International Civil Aviation Organization

FIFTEENTH MEETING OF THE COMMUNICATIONS/NAVIGATION/SURVEILLANCE AND METEOROLOGY SUB-GROUP (CNS/MET SG/15) OF APANPIRG

Bangkok, Thailand, 25 – 29 July 2011

Agenda Item 5: Navigation –

1) review outcome of ATM/AIS/SAR/21 on PBN implmentation including report of the Performance Based Navigation (PBN) Task Force

ICAO ASIA/PACIFIC PERFORMANCE-BASED NAVIGATION (PBN) TASK FORCE

(Presented by the Secretariat)

SUMMARY

This paper presents the key outcomes of the Seventh Meeting of the Performance-Based Navigation Task Force (PBN/TF/7, Bangkok, 1 – 3 September 2010) and Eighth Meeting of the Performance-Based Navigation Task Force (PBN/TF/8, New Delhi, 9-13 May 2011).

This paper relates to –

Strategic Objectives:
A: **Safety** – Enhance global civil aviation safety
C: **Environmental Protection and Sustainable Development of Air Transport** – Foster harmonized and economically viable development of international civil aviation that does not unduly harm the environment

Global Plan Initiatives:
GPI-1 Flexible use of airspace
GPI-5 RNAV and RNP (Performance-based navigation)
GPI-7 Dynamic and flexible ATS route management
GPI-10 Terminal area design and management
GPI-11 RNP and RNAV SIDs and STARs
GPI-12 Functional integration of ground systems with airborne systems
GPI-18 Aeronautical information
GPI-20 WGS-84
GPI-21 Navigation systems
GPI-22 Communication infrastructure

1. INTRODUCTION

1.1 The Seventh Meeting of the Performance-Based Navigation Task Force (PBN/TF/7) was held in Bangkok, 1 – 3 September 2010. The PBN/TF/7 Meeting was attended by 58 participants.

1.2 The Eighth Meeting of the Performance Based Navigation Task Force (PBN/TF/8) was held in conjunction with the PBN Workshop and the PBN Implementation Seminar 2011, which were hosted by the Airports Authority of India (AAI), at New Delhi, India from 09 to 13 May 2011.

1.3 The PBN Workshop was conducted by Eurocontrol from 9 to 12 May 2011 in parallel with the PBN Implementation Seminar, which was held from 10 to 11 May 2011. The PBN/TF/8 itself was held from12 to 13 May 2011. Sixty-three (63) participants attended the meeting.

2. DISCUSSION

Global PBN Implementation and PBN SG Update

2.1 Mr. Erwin Lassooij from ICAO HQ presented PBN/TF/7-WP/7 which highlighted the slow progress of PBN, both due to a lack of expertise in many States as well as lack of resources in ICAO. The paper also highlighted the need under ICAO Assembly Resolution A37-11for implementing RNP APCH LNAV approaches if Approaches with vertical guidance (APV) cannot be implemented. Every approach chart for APV should also have a minima line for LNAV to accommodate aircraft that cannot fly APV.

2.2 PBN/TF/8 was provided an update on PBN initiatives by the ICAO PBN Programme Office in Montreal, including policy decisions, implementation support such as GO-Teams, workshops, courses, and recent outcomes of relevant Panels, Study groups and taskforces. Key global ICAO PBN initiatives and features included the following:

- Measurement of the PBN implementation performance using an actual implementation database coordinated with Jeppesen, and an ATM Operational Improvement tool;
- Adoption of Assembly Resolution 37-11;
- Educational activities of the GO-Teams, which has been to three States, including Thailand in the APAC Regions;
- PBN Airspace design workshops (including Bangkok in 2010); and
- ICAO is developing Operational Approval guidance for global application, based to a large degree on the APAC Cooperative Development of Operational Safety and Continuing Airworthiness Programmes (COSCAP) Handbook in cooperation with the Civil Aviation Safety Authority of Australia (CASA).

2.3 PBN/TF/8 discussed the implications of the new RNP 0.3 and 'Advanced RNP' Navigation Specifications. Participants were not clear on how these specifications would be applied, and in particular some delegates were not aware that the 'Advanced RNP' Specification was a means of bringing together appropriate specifications to account for all phases of flight. The RNP 0.3 navigation specification was explained as being designed for helicopter operations although its use by aeroplanes was not excluded.

