANPIRG in July 2009. The Strategy was subsequently adopted by APANPIRG in its Twentieth meeting held in September 2009 under Conclusion 20/46 and further updated in its Twenty Second Meeting held in September 2011 through Conclusion 22/29 based on a recommendation by CNS/MET SG/15.

Route Operations

5.4 As the routes structure and en-route operation are extensive and complicated in APAC – region, it is difficult to restructure and include the whole airspace in a single implementation plan for en-route operations.

5.5 Considering the traffic characteristics and CNS/ATM capability, en-route operations can be classified as Oceanic, Remote continental, and Continental en-route.

5.6 In principle, each classification of en-route operation (paragraph 5.5 above) should adopt, but not be limited to, a single RNAV or RNP navigation specification. This implementation strategy should be applied by implementing States in coordination with airspace users.

5.7 APANPIRG established the PBN Task Force to develop a PBN implementation plan for the Asia/Pacific Region and to address related regional PBN implementation issues. Accordingly, States are encouraged to work cooperatively bilaterally, multilaterally and with the PBN Task Force to ensure regional and sub-regional harmonization of en-route PBN implementation.

5.8 In areas where operational benefits can be achieved and appropriate CNS/ATM capability exists or can be provided for a more accurate navigation specification than that specified in this plan, States are encouraged to introduce the more accurate navigation specification on the basis of coordination with stakeholders and affected States.

5.9 Similarly, in circumstances where affected States are agreeable to completing an implementation in advance of the timelines specified in this plan, early implementation is encouraged on the basis of coordination between affected States and airspace users.

TMA Operations

5.10 TMA operations have their own characteristics, taking into account the applicable separation minima between aircraft and between aircraft and obstacles. TMA operations also involve–the diversity of aircraft, including low-performance aircraft flying in the lower airspace and conducting arrival and departure procedures on the same path or close to the paths of high-performance aircraft.

5.11 In this sense and as called for under APANPIRG Conclusion 18/53, States shall develop their own national plans for the implementation of PBN in sovereign TMAs. Such national plans should be based on the Asia/Pacific Regional PBN Implementation Plan, seek the harmonization of the application of PBN and avoid the need for multiple operational approvals for intra- and inter-regional operations. Applicable aircraft separation criteria should also be considered.

Instrument Approaches

5.12 States are encouraged to introduce PBN approaches that provide Vertical Guidance to enhance safety. Conventional approach procedures and conventional navigation aids should be maintained to support non-equipped aircraft during the transitional period.

5.13 During early implementation of PBN, IFR Approaches based on PBN should be designed to accommodate a mixed-equipage (PBN and non-PBN) environment. ATC workload should be taken into account while developing approach procedures. One possible way to accomplish this is to co-locate the Initial Approach Waypoint for both PBN and conventional approaches

6. Current Status & Forecast

APAC traffic forecast

6.1 Traffic forecasts have a special role to play in the planning and implementation processes; they represent the demand for future ATM. Global Air Navigation Plan (Doc 9750) requires that the Planning and Implementation Regional Groups (PIRGs) base their work on well developed traffic density forecasts. Guidance on the preparation of traffic forecasts is provided in *Manual on Air Traffic Forecasting* (Doc 8991). At the Asia/Pacific regional level, the traffic forecasting activities were started with the formation of ICAO Pacific Area Traffic Forecasting Group formed in 1991. The scope of the group was subsequently broadened to include Intra-Asia/Pacific traffic also and the group was renamed as Asia/Pacific Area Traffic Forecasting Group (APA TFG).

6.2 Report of the Fourteenth meeting of Asia/Pacific Area Traffic Forecasting Group (APA TFG/14) has been published as Doc 9915. Report includes medium term forecasts of air traffic in the Transpacific area and for selected Transpacific and Asia/Pacific city pair markets through 2012. Report also contains a long term forecast with a horizon to the year 2025 and the short term forecast for the period 2008 – 2010 and intermediate forecasts for each of the years 2015 and 2020. Forecasts are provided for total passenger traffic and aircraft movements and in the case of the aggregate transpacific market also for peak hour movements on selected groups for the year 2012.

