**INTERNATIONAL CIVIL AVIATION ORGANIZATION**

# REPORT OF THE SECOND MEETING OF THE PERFORMANCE BASED NAVIGATION/GLOBAL NAVIGATION SATELLITE SYSTEM TASK FORCE

**PBN/GNSS TF/2**

***(Abu Dhabi, UAE, 19-22 October 2009)***

The views expressed in this Report should be taken as those of the PBN/GNSS Task Force and not of the Organization. This Report will, however, be submitted to the MIDANPIRG and any formal action taken will be published in due course as a Supplement to the Report.

Approved by the Meeting
and published by authority of the Secretary General

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PBN GNSS TF/2
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## PART I – HISTORY OF THE MEETING

### 1. PLACE AND DURATION

1.1 The Second Meeting of the Performance Based Navigation/Global Navigation Satellite System Task Force (PBN/GNSS TF/2) was hosted by General Civil Aviation Authority (GCAA) of the United Arab Emirates in Abu Dhabi, UAE, 19 - 22 October 2009 and was held at the Armed Forces Officers Club and Hotel.

### 2. OPENING

2.1 The Meeting was opened by Mr. Jehad Faqir, ICAO Deputy Regional Director, Middle East Office. In his opening remarks, Mr. Faqir welcomed all delegates to Abu Dhabi and to the second PBN/GNSS Task Force meeting.

2.2 Mr. Faqir thanked GCAA for hosting the meeting and the active role played by the UAE in supporting the ICAO MID Regional office activities. He highlighted the importance of the meeting in view of the deadlines by the Assembly resolution A36-23 for the submission of the States PBN implementation plans, and the role that the implementation of PBN is playing in solving capacity safety and Environment in the MID Region in line with ICAO strategic Objectives.

2.3 Finally, Mr. Faqir underscored the importance of active participation by members of the Task Force from States and other stakeholders, in order for the Region to successfully meet its obligations in respect of the global implementation of PBN.

2.4 Mr. Morne Blignaut ATS instructor in GCAA also welcomed participants on behalf of Mr. Saif Mohammed Al Suwaidi Director General of GCAA and assured the continuation of the support from GCAA to ICAO MID Regional Office and to the PBN programme in particular where USE hosted the PBN procedure design course early in the year, he also mentioning the achievement in implementation of RNAV 1 routes in the UAE which contributed to savings for users.

### 3. ATTENDANCE

3.1 The meeting was attended by a total of twenty six (26) participants from seven (7) States (Bahrain, Egypt, Iran, Jordan, Kuwait, Saudi Arabia and United Arab Emirates) and one (1) International Organizations (IATA). The list of participants is at **Attachment A** to the Report.

### 4. OFFICERS AND SECRETARIAT

4.1 The Chairperson of the meeting was Mr. Mohammed Hassan Al-Asfoor, Senior NAVAIDS Engineer, Civil Aviation Affairs, Bahrain. Mr. Raza Gulam, Regional Officer CNS, was the Secretary of the meeting. He was supported by Mr. Douglas Marek, Technical Officer ATM from ICAO Head Quarters, and Mr. Jehad Faqir, Deputy Regional Director MID Regional Office also supported the meeting.

## 5. LANGUAGE

5.1 The discussions were conducted in the English language and documentation was issued in English.

## 6. AGENDA

6.1 The following Agenda was adopted:

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| Agenda Item 1: | Adoption of the Provisional Agenda |
| Agenda Item 2: | Review of MIDANPIRG/11 Conclusions/Decisions related to PBN and GNSS |
| Agenda Item 3: | Recent Developments in PBN and GNSS |
| Agenda Item 4: | Development of the Regional PBN Implementation Plan and Guidance Material |
| Agenda Item 5: | Development of States PBN Implementation Plan and implementation issues. |
| Agenda Item 6: | GNSS Specific Issues |
| Agenda Item 7: | Future Work Programme/Action Plan |
| Agenda Item 8: | Any other business |

## 7. CONCLUSIONS AND DECISIONS – DEFINITION

7.1 The MIDANPIRG records its actions in the form of Conclusions and Decisions with the following significance:

a) **Conclusions** deal with matters that, according to the Group's terms of reference, merit directly the attention of States, or on which further action will be initiated by the Secretary in accordance with established procedures; and

b) **Decisions** relate solely to matters dealing with the internal working arrangements of the Group and its Sub-Groups

## 8. LIST OF CONCLUSIONS AND DECISIONS

| | |
|---|---|
| *DRAFT CONCLUSION 2/1:* | *IMPLEMENTATION OF CONTINUOUS DESCENT OPERATIONS* |
| *DRAFT CONCLUSION 2/2 :* | *MID REGION PBN IMPLEMENTATION STRATEGY AND PLAN* |

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|---|---|
| *DRAFT CONCLUSION 2/3:* | *PBN IMPLEMENTATION TASK LIST* |
| *DRAFT CONCLUSION 2/4:* | *PBN IMPLEMENTATION SUPPORT* |
| *DRAFT CONCLUSION 2/5:* | *STATE PBN IMPLEMENTATION PLAN* |
| *DRAFT CONCLUSION 2/6:* | *PBN IMPLEMENTATION PROGRESS REPORT* |
| *DRAFT CONCLUSION 2/7:* | *STRATEGY FOR THE IMPLEMENTATION OF GNSS IN THE MID REGION* |
| *DRAFT DECISION 2/8:* | *REVISED TERMS OF REFERENCE (TOR) FOR PBN/GNSS TF* |

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## PART II: REPORT ON AGENDA ITEMS

### REPORT ON AGENDA ITEM 1: ADOPTION OF THE PROVISIONAL AGENDA

1.1 The Secretariat presented the meeting with the Provisional Agenda for the PBN/GNSS TF/2 meeting. The Provisional Agenda of the meeting was adopted with modification as indicated in paragraph 6 of the History of the Meeting.

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**REPORT ON AGENDA ITEM 2: REVIEW OF MIDANPIRG/11 CONCLUSIONS/DECISION RELATED TO PBN AND GNSS**

2.1 The meeting noted that MIDANPIRG/11 meeting held in Cairo, Egypt from 9 to 13 February 2009, reviewed and endorsed relevant PBN/GNSS TF/1 meeting Conclusions and Decisions, furthermore the meeting also noted that in order to enhance efficiency and keep track on the follow-up of conclusions and decision, each MIDANPIRG subsidiary body should review the MIDANPIRG Conclusions/Decisions related to its Terms of Reference (TOR) and decide whether to maintain, remove or replace these Conclusions/Decisions with more up-to-date ones (with new numbers i.e. Conclusion 2/XX).

2.2 The meeting noted MIDANPIRG/11 Decision 11/2 on REVISED MIDANPIRG ORGANIZATIONAL STRUCTURE, where now the PBN/GNSS TF will report to CNS/ATM/IC Sub Group, consequently all meeting materials are posted on the MID Forum under the CNS/ATM/IC.

2.3 Concerning conclusion 11/68 the meeting was informed that ESA and GSA already completed one study, moreover Saudi Arabia delegate advised that he shall further follow-up with the concerned department in GACA and provide feedback to ICAO MID Regional office.