APAC Region PBN Plans and Implementation

Flight Procedure Programme Update

2.4 The FPP Manager, Capt. Dave VanNess, through PBN/TF/7/WP/3 presented to the Seventh Meeting of the Task Force an update on the activities and progress of the ICAO Asia-Pacific Flight Procedure Programme (FPP). The meeting noted with appreciation the establishment of the FPP in Beijing, China and looked forward to a continued communication between FPP and the

PBN/TF. PBN/TF/7 developed a draft Conclusion to encourage States in the Asia/Pacific Region to take part in the FPP (note: It was brought to the attention of APANPIRG/21 by the PBN TF Chairman and was similar to Conclusion 20/35 adopted by APANPIRG/20 in 2009):

Draft Conclusion 7/2: Participation in the Asia-Pacific Flight Procedure Programme

That, States in the Asia/Pacific Region were encouraged to take part in the regional cooperative effort to achieve the safety, access, capacity, efficiency and environmental benefits that are possible with PBN implementation, by joining the Asia-Pacific Flight Procedure Programme (FPP).

State PBN Plan Implementation

2.5 The eighth meeting of PBNTF reviewed and made changes to the State Implementation Progress Report to clarify the data required, to incorporate the latest APANPIRG Conclusions and to capture en-route PBN information. The meeting noted that few States had submitted up-to-date information using the State Implementation Progress Report. The Chairman urged States to ensure they regularly submitted these reports so the Regional Office could regularly update the PBN implementation progress information presented to the Task Force. The meeting participants agreed to provide an update to the Regional Office every six months, prior to the Task Force meeting after being reminded by the Secretariat of the changes in the Report.

2.6 The meeting agreed that mechanisms such as the ICAO Asia/Pacific Flight Procedure Programme (FPP) and COSCAPs, and workshop/seminars held at locations that can benefit States which need direct assistance should be encouraged. The meeting encouraged more advanced 'champion' States to provide direct assistance where this was possible.

Regional PBN Plan

2.7 Proposed amendments to the Asia/Pacific Regional Performance-Based Navigation Implementation Plan were discussed. These changes which are shown in **Appendix 1** to this paper were intended to ensure the Regional Plan continues to provide States with essential information for PBN implementation. The following amendments were endorsed by the PBN/TF/8 meeting.

a) Add an Appendix to the Regional plan to include and describe the Basic Planning Elements[1] (BPEs) identified in the Regional plan review. This will help ensure States address all areas required to successfully implement PBN.

b) Include the area of Regulatory Framework and Process for regulation of Operational Approval and ANSPs as a Basic Planning Element.

c) Amend Appendix C of the Regional Plan to include guidance for States to consider using the COSCAP Ops Approval Handbook as a reference until ICAO guidance materials are released (probably the updated PBN Manual, Doc 9613).

d) Update Appendix D of the Regional Plan to include real examples of specific measurable benefits resulting from States PBN implementation (Australia,

[1] Including new element: 'Regulatory Framework and Processes for regulation of Operational Approval and ANSP Procedure Approvals'.

India, Maldives and Thailand volunteered to provide this information by 1 August 2011).

2.8 Thus, the meeting is invited to consider following Draft Conclusion:

Draft Conclusion 15/xx - The Revised Asia/Pacific Regional PBN Implementation Plan Amendment

That, the revised Asia/Pacific Regional Performance-Based Navigation Plan Version 3.0 as provided in the Appendix XX to the Report be adopted.

REDI Initiatives

The meeting noted the need for a Regional Support Strategy to provide direct support to States in an effort to accelerate PBN implementation within the Asia Pacific Region. PBN/TF/7 agreed (7/9) that the principles and proposed activities of the formal PBN Regional Development and Implementation Team (REDI) teams were very beneficial. However at PBN TF/8 it was noted that ICAO FPP, COSCAP, and industry stakeholders such as Boeing, Airbus and IATA had already made a significant impact to the progress of PBN development. Due to this, IATA concluded that a formal REDI Team under the APANPIRG Contributory Bodies Structure was not required.

2.9 IATA, however noted, that there is a need for formal recognition of PBN support initiatives in order to create broader momentum and to showcase regional progress. In addition, there was a need for the coordination of some of the State and Regional support activities. Therefore, it was proposed that 'PBN REDI initiatives' be used as a term to associate Regional and State support efforts that include the contributions of ICAO supporting agencies, industry partners and volunteering ('champion') States, particularly where multiple stakeholders are involved. Airbus noted that the coordinator of regional PBN activity should not be a commercial entity.