6.3 The February 2008 forecast prepared by IATA–for APAC traffic in respect of passenger, cargo, aircraft movements and new aircraft deliveries in the Regions is also provided in the Appendix B to this plan as reference.

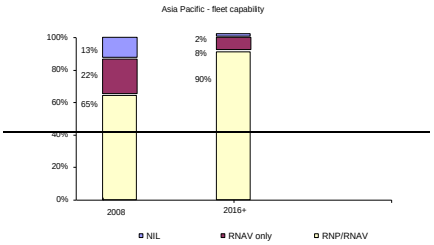
Aircraft fleet readiness status

6.4 2007 was a record year for Asia/Pacific airlines with 418 new aircraft deliveries and more than 1,000 new orders. The overall number of deliveries to Asia/Pacific based airlines in 2008 is expected to total 430 aircraft.

6.5 All major commercial aircraft manufacturers since the 1980's have included RNAV capabilities. The commercial aircraft currently produced incorporate an RNP capability.

6.6 One significant issue for PBN implementation today is directly related to the multitude of FMS installations and varying degrees of capabilities associated with the current fleet of RNAV aircraft. Specifically, there are numerous FMS systems installed in today's fleets, all with varying capabilities.

~~6.7 The diagram below displays a high level analysis based on fleet numbers from Ascend Online Fleets database March 2008 and RNAV/RNP classification by IATA.~~



CNS Infrastructure

Navigation infrastructure

Global Navigation Satellite System (GNSS)

6.~~8~~ 7 Global Navigation Satellite System (GNSS) is a satellite-based navigation system utilizing satellite signals, such as Global Positioning System (GPS), for providing accurate and reliable position, navigation, and time services to airspace users. In 1996, the International Civil Aviation Organization (ICAO) endorsed the development and use of GNSS as a primary source of future navigation for civil aviation. ICAO noted the increased flight safety, route flexibility and operational efficiencies that could be realized from the move to space-based navigation. APANPIRG/23 agreed to GNSS being a requirement for all PBN approvals, and the Seamless ATM Plan was expected to include reference to airspace mandates for the carriage and use of GNSS.

6.~~9~~ 8 GNSS supports both RNAV and RNP operations. Through the use of appropriate GNSS augmentations, GNSS navigation provides sufficient accuracy, integrity, availability and continuity to support en-route, terminal area, and approach operations. Approval of RNP operations with appropriate certified avionics provides on-board performance monitoring and alerting capability enhancing the integrity of aircraft navigation.

6.~~10~~ 9 GNSS augmentations include Aircraft-Based Augmentation System (ABAS), Satellite-Based Augmentation System (SBAS), Ground-Based Augmentation System (GBAS), and Ground-based Regional Augmentation System (GRAS).

Other PBN navigation infrastructure

6.~~11~~ 10 Other navigation infrastructure includes INS, VOR/DME, DME/DME, and DME/DME/IRU. These navigation infrastructures may satisfy the requirements of RNAV navigation specifications, but not those of RNP.

6.~~12~~ 11 INS may be used to support PBN en-route operations with RNAV 10 and RNAV 5 navigation specifications.

6.~~13~~ 12 VOR/DME may be used to support PBN en-route and STAR operations based on the RNAV 5 navigation specification.

6.~~14~~ 13 Uses of DME/DME and DME/DME/IRU may support PBN en-route and terminal area operations based on RNAV 5, RNAV 2 or RNAV 1 navigation specifications. Validation of DME/DME coverage area and appropriate DME/DME geometry should be conducted to identify possible DME/DME gaps, including identification of critical DMEs, and to ensure proper DME/DME service coverage. The use of ground based radio navigation aids for PBN is a transitional measure

while GNSS based infrastructure is implemented. Inertial systems will be integrated with GNSS for improved performance.

Surveillance infrastructure

6.~~15~~ 14 For RNAV operations, States should ensure that sufficient surveillance coverage is provided to assure the safety of the operations. For RNP operations, surveillance coverage may not be required. Details on the surveillance requirements for PBN implementation can be found in the ICAO PBN Manual and ICAO PANS-ATM (Doc 4444), and information on the current existing surveillance infrastructure in APAC can be found in ICAO FASID tables.