2.4 As with regards to conclusion 11/72 PBN IMPLEMENTATION SUPPORT the meeting noted and thanked UAE for hosting the PBN procedure design course in which MID Sates experts got training on the development of PBN RNAV and RNP procedures, and for hosting this PBN/GNSS TF/2 meeting.

2.5 Based on the above the meeting noted the status of relevant MIDANPIRG/11 Conclusions and Decisions related to the PBN and GNSS and the follow up actions taken by concerned parties and updated the follow-up as at **Appendix 2A** to the Report on Agenda Item 2.

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PBN/GNSS TF/2
Appendix 2A to the Report on Agenda Item 2

**FOLLOW-UP ACTION PLAN ON MIDANPIRG/11 CONCLUSIONS AND DECISIONS**

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/1: FOLLOW UP ON MIDANPIRG CONCLUSIONS AND DECISIONS**<br><br>That,<br><br>a) States send their updates related to the MIDANPIRG follow up action plan to the ICAO MID Regional Office on regular basis (at least once every six months);<br><br>b) the MIDANPIRG subsidiary bodies review the appropriate actions/tasks of the MIDANPIRG follow up action plan and undertake necessary updates based on the feedback from States; and<br><br>c) ICAO MID Regional Office post the MIDANPIRG follow up action plan on the ICAO MID website and ensure that it is maintained up-to-date. | Implement Conclusion | ICAO<br>States<br><br>Subsidiary Bodies<br><br>ICAO | State Letter<br>Updated Action Plan<br><br>Updated Action Plan<br><br>Updated follow up Action Plan posted on web | Every six months<br><br>Every six months<br><br>Every six months | Ongoing |
| **DEC. 11/2: REVISED MIDANPIRG ORGANIZATIONAL STRUCTURE**<br><br>That, with a view to increase MIDANPIRG efficiency, MIDANPIRG Organizational Structure be updated as at **Appendix 4B** to the Report on Agenda Item 4. | Update the Procedural Hand Book and conduct the meetings of MIDANPIRG subsidiary bodies in accordance with the revised Structure | ICAO | Updated Procedural Handbook | Feb. 2009 | Actioned |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/3: INCREASING THE EFFICIENCY OF MIDANPIRG** | | | | | |
| That, with a view to increase the efficiency of MIDANPIRG:<br><br>a) States appoint an ICAO Focal Point Person(s) (ICAO-FPP) using the form at **Appendix 4E** to the Report on Agenda Item 4; who would:<br>i. ensure the internal distribution of all ICAO MID Office correspondences related to MIDANPIRG activities and the follow-up within civil aviation administration;<br>ii. follow up the ICAO MID Office postings of tentative schedule of meetings, MIDANPIRG follow up action plan, State Letters, working/information papers, reports of meetings, etc, on both the ICAO MID website and the MID Forum; and<br>iii. ensure that required action and replies are communicated to ICAO MID Regional Office by the specified target dates.<br><br>b) ICAO MID Regional Office copy all correspondences related to MIDANPIRG activities to the designated ICAO-FPP as appropriate. | Implement the Conclusion | ICAO<br>States | State Letter (Reminder)<br><br>List of ICAO FPP | Apr. 2009<br><br>Jun. 2009 | Ongoing |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/4: IMPROVING THE EFFICIENCY OF THE ICAO MID FORUM**<br>That,<br>a) Bahrain in coordination with ICAO:<br>i) explore ways and means for improving the efficiency of the ICAO MID Forum; and<br>ii) investigate the possibility of using the ICAO MID Forum for the posting of AIS publications by States<br>b) States are urged to make use and take full benefit of the ICAO MID Forum | Implement the Conclusion | ICAO<br>Bahrain | Draft Feasibility Study<br><br>Improved MID Forum with new Functionalities | Dec. 2009<br><br>Jun. 2010 | Ongoing |
| **CONC. 11/13: MID BASIC ANP AND FASID (DOC 9708)**<br>That,<br>a) further to the approval of the Proposal for amendment of the MID Basic ANP 08/05-AOP, the ICAO MID Regional Office, on behalf of MIDANPIRG, initiate all necessary Amendment Proposals to the MID Basic ANP and FASID, prior to MIDANPIRG/12, in order to update the AIS, AOP, ATM, CNS and MET tables; and<br>b) ICAO is to allocate sufficient resources and give high priority for the publication of Doc 9708 in English and Arabic languages, incorporating all approved Amendments. | Process Amendments Proposals to the MID Basic ANP and FASID<br>Finalize and publish the approved version of Doc 9708 | ICAO | Amendment Proposal issued<br><br>Amendment Proposal approved and incorporated in the final version of Doc 9708<br><br>Final Version of Doc 9708 published | <br><br>Mar. 2010<br><br>TBD | Ongoing |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/42: IMPLEMENTATION OF WGS-84 IN THE MID REGION** | | | | | |
| That, taking into consideration the status of implementation of WGS-84 in the MID Region as reflected in **Appendix 5.3A** to the Report on Agenda Item 5.3 and recognizing that WGS-84 is an important pre-requisite for the implementation of PBN and for the transition from AIS to AIM; States that have not yet done so are urged to: | Follow up with concerned States | ICAO | State Letter | Apr 2009 | Actioned |
| | | States | WGS-84 implementation plans | Jun 2009 | |
| | | | Report on the status of implementation of WGS-84 | Ongoing | Ongoing |
| a) develop effective and detailed WGS-84 implementation plans with clear timelines and send these plans to the ICAO MID Regional Office, prior to 30 June 2009; | | | | | |
| b) adopt appropriate procedures to validate the WGS-84 data and ensure the quality (accuracy, integrity and resolution) of the published WGS-84 coordinates, in accordance with ICAO Annex 15 requirements; | | | | | |
| c) achieve the total implementation of the WGS-84 System, in accordance with ICAO Annexes 4, 11, 14 and 15 provisions, prior to 31 December 2010 ; and | | | | | |
| d) report the status of implementation of WGS-84 on a regular basis to the ICAO MID Regional Office and appropriate MIDANPIRG subsidiary bodies, until the system is fully implemented. | | | | | |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/60: IMPLEMENTATION OF THE NEW ICAO MODEL FLIGHT PLAN FORM** | | | | | |
| That, MID States: | State Letter | ICAO | State Letter | Mar. 2009 | Actioned |
| a) in order to comply with Amendment No. 1 to the 15th Edition of the PANS-ATM (Doc 4444), establish a Study Group to develop the technical audit guidance material and prepare a Regional Strategy for the transition; | Study Group Established | States | Members of the Group | Jun. 2009 | Ongoing Meeting scheduled Feb2010 |
| | Follow-up with States | Study group | Report of CNS and CNS/ATM/IC SG | Jan. 2010 | Meeting rescheduled Jun2010 |
| - the Study Group to follow the ICAO guidance for the implementation of Flight plan and Implementation check list in **Appendices 5.5B** and **5.5C** to the Report on Agenda Item 5.5; and | | | | | |
| b) implement the new ICAO model Flight Plan form by applicability date. | | | New FPL Implemented | Nov. 2012 | Ongoing |
| **CONC. 11/65: PROTECTION OF GNSS SIGNAL** | | | | | |
| That, MID States with their names listed in the footnotes 5.362B and 5.362C are urged to take necessary measures to delete their names from these footnote as soon as possible in order to protect the GNSS signal. | State Letter | ICAO | State Letter | Nov. 2009 | Ongoing |
| | State CAA Follow up with regulators | State | CNS SG Report Deletion of State Name from FN | On going | |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **DEC. 11/66: DISSOLUTION OF THE RVSM/PBN AND GNSS TASK FORCES AND ESTABLISHMENT OF THE PBN/GNSS TASK FORCE**<br><br>That, taking into consideration the status of implementation of RVSM and PBN in the MID Region and the close inter-relationship between the PBN goals and GNSS implementation, and with in order to enhance the efficiency of MIDANPIRG, the RVSM/PBN and the GNSS Task Forces are dissolved and the PBN/GNSS Task Force is established with TOR as at **Appendix 5.5F** to the Report on Agenda Item 5.5. | Implement the PBN/GNSS TF Work Programme | ICAO<br><br>States | PBN/GNSS TF Reports | Oct. 2009 | Actioned |
| **CONC. 11/67: STRATEGY FOR THE IMPLEMENTATION OF GNSS IN THE MID REGION**<br><br>That, the Revised Strategy for implementation of GNSS in the MID Region is adopted as at **Appendix 5.5G** to the Report on Agenda Item 5.5. | Implement Strategy | PBN/GNSS TF State | PBN/GNSS 2 Report | Oct. 2009 | ongoing<br><br>(To be replaced and superseded by Draft Conc. 2/6) |
| **CONC. 11/68: GNSS STUDIES IN MID REGION**<br><br>That,<br><br>a) ICAO MID Regional Office Communicate with GSA/ESA for the provision of support and detailed studies on EGNOS Extension to the MID Region;<br><br>b) MID States that are in position to support the cost benefit analysis to provide their experience through PBN/GNSS TF to MID Region; and<br><br>c) MID States share experience gained during the GNSS implementation. | Follow-up State Letter<br><br>Support to CB<br><br>Sharing Exp. | ICAO<br><br>MID States Lead by Saudi Arabia<br><br>MID States | State Letter<br><br>PBN/GNSS TF Report<br><br>Experience from States and CBA Report WP/IP | Mar. 2009<br><br>Oct. 2009<br><br>Ongoing | Actioned |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/70: REGIONAL PERFORMANCE FRAMEWORK**<br><br>That,<br><br>a) a regional performance framework be adopted on the basis of and alignment with the Global Air Navigation Plan, the Global ATM Operational Concept, and ICAO guidance material and planning tools. The performance framework should include the identification of regional performance objectives and completion of regional performance framework forms; and<br><br>b) ALLPIRG/5 Conclusion 5/2: Implementation of Global Plan Initiatives (GPIs, be incorporated into the terms of reference of the MIDANPIRG subsidiary bodies | Follow up on Conclusion<br><br>Update Regional performance objectives | ICAO,<br><br>CNS/ATM IC SG<br><br>MIDANPIRG | Adoption of Performance Framework approach and Regional Performance Objectives<br><br>Updated Regional performance objectives | Feb. 2009<br><br>Ongoing | Ongoing<br><br>National Performance Framework Workshop, planned 1-5 Nov 09 |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/71: NATIONAL PERFORMANCE FRAMEWORK**<br><br>That, MID States be invited to adopt a national performance framework on the basis of ICAO guidance material and ensure their alignment with the regional performance objectives, the Regional Air Navigation Plan and the Global ATM Operational Concept. The performance framework should include identification of national performance objectives and completion of national performance framework forms. | Follow up on Conclusion<br><br>Update National performance objectives | ICAO, MIDANPIRG, States | Adoption of National performance framework approach<br><br>Development of State Performance Objectives<br><br>Updated Regional performance objectives | Feb. 2009<br><br>Nov. 2009<br><br>Ongoing | Ongoing<br><br>National Performance Framework Workshop planned , 1-5 Nov 09 |
| **CONC. 11/72: PBN IMPLEMENTATION SUPPORT**<br><br>That, in order to address challenges in PBN implementation, stakeholders in the PBN implementation Air Navigation Service Providers (ANSP's), aircraft operators, user communities, etc.) be encouraged to provide support including resources to the States and ICAO PBN programme. | Communication of Conclusion to stakeholders and follow-up | ICAO, Stakeholders | State Letter<br><br>Stakeholder Inputs | Feb. 2009<br><br>Ongoing | Ongoing<br>(To be replaced and superseded by Draft Conc. 2/4) |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/73: MID REGION PBN IMPLEMENTATION STRATEGY AND PLAN**<br><br>That, in order to provide direction to the Stakeholders in their strategic planning during the transition to full implementation of PBN:<br><br>a) the Middle East Regional Strategy for Implementation of PBN is adopted as at **Appendix 5.5Q** to the Report on Agenda Item 5.5.<br><br>b) The PBN Regional Implementation Plan is adopted as at **Appendix 5.5R** to the Report on Agenda Item 5.5. | Implementation of PBN Strategy and Plan | ICAO,<br>States | Adoption by MIDANPIRG/11<br><br>State Letter<br><br>PBN Implementation | Feb. 2009<br><br>Mar. 2009<br><br>Ongoing | Ongoing<br>(To be replaced and superseded by Draft Conc. 2/2) |
| **CONC. 11/74: PBN STATE IMPLEMENTATION PLAN**<br><br>That, in order to give effect to Assembly Resolution A36-23: Performance based navigation global goals, MID States are urged to complete development of their individual State Implementation plans based on the regional PBN implementation plan by 30 September 2009 so that it may be reviewed by the ATM/SAR/AIS SG as part of the Regional agreement process. | Implement the Conclusion | States | State Implementation Plans<br><br>PBN Implementation | Nov. 2009<br><br>Ongoing | Ongoing<br>(To be replaced and superseded by Draft Conc. 2/5) |