PBN Implementation Issues

Review of follow-up action to APANPIRG Conclusions

2.10 PBN/TF/8/WP05 provided information on the status of APANPIRG Conclusions regarding the implementation of PBN within the APAC Regions and follow-up actions that had taken place. IATA noted that, with regard to Conclusion 21/30 (Limitation of Older Generation FMS), the problem appeared to be the inability to upgrade the capability of systems in a cost-effective manner.

RNP4 Survey

2.11 PBN/TF/8/WP6 presented the results of the two Regional RNP4 Surveys resulting from APANPIRG Conclusion 19/7.

2.12 The PBN/TF/8 noted from the Surveys that it was unlikely that APAC State aircraft operators would achieve RNP4 approval by 2012. Airbus stated there was no additional requirement in terms of equipment, so it was just a matter of the approval process. Australia noted that the refresh rate of the communications and surveillance elements of the 30NM x 30NM separation standard were the limiting factor, not the navigation specification. IATA noted that until there was a priority accorded to RNP4 aircraft or there was a mandate, airlines would continue to resist the cost of RNP4 approval.

2.13 IATA advised that the benefits of RNP4 were not seen as expected by Conclusion 19/17. IATA also stated that there may be a need to mandate RNP4 operations, rather than simply urge its implementation. The meeting noted information in this paper and further encouraged States to present papers that would update the Regional Plan at the same time as the new navigation specifications become available.

Regional RAIM System

2.14 Thailand presented a proposal on the establishment of a Regional RAIM (Receiver Autonomous Integrity Monitoring) System at both PBN/TF/7 and PBN/TF/8. These papers noted that GNSS was considered a main navigation infrastructure supporting PBN operations, and is now also becoming a critical component of surveillance systems, such as ADS-B. Unpredicted outage of GNSS services can cause undesired interruptions on aircraft operations. ICAO Annex 10 and the PBN manual require States and ANSPs to provide timely warnings of GNSS RAIM outages. RAIM predictions were needed by pilots, flight dispatchers, air traffic controllers and airspace planners.

2.15 PBN TF/7 was informed that the APEC GNSS Implementation Team (GIT), a team established under the Asia-Pacific Economic Cooperation (APEC) Transportation Working Group, during its thirteenth meeting in 2009, had expressed its willingness to work cooperatively with ICAO PBN Task Force to support the establishment of a regional RAIM prediction service. The PBNTF also noted with appreciation that Thailand through AEROTHAI was willing to serve as a project coordinator for this important regional activity.

2.16 PBNTF/7 agreed in principle with the establishment of a regional RAIM prediction system and cooperation with the APEC GIT. The PBNTF also endorsed the Minimal Technical and Operational Requirements for a Regional RAIM Prediction System as follows.

- *Basic Common Denominator* - Noting the differences among different RAIM algorithms on-board different aircraft, a regional RAIM prediction system provided by a service provider, such as an ANSP, should provide a "basic common denominator" RAIM prediction service for "basic" GNSS receivers, such as TSO C-129 (Fault Detection) and TSO C-145/146 (Fault Detection and Exclusion).

- *Prediction Period* – A regional RAIM prediction system shall provide prediction for RAIM outages and number of GNSS-satellite availability for a 72 hour period using the latest available GPS NANU.

- *Approach Operation*s - A regional RAIM prediction system shall support aircraft approach operations based on RNP APCH (with/without Baro-VNAV) navigation specification. The system shall calculate the predicted RAIM availability for a 72 hour period for specific Aerodromes. The algorithms shall address the RAIM requirements for GNSS receivers operating in Approach operations (±0.3NM). Both the Fault Detection (FD) and Fault Detection and Exclusion (FDE) algorithms shall be provided. The system shall calculate the predicted RAIM availability at the Aerodrome Reference Point (ARP) for baro (pressure altitude) aided and non-baro aided GNSS user equipment at 1 minute intervals or better.

2.17 To encourage States' participation on the regional RAIM prediction service and to harmonize the operational and technical requirements, PBN TF/7 the Minimum Technical and Operational Requirements for a regional RAIM Prediction System as shown in the **Appendix 2** to this paper and formulated the following Draft Conclusions for consideration by the meeting:

Draft Conclusion 7/11: Endorsement of Minimum Technical and Operational Requirements for a Regional RAIM Prediction System

That, the Minimum Technical and Operational Requirements for a regional RAIM Prediction System for the APAC Region as shown in Appendix XX be adopted.