Communication infrastructure

6.~~16~~ 15 Implementation of RNAV/RNP routes includes communication requirements. Details on the communication requirements for PBN implementation can be found in ICAO PANS-ATM (Doc 4444), ICAO RCP Manual (Doc 9869), and ICAO Annex 10. Information on the current existing communication infrastructure in APAC can also be found in ICAO FASID tables.

7. Implementation Plan for Performance Based Navigation

ATM Operational Requirements

7.1 The Global ATM Operational Concept (Doc 9854) makes it necessary to adopt an airspace concept able to provide an operational scenario that includes route networks, minimum separation standards, assessment of obstacle clearance, and a CNS infrastructure that satisfies specific strategic objectives, including safety, access, capacity, efficiency, and environment.

7.2 In this regard, the following programmes will be developed:

a) traffic and cost benefit analyses

b) necessary updates on automation

c) operational simulations in different scenarios

d) ATC personnel training

e) Flight plan processing

f) Flight procedure design training to include PBN concepts and ARINC-424 coding standard

g) Enhanced electronic data and processes to ensure appropriate level of AIS data accuracy, integrity and timeliness

h) WGS-84 implementation in accordance with ICAO Annex 15

i) iuniform classification of adjacent and regional airspaces, where practicable

j) RNAV/RNP applications for SIDs and STARs

k) Coordinated RNAV/RNP routes implementation

l) RNP approach with vertical guidance

~~Short Term~~ Implementation Plan

Route Operations

7.3 During the planning phase of any implementation of PBN routes, States should gather inputs from all aviation stakeholders to obtain operational needs and requirements. These needs and requirements should then be used to derive airspace concepts and to select appropriate PBN navigation specification. For specific details of expected PBN applications, reference should be made to the Asia/Pacific Seamless ATM Plan.

~~7.4 In this phase, the application of RNAV 10 and RNP 4 navigation specifications is expected for Oceanic and Remote continental routes. Prior to implementation of RNP 4, States should consider air traffic demands, ATC workload, surveillance and communication capabilities and fleet readiness statistics, and consult all stakeholders.~~

~~7.5 For Continental routes, the application of RNAV 5 and RNAV 2 navigation specifications is expected. In the continental en route areas of operation, States may choose to implement RNAV 2 routes to enhance efficiency of airspace usage and support closer route spacing, noting that appropriate communication and surveillance coverage must be provided. The RNAV 2 navigation specification can also be used in airspace, where sufficient CNS capability is provided and there are operational benefits.~~

~~TMA Operations~~

~~7.6 In selected TMAs, the application of RNAV 1 in a radar environment can be supported though the use of GNSS or ground navigation infrastructure, such as DME/DME and DME/DME/IRU. In this phase, mixed operations (equipped and non-equipped) will be permitted.~~

~~7.7 In a non-radar environment and/or in an environment without adequate ground navigation infrastructure, the SID/STAR application of Basic-RNP1 is expected in selected TMAs with exclusive application of GNSS. In this phase, mixed operations (equipped and non-equipped) will be permitted.~~

~~Instrument Approaches~~ Terminal Airspace

7.~~8~~ 4 For specific details of expected PBN terminal airspace applications, reference should be made to the Asia/Pacific Seamless ATM Plan.

7.~~8~~ 5 The application of RNP APCH with Baro-VNAV procedures is expected to be implemented in the maximum possible number of airports, commencing primarily with international airports. To facilitate transitional period, conventional approach procedures and conventional navigation aids should be maintained for non-equipped aircraft.

7.~~9~~ 6 States should promote the use of APV operations (Baro-VNAV or augmented GNSS) to enhance safety and accessibility of RNP approaches.

7.~~10~~ 7 The application of RNP AR APCH procedures should be considered in selected airports, where obvious ~~operational~~ safety and operational benefits can be obtained ~~due to the existence of significant obstacles~~.