| CONCLUSIONS AND DECISIONS | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 11/86: ELIMINATION OF AIR NAVIGATION DEFICIENCIES IN THE MID REGION**<br><br>That,<br>a) States review their respective lists of identified deficiencies, define their root causes and forward an action plan for rectification of outstanding deficiencies to the ICAO MID Regional Office;<br><br>b) States and Users Organizations use the online facility offered by the ICAO MID Air Navigation Deficiency Database (MANDD) for submitting online requests for addition, update and elimination of air navigation deficiencies;<br>c) States increase their efforts to overcome the delay in mitigating air navigation deficiencies identified by MIDANPIRG and explore ways and means to eliminate deficiencies;<br>d) ICAO continue to provide assistance to States for the purpose of rectifying deficiencies; and when required, States request ICAO assistance through Technical Co-operation Programme, Special Implementation Projects (SIP) and/or other available mechanisms such as IFFAS; and<br>e) States are encouraged to seek support from regional and international organizations (i.e: ACAC, GCC, etc.) for the elimination of identified air navigation deficiencies. | Implementation of the Conclusion | States<br><br><br>Users<br><br><br>ICAO | Action plans for elimination of deficiencies<br><br>Feedback from Users and States received through MANDD<br><br>Assistance provided to States, as requested and as appropriate | May 2009<br><br><br>Ongoing<br><br><br>Ongoing | ongoing |

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## REPORT ON AGENDA ITEM 3: RECENT DEVELOPMENT IN PBN AND GNSS

3.1 The meeting noted that the ICAO Navigation Systems Panel (NSP) has been tasked by the Air Navigation Commission to “address technical and operational issues related to radio navigation systems to ensure their compatible operation to meet ATM functional and performance requirements, and to support implementation strategies, in this regard the meeting received the following brief reviews on recent developments in NSP.