Draft Conclusion 7/12: Participation in Regional RAIM Prediction Service

That, States in the Asia/Pacific Regions be encouraged to take part in the Regional RAIM Prediction System.

2.18 AEROTHAI had approved the initial investment for the establishment of the APAC Regional RAIM Prediction System to support ABAS (Aircraft-Based Augmentation System), and not SBAS (Satellite-Based Augmentation System) and GBAS (Ground-Based Augmentation System). Initial operation for the Bangkok FIR is expected to be available near the end of 2011. The system would be capable of providing RAIM prediction services for all participating States within the Asia/Pacific Region within 2012. AEROTHAI estimated the level of financial contribution for each participating State to be a monthly fee of less than USD 1,500, with a one-time database set-up cost of less than USD 3,500 per State. India commented that some advanced States would have their own RAIM prediction services.

Integration of PBN Navigation Specifications

2.19 Australia presented PBN/TF/8/WP10, which discussed the problem of PBN navigation specifications not being vertically or horizontally integrated, and suggested a methodology to manage the inconsistency of navigation performance across the Region. Vertical integration would mean that a specification such as RNP1 would be certified to RNP2 standard. Horizontal integration would mean that RNP1 would be certified for RNAV1.

2.20 The paper noted that GNSS was required for RNP 4, RNP 0.3 en-route, RNP APCH and RNP AR APCH and DEP, and was acknowledged as the primary navigation system to support RNP2 and RNP1. In areas with poor DME density, GNSS was the only infrastructure available for RNP navigation specifications.

2.21 The paper proposed that APAC should adopt GNSS-enabled area navigation systems as the minimum requirement for all RNP navigation authorizations, in order to achieve technical, operational and regulatory interoperability. Furthermore, the same effect could be achieved globally should ICAO adopt GNSS-enabled area navigation systems as the minimum requirement for all RNP navigation authorizations, and would be a key enabler for Seamless ATM.

2.22 Hong Kong China asked whether the continued development of RNP2 would affect the requirement for GNSS. Australia stated that the draft navigation specification for RNP2 strongly suggested that GNSS would be required in this specification. IATA strongly supported the initiative as it would assist the implementation of Seamless ATM. PBN/TF/8 agreed to the following Draft Conclusion.

Draft Conclusion 8/2: GNSS Requirement for Navigation Authorizations and Specifications

(That, the *Strategy for the Provision of Navigation Services in the Asia/Pacific Region* should include the minimum requirement of GNSS-enabled area navigation systems for all RNP navigation authorizations; and)

That ICAO should adopt, as a minimum requirement, GNSS-enabled area navigation systems for all RNP navigation specifications.

State/Industry Updates

Japan - MTSAT Service Update

2.23 An update on the status of MTSAT (Multifunctional Transport Satellite) services was provided by Japan to PBNTF/8 meeting. The MTSAT service commenced in 2007, and had 100% availability until an unplanned service interruption of 1 hour 46 min in November 2010. This interruption was due to a JCAB-Datalink Service Provider (DSP) line failure. MTSAT Operations foresaw the failure and intentionally halted transmission from the GES (Ground Earth Station), making an immediate handover to the Inmarsat service provider in order to resume discontinued aircraft communications.

2.24 The paper noted that the service area of MSAS (Multi-functional Satellite Augmentation System) was currently only within the Fukuoka FIR, although MTSAT coverage was over much of the APAC regions. The paper also noted that MSAS had been achieving very stable performance since its commissioning, with horizontal accuracy of less than 1.5 m in most parts of Japan except Naha in the Southwest.

Task Force Role

2.25 Australia introduced PBN/TF/8/WP7, which discussed the future role of the PBN TF. The role, tasks and meeting frequencies and schedules had been reviewed by the Task Force and APANPIRG on a number of occasions since the Task Force was established. Various options have been considered that ranged between integration of the work program into existing APANIRG subgroups to the current twice yearly meetings, with one including a PBN Seminar.

2.26 It was noted that where possible, a meeting with a seminar would be held outside ICAO Regional Office to maximise the training benefits. The reviews recognised that other significant PBN activities were taking place globally and in the region and that the Task Force work program and meeting schedules should be integrated with these where possible.

2.27 The Maldives supported the continuation of the Task Force. India suggested alternately running a Workshop (which had been run very successfully in India), and a Seminar in conjunction with the Task Force. The Secretariat reminded the meeting that holding a Workshop alone was not viewed as sufficient justification for some delegates to travel to attend.