~~Summary table & Implementation targets~~

~~Short Term (2008-2012)*~~		
~~Airspace~~	**~~Preferred Nav. Specifications~~**	**~~Acceptable Nav. Specifications~~**
~~Route – Oceanic~~	~~RNP 4~~	~~RNAV 10~~
~~Route – Remote continental~~	~~RNP 4~~	~~RNAV 10~~
~~Route – Continental en-route~~	~~RNAV 2, RNAV 5~~	
~~TMA – Arrival~~	~~RNAV 1 in radar environment and with adequate navigation infrastructure.~~ ~~Basic RNP 1 in non-radar environment~~	
~~TMA – Departure~~	~~RNAV 1 in radar environment and with adequate navigation infrastructure.~~ ~~Basic RNP 1 in non-radar environment~~	
~~Approach~~	~~RNP APCH with Baro-VNAV in most possible airports~~ ~~RNP AR APCH in airport where there are obvious operational benefits.~~	
~~Implementation Targets~~ • ~~RNP APCH (with Baro-VNAV) in 30% of instrument runways by 2010 and 50% by 2012 and priority should be given to airports with operational benefits~~ • ~~RNAV 1 SID/STAR for 50% of international airports by 2010 and 75% by 2012 and priority should be given to airports with RNP Approach~~ • ~~Re-defining existing RNAV/RNP routes into PBN navigation specification by 2012~~ • ~~Implementation of additional RNAV/RNP routes~~		

~~*** Note:** Early completion of an implementation is encouraged within the timeframe on the basis of coordination between affected States and airspace users.~~

~~Medium Term Implementation Plan~~

~~Route Operations~~

~~7.11 Noting the current development of route spacing standards for RNAV 1, RNAV 2, RNP 2, in this phase, it is expected that the implementations of all existing RNAV/RNP routes are consistent with PBN standards. States are encouraged, to harmonize their RNAV/RNP routes based on consistent PBN navigation specifications and separation standards. Implementations of additional RNAV/RNP routes are also encouraged.~~

~~7.12 With the utilization of ADS and CPDLC, the application of RNP routes in the Oceanic and Remote continental airspace in the APAC Region is expected. This will permit the use of smaller lateral and longitudinal separation, such as 30 NM based on the RNP 4 navigation specification. States should also consider the fleet readiness status during their planning.~~

~~7.13 Noting the current development of RNP 2 navigation specification, in this phase, the application of RNP 2 is expected for the continental en route airspace with high air traffic density. Depending on the sufficiency of DME/DME coverage or GNSS availability, States may consider the use of RNAV 2 navigation specification.~~

~~TMA Operations~~

~~7.15 Noting the current development of Advanced RNP 1 navigation specification, in this phase, it is expected that the application of RNAV 1 or RNP 1 will be expanded in selected TMAs. The application of RNAV 1/RNP 1 will also depend on DME/DME infrastructure, GNSS availability and aircraft navigation capability. In TMAs of high air traffic complexity and movement, the use of RNAV 1 or RNP 1 equipments will be mandatory. In TMAs of less air traffic complexity, mixed operations will be permitted (equipped or non-equipped).~~

~~Instrument Approaches~~

~~7.16 In this phase, the extended application of RNP APCH with Baro-VNAV or APV in most airports is expected. These applications may also serve as a back-up to precision approaches and provide vertical guided approaches for the runways without precision approach capability.~~

~~7.17 The extended application of RNP AR Approaches is expected for airports where there are operational benefits.~~

7.~~18~~ 8 The introduction of application of landing capability using GNSS and its augmentations is expected to guarantee a smooth transition toward high-performance approach and landing capability.

Contingency

7.~~14~~ 9 ~~In this phase,~~ The establishment of a backup system in case of GNSS failure or the development of contingency procedures ~~will be necessary. Contingency~~ should be considered as part of the Safety Assessment.