### AMENDMENT 84 TO ANNEX 10, VOLUME I

3.1.1 The NSP completed the development of a proposal for Amendment 84 to Annex 10, Volume I, in early 2008. After review by the Air Navigation Commission and consultation with States and international organizations, the Amendment was adopted by the ICAO Council in March 2009 and will become applicable on 19 November 2009.

3.1.2 Most of the Amendment addresses conventional navigation aids. Specifically, the amendment includes:

a) a complete reorganization of the material on general provisions for radio navigation aids contained in Chapter 2 of the Volume;

b) updates of obsolete or ambiguous provisions for the instrument landing system (ILS) and very high frequency (VHF) omnidirectional radio range (VOR);

c) deletion of material on testing of non-directional beacons (NDB), which duplicates existing guidance contained in Doc 8071, *Manual on Testing of Radio Navigation Aids*;

d) updates resulting from the review of the distance monitoring equipment (DME) issues identified in Recommendations 6/14 and 6/15 of the Eleventh Air Navigation Conference;

e) updates to the DME accuracy Standard in light of actual avionics performance, and clarification and simplification of existing material; and

f) updates addressing potential safety issues identified in the course of microwave landing system (MLS) Category III certification.

3.1.3 With regard to GNSS, the amendment does not introduce any substantial changes, the material on GNSS has been editorially rearranged.

### AMENDMENT 85 TO ANNEX 10, VOLUME I

3.1.4 The NSP completed the development of a proposal for Amendment 85 to Annex 10, Volume I, in October 2008. After review by the Air Navigation Commission, the consultation with States and international organizations is currently underway (State letter 09/46, dated 18 June 2009, deadline for comments was 28 September 2009). The proposed Amendment is envisaged for applicability on 18 November 2010.

3.1.5 Amendment 85 comprises three main elements:

a) updates to improve the ILS localizer signal quality at aerodromes where building or terrain reflections cause interference of the reflected signal with the desired signal, by introducing appropriate relaxations to the coverage requirements in Chapter 3, 3.1.3.3 of the Volume;

b) updates enabling (under certain conditions) Category I approach operations supported by satellite-based augmentation system (SBAS), developed on the basis of system safety studies and operational experience with the wide area augmentation system (WAAS) which is explained further in para 3.1.6 ; and

c) updates reflecting the evolution of the GLONASS system.

3.1.6 **Category I approach operations supported by SBAS**

3.1.6.1 The proposed amendments address GNSS signal-in-space (SIS) performance requirements, to enable Category I approach operations supported by satellite-based augmentation system (SBAS).

3.1.6.2 Current provisions in Annex 10 (Volume I, 3.7.3.4.2, Note) permit, in principle, the use of SBAS down to Category I precision approach, subject to meeting the relevant SIS performance requirements in Annex 10, Volume I, Table 3.7.2.4-1. Given the significant technical challenges associated with meeting the Category I requirements (established based on equivalency to ILS glide path requirements), initial SBAS operations were based on a less demanding set of performance requirements, which enabled approach with vertical guidance (APV) operations with approach minima as low as 75 m (250 ft) decision height.

3.1.6.3 As more experience was gained with the wide area augmentation system (WAAS), the first SBAS to enter into service, the United States Federal Aviation Administration (FAA) conducted a system safety study to assess the potential to support approach minima as low as 60 m (200 ft) decision height, corresponding to Category I operation. The study was based on data accumulated over several years of WAAS operations to characterize positioning errors and integrity performance, and on analysis and simulation to evaluate the safety risk of vertical positioning errors.

3.1.6.4 The study concluded that WAAS could safely support the intended Category I minima, meeting all the Category I SIS parameters of Table 3.7.2.4-1, with the exception of the value of the vertical alert limit (VAL)[1] used (35 m), which was outside the range specified in the table (15 m to 10 m). Based on the results of the study confirming the feasibility and safety of the operation, the FAA in 2007 began implementation of WAAS-based procedures with decision height lower than 250 ft, using a 35 m VAL.

3.1.6.5 The NSP conducted an in-depth review of the results of the WAAS study, over several meetings, with the participation of experts involved in the development of other SBAS, and in close coordination with the Instrument Flight Procedure Panel (IFPP). In the review, the panel also considered the results of a European Geostationary Navigation Overlay Service (EGNOS) performance assessment campaign, which indicated that EGNOS performance was similar to WAAS and suggested that EGNOS may be able to take advantage of the same operation.

[1] The VAL is one of the elements of the GNSS SIS integrity requirement (see Annex 10, Volume I, Table 3.7.2.4-1, Note 2). It specifies the maximum vertical position error before a user must be alerted.

3.1.6.6 On the basis of the review, the panel concluded that it was appropriate to extend up to 35 m the VAL range specified in Annex 10 for Category I, as long as it was clearly stated in the Annex that a specific safety analysis must be completed for each SBAS intending to use any value greater than the minimum value in the range (10 m). The restriction was required because some elements of the WAAS analysis were system-specific and could not be generalized a priori to other SBAS without further analysis. The panel also developed guidance material providing an outline of the type of safety studies that would be required to support the extension. Parallel developments are currently under way in the IFPP to finalize the corresponding changes to the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168).

3.2 The meeting noted the NSP is currently engaged among others in the development of provisions enabling Ground-Based Augmentation System (GBAS) Category II and III approach and landing operations. (Current GBAS provisions support Category I only).

3.3 The meeting further noted that the Additional developments underway or planned include:

a) provisions supporting the introduction of the Galileo system;

b) provisions supporting the evolution of the GPS and GLONASS systems;

c) updates of navigation infrastructure related guidance material (Doc 9849, *GNSS Manual*, and Doc 8071, *Manual on Testing of Radio Navigation Aid*); and

d) further updates of conventional navaids provisions as required.

3.4 The meeting received information on the approval of ground based augmentation system (GBAS) by FAA which marks the successful completion of a partnership between the FAA and Airservices Australia to build and certify a GBAS which is expected to become an asset to airports around the world clearing the way for increased safety and efficiency at airports by providing precise navigation service based on the global positioning system (GPS), furthermore the meeting noted that Australia's decision on the discontinuation of the t Ground-based Regional Augmentation System (GRAS) project.