2.28 Australia suggested running an Operational Approval course in conjunction with the Task Force meeting. The meeting agreed that, for the meantime, the current format of having a Task Force twice a year, which may be supported by a Seminar/Workshop, should be continued.

2.29 The meeting was asked how long the Task Force would continue. The Acting Chairman advised that APANPIRG/21 had indicated that the Task Force should continue for three to five years.

2.30 IATA suggested that the Task Force should monitor progress and encourage State reporting of PBN implementations. The meeting agreed to include this role into the Task Force Terms of Reference (TORs). IATA, Australia, Fiji and Thailand volunteered to assist with drafting the revision of the TOR.

2.31 One area in which there had been little progress was the introduction of RNP based air routes within the APAC region. The paper noted that regional implementation of ADS-C should be coupled with PBN based air route reviews using either RNAV10 or RNP4 or perhaps even the RNP2 standard that is being developed by the PBN Study Group. Such routes would provide significant capacity and efficiency gains to the airlines.

2.32 While APANPIRG had a Route Review Task Force, its area of interest was very limited. The development of a revised PBN based air-route structure was not considered to be an appropriate task for the regional PBNTF. It would be best achieved by the establishment of a full-time project group within the Regional Office with States providing the appropriately qualified staff. India also asked about the capability of Regional Office to support a full-time project team within the Regional Office.

Annex 11 Issue

2.33 The Task Force discussed Flimsy 2, which was presented by Nepal. Nepal recommended that the following paragraph in Annex 11 be amended to remove the prescriptive reference regarding self-contained airborne navigation aids, which precludes RNAV waypoints.

> *Annex 11, Appendix 2, paragraph 1.2*
> *Where such ground-based radio navigation aids do not exist, significant points shall be established at locations which can be determined by self-contained airborne navigation aids, or, where navigation by visual reference to the ground is to be effected, by visual observation.*

2.34 Nepal would write to the Regional Office to formally request a change to Annex 11, removing the words 'self-contained' in order to allow area navigation derived RNAV waypoints. Australia supported the Nepalese position that the Annex needed to be amended. The Task Force endorsed the need for this change and noted that this would bring the Annex in line with the PBN Manual references (such as paragraph 2.2.1.2). (Letter from Nepal was received on 26 June 2011 and the proposal has been forwarded to ICAO HQ for consideration).

PBN Workshop (New Delhi, 9-12 May 2011)

2.35 The PBN Workshop was held at Hotel Ashok, New Delhi, India from 9-12 May 2011. The Workshop, which was intended for the participants who had entry level exposure to PBN, was attended by 26 participants. The PBN Workshop was conducted with the kind support of EUROCONTROL, Belgium, by Mr. Henri Lissone (Mike) and Mr. Richard Eliot (Charlie).

2.36 The main objective of the workshop was to educate participants on how to develop a PBN airspace concept, supporting PBN Planning. The Workshop provided a broad background on PBN and focused on practical applications of PBN. India noted that the Workshop had been highly successful in providing a number of its attendees the opportunity to learn from the hands-on format of the Workshop.

PBN Implementation Seminar 2011 (New Delhi, 10-11 May 2011)

2.37 The PBN Implementation Seminar 2011 was held in parallel to the PBN Workshop at Hotel Ashok, New Delhi, India from 10-11 May 2011. The Seminar focused on the progress, barriers and innovations in PBN implementation.

2.38 The Seminar programme covered a wide range of subjects related to PBN. The speakers and subjects presented were as follows.

- ICAO Global PBN Update – Mr. Erwin Lassooij, ICAO PBN Study Group Secretary − Global PBN Activities (presented by; Mr. Len Wicks, Regional Officer, ATM, ICAO Asia and Pacific Office);
- India discusses PBN and APV implementation including GAGAN project (Mr. Sundara Raman, ED (CNS-P) AAI and Mr. N.V. Atale, Jt, General Manager (ATM) AAI-CHQ)
- APAC FPP Beijing update (Captain Dave Van Ness, presented by Mr. Noppadol Pringvanich);
- Performance-Based Navigation: Area Navigation (RNAV) and Required Navigation Performance (RNP) Program (Mr. Joe McCarthy, FAA);
- PBN Implementation Barriers and Solutions for Small States Presented by Mr. Ilaitia Tabakaucoro, Fiji and Mr. James Tuguru, Papua New Guinea;
- The IATA PBN Experience (Mr. Anthony Houston of IATA);
- Enhancing Airspace Safety and Capacity using PBN (Mr. Noppadol Pringvanich, Aerothai);
- Implementation of Terminal Area RNP – ITAR Project (Mr. Phil Owen, Airservices Australia);
- PBN Implementation in Hong Kong, China (Mr. Gabriel Cheng)
- Application of the terminal PBN separation standard (Mr. Len Wicks);
- GE Aviation – the Role of Commercial Organisations in developing State PBN Capability (Mr. Juergen Ruppert, PBN Director Australasia); and
- RNP Regional Interoperability Presented by Mr. Dirk Noordewier, CASA.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) discuss the proposed changes to the Regional PBN Plan (Draft Conclusion 15/xx in paragraph 2.9);