Summary table & Implementation targets

Medium Term (2013-2016)*		
Airspace	**Preferred Nav. Specification**	**Acceptable Nav. Specification**
Route – Oceanic	RNP 2**, RNP 4	RNAV 10
Route – Remote continental	RNP 2	RNAV 2, RNP 4, RNAV 10
Route – Continental en-route	RNAV 1, RNP 2	RNAV 2, RNAV 5
TMA – Arrival	Expand RNAV 1 or RNP 1 application Mandate RNAV 1 or RNP 1 approval for aircraft operating in higher air traffic density TMAs	
TMA – Departure	Expand RNAV 1 or RNP 1 application Mandate RNAV 1 or RNP 1 approval for aircraft operating in higher air traffic density TMAs	
Approach	Expansion of RNP APCH (with Baro-VNAV) and APV Expansion of RNP AR APCH where there are operational benefits Introduction of landing capability using GNSS and its augmentations	
Implementation Targets • RNP APCH with Baro-VNAV or APV in 100% of instrument runways by 2016 • RNAV 1 or RNP 1 SID/STAR for 100% of international airports by 2016 • RNAV 1 or RNP 1 SID/STAR for 70% of busy domestic airports where there are operational benefits • Implementation of additional RNAV/RNP routes		

*** Note 1:** In circumstances where affected States are agreeable to completing an implementation in advance of the timeline, early implementation is encouraged on the basis of coordination between affected States and airspace users.

** **Note 2:** Related CNS requirements and operational procedures for RNP 2 application in Oceanic Airspace are yet to be determined.

*** **Note 3:** When establishing the implementation targets in accordance with Assembly Resolution A37-11, the States should first conduct an analysis of the instrument RWY eligibility for APV approach. This analysis should include the feasibility of the APV at a particular location, the presence of regular commercial operations and the current or projected user fleet capability for APV. Locations where APV approach is either not feasible or where the regular operators cannot realize the benefit of APV within the set implementation timeline, need not be included. Where APV is not implemented, States should consider implementation of RNP APCH with LNAV minima instead of APV to provide the safety benefits of straight-in approach procedures.

~~Long Term~~ GNSS Implementation Strategies ~~(2016 and beyond)~~

7.19 ~~In this phase,~~ GNSS is expected to be a primary navigation infrastructure for PBN implementation. States should work co-operatively on a multinational basis to implement GNSS in order to facilitate seamless and inter-operable systems and undertake coordinated research and development programmes on GNSS implementation and operation.

7.20 ~~Moreover, during this phase,~~ States are encouraged to consider segregating traffic according to navigation capability and granting preferred routes to aircraft with better navigation performance.

7.21 With the expectation that precision approach capability using GNSS and its augmentation systems will become available, States are encouraged to explore the use of such capability where there are operational and financial benefits.

8. Transitional Strategies

8.1 During transition to PBN, sufficient ground infrastructure for conventional navigation systems must remain available to serve non-equipped flights. Before existing ground infrastructure is considered for removal, users should be given reasonable transition time to allow them to equip appropriately to attain equivalent PBN-based navigation performance. States should approach removal of existing ground infrastructure with caution to ensure that safety is not compromised. Performance of safety assessments and consultation with users through regional air navigation planning processes will be necessary.

8.2 States should coordinate to ensure that harmonized separation standards and procedures are developed and introduced concurrently in all flight information regions along major traffic flows to allow for a seamless transition towards PBN.

8.3 States should cooperate on a multinational basis to implement PBN in order to facilitate seamless and inter-operable systems and undertake coordinated research and development programmes on PBN implementation and operation.

8.4 States are encouraged to consider segregating traffic according to navigation capability and granting preferred routes to aircraft with better navigation performance**,** taking due consideration of the needs of State aircraft.

8.5 States should encourage operators and other airspace users to equip with PBN-capable avionics. This can be achieved through early introductions of RNP approaches, preferably those with vertical guidance.

8.6 ICAO Asia-Pacific Regional Office should provide leadership supporting implementation and transition towards PBN.

9.

Safety Assessment & Monitoring Requirements

Need for a safety assessment

9.1 To ensure that the introduction of PBN applications within the Asia/Pacific Region is undertaken in a safe manner, in accordance with relevant ICAO provisions implementation shall only take place following conduct of a safety assessment by the implementing State or group of States that demonstrates that an acceptable level of safety will be met. This assessment may also need to demonstrate that residual levels of risk associated with specific PBN implementations are acceptable. Additionally, after implementation ongoing periodic safety reviews shall be undertaken by the implementing State or group of States, where required, in order to establish that operations continue to meet acceptable levels of safety.