**Global PBN Task Force:**

3.5 The meeting noted that in December 2008, at the invitation of ICAO and IATA, representatives of States, industry and international organizations came together for the first meeting of the Global PBN Task Force (GPBNTF). The objectives were to build upon the global and regional structures, which have already been put in place for PBN implementation, and to produce tools and enablers to facilitate and expedite the work. The first meeting resulted in agreement among the participants on the need for a global effort such as this, and divided the TF into three Teams to work on specific plans and deliverables, the second meeting, of the GPBNTF 2-6 February 2009, was held to develop work plans for the teams and the following is progressed:

**A) Promotion Team.** The Promotion Team completed and sent out the second quarterly PBN Newsletter, *Waypoints*, in August. This issue of *Waypoints* is available on the PBN web site, http://www2.icao.int/en/pbn/Pages/default.aspx.

B) **Implementation Support Team (IST).** The IST produced a consolidated model action plan and several model action plans directed at the enroute, terminal, and approach phases of implementation. These model action plans are available on the PBN web site, http://www2.icao.int/en/pbn/Pages/default.aspx. The IST had revised the plans based on several inputs developed new version. It furthermore made progress on the development of Ops approval guidance and training and ICAO is in the process of developing a train the trainer course for ops approval. The Implementation Support team is also in the process of developing guidance for States on the implementation of GNSS

C) **Implementation Management (GO) Team.** The GO Team met to discuss specific implementation activities that would develop regional pockets of knowledge and expertise in various States, and could serve as an example of successful implementation to other States in the region. The concept of the GO Team, as successfully used by IATA to implement fuel efficiency measures at the member airlines, was discussed in depth. The Implementation Management Team is presently working on a trial GO Team visit in the fall of this year.

3.6 The meeting further received update on the following panels and study groups and noted the achievement of the following progress:

3.6.1 **Instrument Flight Procedures Panel (IFPP).** The IFPP amendments to PANS OPS and annexes was approved by the ANC in late June and are out for State comments SP 65/4-09/66 (response date 13 November 2009). The PANS OPS amendments should be applicable in March 2010. A summary of these amendments follows.

3.6.2 **Helicopter flight procedures.** The amendment proposals regarding helicopter procedures provide for Point-in-Space (PinS) helicopter “Proceed visual flight rules (VFR)” and “Proceed Visually” approach procedures as well as heliport route departures with direct visual segments based on RNAV 1 and Basic-RNP 1 navigation specifications. The amendment proposals include pilot, procedure design and charting requirements and affect Annex 4 and PANS-OPS, Volumes I and II.

3.6.3 **Quality assurance.** The amendment proposal to PANS-OPS, Volume II regarding quality assurance explains the instrument flight procedure process and documentation requirements in more detail. It also clarifies the provisions for qualifications of flight validation pilots by providing more defined minimum qualifications.

3.6.4 **Alignment of RNAV Holding criteria with PBN.** The proposed amendment to PANS-OPS, Volume I pertains to RNAV holding requirements and are consequential to existing PANS-OPS, Volume II design criteria and seek alignment with the PBN concept. It furthermore removes impracticable requirements, incorporated before the PBN concept materialized, that cannot be coded into the navigation database.

3.6.5 **Use of SBAS equipment flying APV/Baro-VNAV procedures.** The amendment proposals to PANS-OPS, Volume I concerning the use of SBAS equipment to fly APV/Baro-VNAV procedures are consequential to existing PANS-OPS, Volume II design criteria. In addition, in the process of developing these proposals, a need was found for a correction to the PANS-OPS, Volume II criteria related to this subject.

3.6.6 **Aeronautical database and procedure design interface issues.** The amendment proposals relate to PANS-OPS, Volume II design criteria which include instructions to the procedure designer to allow a better interpretation of the design criteria by navigation database encoders. It affects both conventional criteria as well as RNAV criteria. These type of amendments are part of an ongoing review by the panel to ensure complete alignment of the criteria with the navigation database. To ensure close coordination with industry, and this topic in particular, ARINC has agreed to participate as a member of the IFPP.

3.6.7 **Flight Validation.** The International Committee on Airspace Safety and Calibration (ICASC) is developing a new volume or volumes to be incorporated in the Quality Assurance Manual for Flight Procedure Design, Doc 9906, with Flight Validation guidance and Flight Validation Pilot Training requirements. The IFPP will review this work at its meeting in September and, if approved, the new guidance will be available as an Advance Copy from ICAO shortly thereafter.

3.6.8 **Separation and Airspace Safety Panel (SASP).** During the 15th meeting of the Working Group of the Whole of the SASP that concluded June 5, 2009, the group reported significant progress on several fronts. Among the most notable were:

- Advanced work on clarified guidance for RVSM monitoring requirements as well as the use of ADS-B for height keeping performance monitoring
- Work was nearly completed on an in-trail climb/descent procedure that utilizes ADS-B reports between aircraft to ensure separation is maintained during the climb/descent.
- Work essentially completed on separation minima to be applied between PBN approved aircraft in terminal airspace to be applicable in 2010..
- Completed PANS ATM amendment proposal on the use of ADS-B and MLAT for 3 and 5 NM separation. The Air Navigation Commission will carry out a preliminary review of this material later this year.

3.6.9 **Performance Based Navigation Study Group (PBN SG).** The PBN SG met in late September and worked on the next phase of PBN. Decisions were made on the direction to take with respect to new navigation specifications. Included in those decisions were:

- Development of a navigation specification for SBAS and its inclusion in the PBN Manual
- Development of an RNP 2 nav spec for enroute continental application, including remote continental
- Development of an advanced RNP nav spec for approach and terminal application
- Application of RF turns outside final approach in RNP APCH, advanced RNP and Basic-RNP 1 nav specs.

3.7 The meeting was updated that an amendment to the PBN Manual is expected to be ready by Fall 2010, incorporating all or most of the work conducted.

3.8 Furthermore the meeting noted that the Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual **RNP AR (Doc9905)** and accompanying spreadsheets has been completed, and available on ICAONET.

3.9 The meeting noted that ICAO is in the process of developing a manual that provides guidance on the development and implementation of Continuous Descent Operations (CDO) that should be available in the Spring of 2010. The Manual will contain guidance material on the airspace design, instrument flight procedures, ATC facilitation and flight techniques necessary to enable Continuous Descent (CD) profiles. It therefore provides background and implementation guidance for:

- Airspace and procedure designers
- Air traffic managers and controllers
- Service providers (Airports and Air Navigation Service Providers (ANSP))
- Pilots.

Key objectives of the manual are to improve the:

- Overall management of traffic and airspace in order to enable uninterrupted continuous descents, without disrupting departures
- Understanding of continuous descent procedures and profiles
- Harmonization and standardization of associated terminology

3.10 The meeting noted that Continuous Descent is one of several tools available to aircraft operators and ANSPs to increase safety, flight predictability, and airspace capacity, while reducing noise, ATC/Pilot communications, fuel burn and the emission of greenhouse gases. Over the years, different route models have been developed to facilitate CDs and several attempts have been made to strike a balance between the ideal of environmentally friendly procedures and the requirements of a specific airport or airspace.

3.11 Future developments in this field are expected to allow different means of realising the performance potential of CDO without compromising the optimal Airport Arrival Rate (AAR). The core CDO definition and the concept at the heart of the manual will also apply to these increasingly sophisticated methods of facilitating CD operations.