c) note that 'PBN REDI initiatives' as opposed to a formal team was agreed to describe regional support strategies for PBN implementation;

d) discuss the implications of the RNP4 survey (noting that there was on-going work by the ATM/AIS/SAR SG to develop an Airspace Concept of Operations that included a mandate for PBN navigation specifications);

e) discuss the development of a sub-regional RAIM system (Draft Conclusions 7/11 and 7/12);

f) discuss the implications of the recommended mandate for GNSS in the Asia/Pacific Regions (Draft Conclusion 8/2); and

g) discuss any relevant matters as appropriate.

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INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

ASIA/PACIFIC REGIONAL PERFORMANCE-BASED NAVIGATION IMPLEMENTATION PLAN

DRAFT VERSION 3.0

July 2011

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

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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. 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. For the long term (2016 and beyond) it has been envisaged that GNSS will be the primary navigation infrastructure. It is also expected that precision approach capability using GNSS and its augmentation system will 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 updated strategy was reviewed and adopted by APANPIRG in its Twentieth meeting held in September 2009 under Conclusion 20/46.

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.

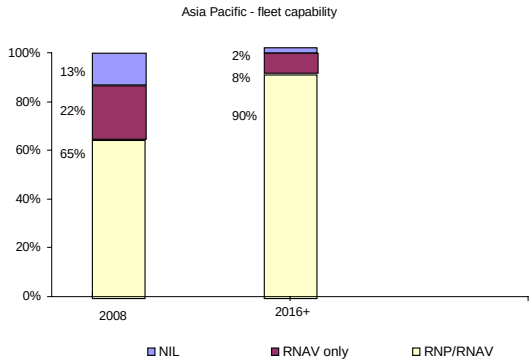
Aircraft fleet readiness status

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 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.

6.9 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 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 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 INS may be used to support PBN en-route operations with RNAV 10 and RNAV 5 navigation specifications.

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

6.14 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.

Surveillance infrastructure

6.15 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 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.

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

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

7.10 The application of RNP AR APCH procedures should be considered in selected airports, where obvious 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.

7.14 In this phase, the establishment of a backup system in case of GNSS failure or the development of contingency procedures will be necessary.

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 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.

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 A36/23, 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 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.

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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

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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 [insert link to Internet copy] as a reference until ICAO Operational Approval guidance material is published.

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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

Insert here real examples of specific measurable benefits resulting from States PBN implementation (Australia, India, Maldives and Thailand volunteered to provide this information by 1 August 2011 prior to APANPIRG/22)

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

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Appendix 2

The Minimum Technical and Operational Requirements for a Regional RAIM Prediction System

Basic Common Denominator - Noting the differences among different RAIM algorithms on-board different aircraft, a regional RAIM prediction system provided by a service provider, such as an ANSP, should provide a "basic common denominator" RAIM prediction service for "basic" GNSS receivers, such TSO-129 (Fault Detection) and TSO-145/146 (Fault Detection and Exclusion).

Prediction Period – A regional RAIM prediction system shall provide prediction for RAIM outage and number of GNSS-satellite availability for a 72 hour period using the latest available GPS NANU.

*Approach Operation*s - A regional RAIM prediction system shall support aircraft approach operations based on RNP APCH (with/without Baro-VNAV) navigation specification. The system shall calculate the predicted RAIM availability for a 72 hour period for specific Aerodromes. The algorithms shall address the RAIM requirements for GNSS receivers operating in Approach operations (±0.3NM). Both the Fault Detection (FD) and Fault Detection and Exclusion (FDE) algorithms shall be provided. The system shall calculate the predicted RAIM availability at the Aerodrome Reference Point (ARP) for baro (pressure altitude) aided and non-baro aided GNSS user equipment at 1 minute intervals or better.

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