En-route safety assessment and monitoring

9.2 When considering en-route PBN implementations, the ICAO *Procedures for Air Navigation Services – Air Traffic Management* (PANS-ATM, Doc 4444, Chapter 5, Section 5.4) contains procedures and RNAV procedural separation minima for use in the separation of aircraft in the en-route phase. In some cases, these separation minima require specific RNP capabilities and are based on collision risk modelling which determines communications and surveillance requirements. However, this modelling does not include all operational and technical aspects and is dependent upon parameter values that may vary depending on the particular airspace where the separation minimum will be applied. Therefore, prior to implementation, a system verification of sufficient duration and integrity must be performed to assess such parameters and conditions including weather deviations or other contingency events for the airspace concerned and to demonstrate that operational and technical requirements will be met.

9.3 APANPIRG has established the Regional Airspace Safety Monitoring Advisory Group (RASMAG) to facilitate the airspace safety monitoring aspects for implementations of reduced separation minima and CNS/ATM applications within the Asia and Pacific Regions. RASMAG has adopted the term En-route Monitoring Agency (EMA) to describe an organization providing airspace safety assessment, monitoring and implementation services for international airspace in the Asia/Pacific region to assist the implementation and operation of reduced horizontal (lateral and longitudinal) separation minima. To ensure regional harmonization of en-route safety assessment requirements and methodologies, implementing States are encouraged to work cooperatively with RASMAG who will provide guidance and technical assistance to States to support their en-route PBN implementations.

Undertaking a safety assessment

9.4 The implementing State or group of States shall ensure that a safety assessment and, where required, ongoing monitoring of PBN implementations are conducted. The implementing State or group of States may have the capability to undertake such activities or, in the case of en-route implementations, may seek assistance from an En-route Monitoring Agency. The latter course of action is preferred as an EMA can establish the necessary monitoring and data collection activity in an effective manner for the international airspaces in which the EMA holds responsibility.

9.5 In undertaking a safety assessment to enable en-route implementation of PBN, a State authority or EMA shall:

1) Establish and maintain a database of PBN approvals;
2) Pre-implementation - conduct safety and readiness assessments and, for international implementations, report results to RASMAG;
3) Post-implementation - maintain awareness of data link performance and monitor aircraft horizontal-plane navigation performance and the occurrence of large navigation errors (lateral and longitudinal), implement remedial actions as necessary and, for international implementations, report results to RASMAG;
4) Monitor operator compliance with State approval requirements after PBN implementation;
5) Initiate necessary remedial actions in any instances where PBN requirements are not met.

9.6 Detailed information relating to the international airspace jurisdiction, roles and responsibilities of regional EMAs is contained in the *Asia/Pacific En-route Monitoring Agency Handbook*, which is available from the ICAO Asia/Pacific Regional Office.

– – – – – – – – – – – –

Intentionally Left Blank

Appendix A – CHANGES TO THE ASIA/PACIFIC REGIONAL PBN IMPLEMENTATION PLAN

Whenever a need is identified for a change to this document, the Request for Change (RFC) Form (see below) should be completed and submitted to the ICAO Asia and Pacific Regional Office. The Regional Office will collate RFCs for consideration by the Performance Based Navigation Task Force (CNS/MET Sub-group of APANPIRG).

When an amendment has been agreed by a meeting of the Performance Based Navigation Task Force then a new version of the PBN Regional Plan will be prepared, with the changes marked by an "|" in the margin, and an endnote indicating the relevant RFC, so a reader can see the origin of the change. If the change is in a table cell, the outside edges of the table will be highlighted; e.g.:

Final approval for publication of an amendment to the PBN Regional Plan will be the responsibility of APANPIRG.