3.12 Continuous Descent Operations are enabled by airspace design, procedure design and ATC facilitation, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the Final Approach Fix (FAF)/Final Approach Point (FAP). An optimum CD starts from the Top of Descent and uses descent profiles that reduce ATC/Pilot communication, segments of level flight, noise, fuel burn and emissions, while increasing predictability to ATC/Pilots and flight stability.

3.13 Before any CDO trials or operations commence, the proposed implementation should be the subject of a local safety assessment.

3.14 The meeting was in line with the views that Terminology and procedural standardization are important for flight safety, hence standardization and harmonization are important. From the pilots' and air traffic controllers' perspective, flight procedures and pilot communications should be unambiguous. For the procedure designer, it is important to understand the flight characteristics, limitations and capabilities of aircraft expected to perform CDs, as well as the characteristics of the airspace and routes where it will be used. For airport operators and environmental entities, it is important to understand, the extent and limitations of environmental benefits, aircraft performance, and airspace limitations when proposing to introduce CD operations. Considering the high cost of fuel and growing concerns about the environment and climate change, collaborating to facilitate CDs is an operational imperative where all stakeholders benefit.

3.15 To standardize and harmonize the development and implementation of CD operations, the airspace and instrument flight procedure design and ATC techniques should all be employed in a cohesive manner. This will then facilitate the ability of flight crews to use in-flight techniques to reduce the overall environmental footprint and increase the efficiency of commercial aviation. The implementation guidance in the CDO Manual is intended to support collaboration among the different stakeholders involved in implementing these Continuous Descents:

- Airspace and procedure designers,
- Air traffic managers and controllers,
- Service providers (Airports and Air Navigation Service Providers (ANSP))
- Pilots.

3.16 The meeting was presented with some of the content found in the manual which are in **Appendix 3A** to the Report on Agenda Item 3.

3.17 The meeting concluded that in light of the near completion of the ICAO CDO manual which will standardize and harmonize the development and implementation of CD operations. The meeting agreed that MID States are encouraged to proceed, cautiously, with their CDO implementation plans, however MID States that are currently working towards CDO should either wait for the CDO manual or seek guidance from ICAO before proceeding to ensure global harmonization and avoid having to make changes to their CDO. Nevertheless, recognizing the efficiency, environmental and other benefits of Continuous Descent operations, and the need to harmonize these operations in the interest of safety, consequently the meeting agreed on the following Draft Conclusion:

***DRAFT CONCLUSION 2/1: IMPLEMENTATION OF CONTINUOUS DESCENT OPERATIONS***

*That, recognizing the efficiency and environmental benefits of Continuous Descent Operations, and the need to harmonize these operations in the interest of safety, MID States are encouraged to include implementation of Continuous Descent Operations (CDO) as part of their PBN implementation plans and to implement CDO in accordance with the ICAO CDO Manual.*

3.18 The meeting noted that Egypt is persuading NAVISAT Middle East and Africa Project which has progressed well. Furthermore, the meeting was informed on the progress of the different phases of the project, where as the current status for Phase 1-B (business plan and specification) has been completed.

3.19 The meeting had long discussion on the feasibility of the project and other issues and was informed that as per studies conducted by the consultants having only the aeronautical services, the project is not economically feasible; however having the complementary services would make it economically feasible, in this regard the meeting reiterated the need for sharing the studies with concerned States and stake holders and keeping the task force updated on the progress.

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Appendix 3A to the Report on Agenda Item 3

## CONTENTS OF CDO Manual

Some of the content found in the manual follows:

- Facilitating CD Operations
    - Benefits
- Concepts of Operation
- Continuous Descent Operations
    - Less noise at intermediate distances (10-30 NM) from the runway
    - Lower emissions
    - Reduced fuel burn
    - Maximum Benefit
- Design Options
    - Closed Path Designs
    - Open Path Designs
    - Sequencing Methods
    - Basic Design Examples
    - Closed path CDO layout
    - Developing a CD concept of operations
- Specific Stakeholder Issues
    - Procedure Design
    - Airspace Collaboration and Standardisation
    - Speed Restrictions
    - Transition Level
    - Database Coding
    - Charting issues
- Flight operation
    - Cockpit Workload
    - Pilot Training
    - ATC Techniques
    - Transition Level
    - CD, Optimal AAR and ATFM considerations
    - ATC Training
    - ATC workload
    - Different CD options

    - Sequencing Techniques in Relation to CD and Optimal AAR
- CD Implementation Overview and Pre-Requisites
    - The Importance of Effective Collaboration
    - Community Relations and Consultation
    - Policy Context
- Introduction To Implementation Processes
    - Implementation Steps
- Prepare an Outline CD Case
- Establish Collaborative CD Implementation Group
    - Planning
- Joint Preliminary Assessment
- Consider Options and Jointly Agree on Preferred Implementation Options
- Design Preferred CD Facilitations Option(s)
- Strategic Planning
    - Implementation

Simulate and validate
Decision Point (go-no-go)
Make CD Operational and implement Iterative improvements
Assessment
Training, Marketing and Awareness Material

**ATTACHMENTS**
Implementation examples
Human Factors discussion
VNAV capability technical differences
Flight Performance information

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**REPORT ON AGENDA ITEM 4: DEVELOPMENT OF THE REGIONAL PBN IMPLEMENTATION PLAN AND GUIDANCE MATERIAL**

4.1 The meeting noted that a procedure design course was generously hosted by UAE GCAA and held in Hilton Abu Dhabi during March 2009, where fifteen experts from eight MID States were trained on the development and design of the PBN procedures.

4.2 The meeting was provided with a back ground information on PBN, were the Air Navigation Commission established the RNP Special Operational Requirements Study Group (RNPSORSG) in June 2003 to act as focal point for addressing several issues related to RNP/RNAV, and that the RNPSORSG developed the concept of performance-based navigation (PBN) in May 2007.

4.3 The meeting was apprised on MIDANPIRG/10, Decision 10/42: Establishment of the RVSM/PBN Task Force, and Decision 10/43: MID Region PBN Strategy, establishing the RVSM/PBN Task Force and calling for development of the MID Region strategy to implement the PBN.

4.4 The meeting recalled that ICAO Assembly Resolution A36-23: *Performance based navigation global goals*, urges Planning and Implementation Regional Groups (PIRGs) and States, *inter alia*, to complete a States PBN implementation plan by 2009 to achieve specific implementation goals starting with 2010.

4.5 In this regarded the meeting noted that in accordance with its terms of reference, the first meeting of the PBN/GNSS Task Force held in Cairo, 20 - 23 October 2008 developed the first version of the MID Regional PBN Implementation Strategy and Plan, in order to allow sufficient time for the MID States to complete development their national States PBN plans by December 2009.

4.6 The meeting also recalled that the Performance Based Navigation concept is made up of three inter-related elements: the navigation specification, the Navaid infrastructure, and the navigation application and the use of the ICAO navigation specifications as contained in ICAO PBN manual Doc 9613 were originally developed for Regional use to respond to the operational requirements of specific airspace concepts. Some of the applications of these navigation specifications are used in airspace concepts for Oceanic or Remote Continental Airspace. Others are used in airspace concepts for Continental or Terminal Airspace.