PBN Regional Plan REQUEST FOR CHANGE FORM

RFC Nr:	

Please use this form when requesting a change to any part of this PBN Regional Plan. This form may be photocopied as required, emailed, faxed or e-mailed to ICAO Asia and Pacific Regional Office +66 (2) 537-8199 or icao_apac@bangkok.icao.int

1. SUBJECT:			
2. REASON FOR CHANGE:			
3. DESCRIPTION OF PROPOSAL: [expand / attach additional pages if necessary]			
4. REFERENCE(S):			
5. PERSON INITIATING:		**DATE:**	
ORGANISATION:			
TEL/FA/X/E-MAIL:			

6. CONSULTATION		**RESPONSE DUE BY DATE:**		
	Organization	**Name**	**Agree/Disagree**	**Date**
7. ACTION REQUIRE :				
8. PBN REGIONAL PLAN EDITOR			**DATE REC'D :**	
9. FEEDBACK PASSED			**DATE :**	

AMENDMENT RECORD

Amendment Number	Date	Amended by	Comments

Intentionally Left Blank

Appendix B – IATA Traffic Forecast

"By 2010 Asia will be the largest single market for aviation" - IATA 27th Feb 2008. Globally predicted passenger traffic will rise by 4.9 per cent per year between 2007 and 2026, almost trebling in two decades as jet planes got bigger and more people flew on them. Meanwhile airfreight will rise by 5.8 per cent annually in the same period.The greatest demand will come from the Asia-Pacific region, where airlines will take delivery of 31 per cent of new planes in the next 20 years, compared with 24 per cent for Europe and 27 per cent for North America.

Passenger
Asia Pacific airlines saw a marginal drop in demand growth from 6.2 per cent in December 2007 to 5.7 per cent in January 2008. Currently, airlines in the region benefited from increased competitiveness due to the strong Euro and the booming economies of both India and China.

Cargo
Steady year-on-year airfreight growth of 4.5 per cent was recorded in January 2008. In the larger freight markets there is continued strength. Asia Pacific airlines saw demand increase 6.5 per cent, up from 6 per cent in December 2007, boosted by the booming economies in China and India.

For the period 2002-2020 aircraft movements are expected to increase at an annual growth rate of 5.4 per cent, to reach almost 294 thousand aircraft movements by the year 2020. Average annual growth rates of 6.5, 5.7 and 5.2 per cent are forecast for the periods 2005 - 2010, 2010-2015 and 2015 - 2020, respectively.

TRANSPACIFIC PASSENGER FORECAST			
Average Annual Percentage Growth Rates			
	Low	Medium	High
2005-2010	5.3	6.5	7.8
2010-2015	4.5	5.7	7.0
2015-2020	4.0	5.2	6.5
2002-2020	4.1	5.4	6.7

The Intra-Asia/Pacific passenger aircraft movements are expected to increase at an average annual growth rate of 4.6 per cent to the year 2020. The growth rates for the intermediate periods of 2005-2010, 2010- 2015 and 2015-2020 are 5.0, 4.3 and 4.2 per cent, respectively.

INTRA ASIA /PACIFIC AIRCRAFT MOVEMENT FORECAST			
Average Annual Percentage Growth Rates			
	Low	Medium	High
2005-2010	3.6	5.0	5.5
2010-2015	3.1	4.3	5.2
2015-2020	3.1	4.2	5.2
2002-2020	3.3	4.6	5.6

New Aircraft Deliveries by Region

Record new aircraft orders were placed by the airline industry in 2005 – 2007. The large numbers of new orders represent strong confidence in the future prospects of the global airline industry. In its latest forecast of aviation growth, European aircraft maker Airbus said the world's fleet of large passenger jets (of more than 100 seats) would double in the next 20 years to nearly 33,000. The greatest demand will come from the Asia-Pacific region, where airlines will take delivery of 31 per cent of new planes in the next 20 years, compared with 24 per cent for Europe and 27 per cent for North America.

New Aircraft Deliveries by Region	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012+**
	Existing						
Africa	**665**	**26**	**15**	**20**	**16**	**13**	**28**
Asia Pacific	**3,578**	**329**	**428**	**407**	**344**	**267**	**440**
Europe	**5,301**	**292**	**348**	**364**	**251**	**153**	**297**
Latin America/Caribbean	**1,031**	**93**	**91**	**45**	**66**	**43**	**65**
Middle East	**626**	**41**	**57**	**44**	**36**	**27**	**164**
North America	**6,987**	**240**	**293**	**309**	**222**	**163**	**412**
Total	**18,188**	**1,026**	**1,237**	**1,208**	**944**	**679**	**1,551**
Increase in Global aircraft fleet (%)	**4.2**	**4.9**	**4.6**	**4.9**	**3.4**	**2.4**	**2.4**

Appendix C - Reference documentation for developing operational and airworthiness approval

General Guidelines for Obtaining Airworthiness and Operational Approvals for PBN Navigation Specifications, Version 1.0, **International Air Transport Association**,
August 2008. (URL - http://www2.icao.int/en/pbn/ICAO%20Documentation/State%20and%20International%20Organization%20Publications/IATA%20Guidelines%20for%20PBN%20Operational%20Approval.pdf**)**

States should consider using the COSCAP Operational Approval Handbook http://www.bangkok.icao.int/edocs/COSCAP_PBNOPS_HANDBOOK%20Version%202_4.pdf as a reference until ICAO Operational Approval guidance material is published.

Intentionally Left Blank

Appendix D – Practical Example of tangible benefits

Practical examples of tangible benefits derived from the implementation of PBN are:

- Increased airspace safety through the implementation of continuous and stabilized descent procedures using vertical guidance;
- Provision of runway-aligned final approach path which may not be possible from conventional navigation
- Reduced aircraft flight time due to the implementation of optimal flight paths, with the resulting savings in fuel, noise reduction, and enhanced environmental protection;
- Improved airport and airspace arrival paths in all weather conditions, and the possibility of meeting critical obstacle clearance and environmental requirements through the application of optimized RNAV or RNP paths;
- Implementation of more precise approach, departure, and arrival paths that will reduce dispersion and will foster smoother traffic flows;
- Reduced delays in high-density airspaces and airports through the implementation of additional parallel routes and additional arrival and departure points in terminal areas;
- Reduction of lateral and longitudinal separation between aircraft to accommodate more traffic;
- Decrease ATC and pilot workload by utilizing RNAV/RNP procedures and airborne capability and reduce the needs for ATC-Pilot communications and radar vectoring;
- Increase of predictability of the flight path.
- Reduction of maintenance and flight inspection costs associated with conventional navigation aids

Examples of measurable benefits resulting from PBN implementation in Australia are attached as **Attachment A** and **Attachment B**.

An example of measurable benefits resulting from PBN implementation in Thailand is attached as **Attachment C**.

Appendix E: Basic Planning Elements (BPEs) Table

Basic Plan Elements	Regional Plan References
1. Policy and Implementation Planning Formation of a key working group Standards & Requirements in accordance with ICAO Communication with stakeholders	4.0
2. Assessment of CNS infrastructure	6.11-6.16
3. Assessment for PBN fleet readiness Based on actual operator traffic	6.4-6.7
4. Selection of appropriate PBN navigation specification	7.3-7.18
5. Strategies for en-route implementation Key traffic flows and city pairs identified Domestic International Harmonization in en-route, across FIRs	5.4-5.9
6. Strategies for terminal area implementation, including timeline Specify terminal areas selected for implementation by 2010	5.10- 5.11
7. Strategies for Instrument approach implementation, including timeline Specify procedures selected for implementation by 2010 APV (Baron-VNAV and/or augmented GNSS) Designate RNP APRCH (LNAV or LNAV/VNAV) Designate RNP AR APCH (with operational justification)	4.16(b) / 5.12-5.13 / 7.8-7.10 / 7.16- 7.18
8. Transition strategy Include decommissioning plan	4.17(b) / 8.0
9. Safety Assessment Pre- and post- implementation safety assessments conducted in accordance with ICAO provisions Seek guidance and technical assistance from RASMAG Periodic safety reviews undertaken by the State or group of States where required	4.17(a) / 9.0
10. Description of the tangible benefits Benefits to operations derived from PBN implementation	4.10 / Appendix D
11. Regulatory Framework and Process for Operational Approval	Appendix C