4.7 The meeting noted that Proliferation of Regional or State navigation specifications is avoided by publishing these ICAO navigation specifications, which allow all Regions and States to use *existing* ICAO navigation specifications rather than developing new ones and the table below shows the application of specification by flight phase.

***Table 1: Application of Navigation Specification by Flight Phase***

| NAVIGATION SPECIFICATION | FLIGHT PHASE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | En Route OCEANIC /REMOTE | En Route Continental | ARR | APPROACH | | | | DEP |
| | | | | Initial | Interm. | Final | MISSED | |
| RNAV 10 | 10 | | | | | | | |
| RNAV 5 | | 5 | 5 | | | | | |
| RNAV 2 | | 2 | 2 | | | | | 2 |
| RNAV 1 | | 1 | 1 | 1 | 1 | | $1^{b}$ | 1 |
| RNP 4 | 4 | | | | | | | |
| Basic-RNP 1 | | | $1^{a,c}$ | $1^{a}$ | $1^{a}$ | | $1^{ab}$ | $1^{a,c}$ |
| RNP APCH | | | | 1 | 1 | 0.3 | 1 | |
| RNP AR APCH | | | | 1-0.1 | 1-0.1 | 0.3 – 0.1 | 1-0.1 | |

4.8 The meeting was apprised on RNAV and RNP implementation in the MID Region and noted that, the MID Region implemented RNP 5, before the current PBN Concept in which there are no provisions for RNP 5. Therefore and in order to align with the harmonized PBN terminology, the term RNP 5 needs to be replaced by RNAV 5 in the MID Region, and States to take action by issuing the necessary notams and update their AIP.

4.9 Furthermore it was noted that the RNAV 5 cannot be used for oceanic/remote airspace and that in principle RNAV 10 should be used for that particular airspace. It was recognized also, that presently some of the airspace in the MID Region that had previously been classified as remote continental/oceanic, now has the required surveillance capability to support RNAV 5. Nevertheless, there remains other airspace in the MID region that still can be classified as oceanic and therefore, RNAV 10 would be appropriate as the navigation specification, at least for the short term (2008-2012).

4.10 The meeting was further apprised that MIDANPIRG/11 noted the PBN/GNSS TF/1 work, including the thorough examination of the various navigation specifications for applications in all applicable phases of flight and the planning time frames (short, medium and long terms), leading to successful development of both the PBN Regional Implementation Strategy and Implementation plan in October 2008. This allowed sufficient time for the MID States to complete development of their individual national implementation plans by 2009 pursuant to Assembly Resolution A36-23. Accordingly MIDANPIRG/11 agreed to Conclusion 11/73: *MID REGION PBN IMPLEMENTATION STRATEGY AND PLAN.*

4.11 The meeting had thorough review of the Regional plan, and discussed various implementation issues and the recent developments in the PBN and developed a revised and comprehensive version 2 of the MID PBN Regional Implementation Strategy and Plan and agreed to the following Draft Conclusion which will replace and supersede MIDANPIRG conclusion 11/73:

***DRAFT CONCLUSION 2/2: MID REGION PBN IMPLEMENTATION STRATEGY AND PLAN***

*That, the revised MID Region PBN Implementation and Plan be updated as at* ***Appendix 4A*** *to the report on Agenda Item 4.*

4.12 The meeting noted that there are many important tasks related to PBN implementation plan that were agreed by the RVSM/PBN Task force still not completed. Consequently the meeting agreed to the following Draft Conclusion:

***DRAFT CONCLUSION 2/3: PBN IMPLEMENTATION TASK LIST***

*That, PBN Implementation Task List be updated with new task assignment as at* ***Appendix 4B*** *to the Report on Agenda Item 4.*

4.13 The meeting noted that several PBN implementation challenges needs to be met in order to progressively implement PBN and get the desired benefits, the list of challenges faced among others:

- Airspace concept development
- WGS-84 surveys
- Electronic Terrain and Obstacle Data
- Procedure design
- Ground and Flight Validation
- Operational approval
- Safety assessment
- Awareness and training for pilots and ATC

4.14 Therefore the meeting reiterated MIDANPIRG/11 Conclusion 11/72: PBN IMPLEMENTATION SUPPORT and agreed to redraft the Conclusion as follows:

***DRAFT CONCLUSION 2/4: PBN IMPLEMENTATION SUPPORT***

*That, in order to address challenges in PBN implementation, stakeholders in the PBN implementation (Air navigation service providers (ANSP's), aircraft operators, user communities, etc.) be encouraged to continue providing support including resources to States and ICAO PBN programme.*

4.15 The meeting was apprised, among others, on the GPBNTF activities and mainly the formation of the GO Team that would assist in developing knowledge and expertise is various States in the Regions.

4.16 The meeting agreed that States willing to take advantage of the services offered by the GO team to communicate with ICAOMID Regional office in order to coordinate with ICAO HQ, in this regard and to support PBN implementation activities in the Region an Air Space planning seminar will be organized by ICAO in collaboration with FAA and EUROCONTROL between 26-28 October 2010 were invitation letter will be sent to all MID States, in due time.

4.17 The objective of this workshop is to provide an insight and basic understanding of the development of a PBN Airspace Concept. It will address the methodology to be used in developing such concepts, apply this methodology through group work by providing unique hands on experience in the actual development of an Airspace Concept based on generic scenarios.

4.18 The workshop will be limited to 30 participants, who will actively engage in workshop exercise and present the results; participants will work in multi disciplinary teams. The workshop will take three full days and the participants are expected to have a basic understanding of RNAV and Navigation applications in general and good command of English.

4.19 The meeting recalled that ICAO is transitioning to performance based approach which emanated from good industry practices that have emerged over many years. As the aviation industry has evolved into a less regulated and more corporatized environment with greater accountabilities, the advantages of transitioning from systems based to performance-based planning are apparent.

4.20 The meeting also recalled that ICAO *Global ATM Operational Concept* (Doc 9854) provides a clear statement of the expectations of the Air Traffic Management (ATM) Community. Eleven of these expectations, also referred to as key performance areas (KPAs) have been identified in the operational concept. To support this approach, the *Manual on Global Performance of the Air Navigation System* (Doc 9883) was developed. Doc 9883 provides a step by step approach to performance-based planning on the basis of the KPAs identified in the operational concept.

4.21 In this regard the meeting was provided with presentation showing the various documents and guidance material available from ICAO and how to make use of the documents and guidance material.

4.22 The meeting noted the importance of the bottom – up planning where it is necessary to have such a feedback from State in order to reflect it in the Regional Plan which is forming part of the global plan.

4.23 The meeting noted that MIDANPIRG/11 meeting adopted *CONCLUSION 11/70: REGIONAL PERFORMANCE FRAMEWORK and CONCLUSION 11/71: NATIONAL PERFORMANCE FRAMEWORK*, approving the Performance Framework Forms (PFF) containing the initial performance objectives.

4.24 The meeting reviewed and updated the PFF related to PBN implementation in the Region as at **Appendix 4C** to the Report on Agenda Item 4. Furthermore the meeting noted with appreciation that Jordan had reviewed and updated the PFF related to their air Space as at **Appendix 4D** to the report on Agenda Item 4.

4.25 The meeting was informed that in accordance with the current ICAO Business Planning process, the work of the Planning and Implementation Regional Groups (PIRGs) has to be justified and based on clearly established performance objectives in support of the ICAO Strategic Objectives, in this regard a workshop on the development of national performance framework for air navigation systems will be held at the ICAO MID Regional Cairo, Egypt, 1-5 November 2009 office with support from ICAO HQ.

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PBN/GNSS TF/2
Appendix 4A to the Report on Agenda Item 4

## DRAFT MID PERFORMANCE-BASED NAVIGATION IMPLEMENTATION REGIONAL PLAN

### 1. EXECUTIVE SUMMARY

1.1 This Middle East PBN Implementation Regional Plan has been produced in line with Resolution A 36/23 adopted by ICAO Assembly in its 36th Session held in September 2007. The Regional Plan addresses the strategic objectives of 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.

1.2 The Plan envisages pre- and post-implementation safety assessments and continued availability of conventional air navigation procedures during transition. The Plan 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 (2011 – 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 envisaged 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 **Middle East PBN Implementation Plan -** A document offering appropriate guidance for air navigation service providers, airspace operators and users, regulating agencies, and international organizations, on the evolution of navigation, 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 MID 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:

| | |
|---|---|
| AACO | Arab Air Carrier Association |
| ABAS | Aircraft-Based Augmentation System |
| ACAC | Arab Civil aviation Commission |
| AIS | Aeronautical Information System |

| | |
|---|---|
| APAC | Asia and Pacific Regions |
| 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 |
| 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 |
| MIDANPIRG | Middle East Air Navigation Planning and Implementation Regional Group |
| MID RMA | Middle East Regional Monitoring Agency |
| PANS | Procedures for Air Navigation Services |
| PBN | Performance Based Navigation |
| PIRG | Planning and Implementation Regional 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 roadmap**

4.1 The Performance Based Navigation (PBN) concept specifies aircraft RNAV 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 this context, the PBN concept represents a shift from sensor-based to performance –based navigation.

4.2 The implementation of RVSM on 27 NOV 2003 in the MID Region brought significant airspace and operational benefits to the Region. However, the realization of new benefits from RVSM have reached a point of diminishing returns. The main tool for optimizing the airspace structure is the implementation of performance based navigation (PBN), which will foster the necessary conditions for the utilization of RNAV and RNP capabilities by a significant portion of airspace users in the MID region.

4.3 In view of the need for detailed navigation planning, it was deemed advisable to prepare a PBN Roadmap to provide proper guidance to air navigation service providers, airspace operators and user, regulating agencies, and international organization, on the evolution of performance base navigation, as one of the key systems supporting air traffic management, which describes the RNAV and RNP navigation applications that should be implemented in the short and medium term in the MID Region.

4.4 Furthermore, the MID PBN Roadmap will be the basic material for the development of a boarder MID air navigation strategy, which will serve as guidance for regional projects for the implementation of air navigation infrastructure, such as SBAS, GBAS, etc., as well as for the development of national implementation plans.

4.5 The PBN Manual (Doc 9613) provides guidance on RNAV/RNP navigation specifications and encompasses two types of approvals: airworthiness, exclusively relating to the approval of aircraft, and operational, dealing with the operational aspects of the operator. RNAV/RNP approval will be granted to operators that comply with these two types of approval.

4.6 After the implementation of PBN as part of the airspace concept, the total system needs to be monitored to ensure that safety of the system is maintained. A system safety assessment shall be conducted during and after implementation and evidence collected to ensure that the safety of the system is assured.

**Benefits of Performance-Based Navigation**

a) Reduces need to maintain sensor- specific routes and procedures, and their associated costs.

b) Avoids need for development of sensor- specific operations with each new evolution of navigation systems; the present requirement of developing procedures with each new introduction is often very costly.

c) Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).

d) In true harmony with the way in which RNAV systems are used.

e) Facilitates the operational approval process for operators by providing a limited set of navigation specification intended for global use.

f) 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.

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

h) For the pilots, the main advantage of using this system is that the navigation function is performed by highly accurate and sophisticated onboard equipment and thus allowing reduction in cock-pit workload, with increase in safety.

i) For Air Traffic Controllers, the main advantage of aircraft using a RNAV system is that ATS routes can be straightened as it is not necessary for the routes to pass over locations marked by conventional NAVAIDS.

j) RNAV based arrival and departure routes can complement and even replace radar vectoring, thereby reducing approach and departure controllers' workload.

k) Increase of predictability of the flight path.

**Goals and Objectives of PBN Implementation**

4.7 The MIDANPIRG/11 meeting required that PBN be implemented in a strategic manner in the MID Region and accordingly established the PBN/GNSS Task Force which, *inter alia*, was required to follow up developments related to PBN and develop an implementation strategy. The 36th Session of ICAO Assembly adopted Resolution A36-23: *Performance based navigation global goals*, which, amongst others, highlighted global and regional harmonization in the implementation of PBN. Accordingly, the MID PBN Implementation Regional Plan has the following strategic objectives:

(a) To ensure that implementation of the navigation element of the MID CNS/ATM system is based on clearly established operational requirement.

(b) To avoid unnecessarily imposing the mandate for multiple equipment on board or multiple systems on ground.

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

(d) To avoid an eclipsing of ATM operational requirements by commercial interests, generating unnecessary costs States, international organization, and airspace users.

(e) To explain in detail the contents of the MID air navigation plan and of the MID CNS/ATM plan, describing potential navigation application.

4.8 Furthermore, the MID PBN Roadmap will provide a high-level strategy for the evolution of the navigation applications to be implemented in the MID region in the short term (2008-2012), medium term (2013-2016). This strategy is based on the coverage of area navigation (RNAV) and required navigation performance (RNP), which 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.

4.9 The MID PBN Implementation Regional Plan is developed by the MID States together with the international and Regional organizations concerned (AACO, ACAC, IATA, IFALPA, IFATCA), and is intended to assist the main stakeholders of the aviation community to plan a gradual transition to the RNAV and RNP concepts. The main stakeholders of the aviation community that benefit from this roadmap are:

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

4.10 The Plan is intended to assist the main stakeholders of the aviation community to plan the future transition and their investment strategies. For example, airlines and operators can use this Regional Plan to plan future equipage and additional navigation capability investment; 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.

**Planning principles**

4.11 The implementation of PBN in the MID Region shall be based on the following principles:

(a) develop strategic objectives and airspace concepts as described in the PBN manual (Doc 9613) to justify the implementation of the RNAV and/or RNP concepts in each particular airspace;

(b) States conduct pre- and post–implementation safety assessments to ensure the application and maintenance of the established target level of safety;

(c) development of airspace concept, applying airspace modelling tools as well as real-time and accelerated simulations, which identify the navigation applications that are compatible with the aforementioned concept; and

(d) continued application of conventional air navigation procedures during the transition period, to guarantee the operation by users that are not RNAV- and/or RNP–equipped.

4.12 Planning documentation. The implementation of PBN in the MID Region will be incorporated into the Regional Supplementary Procedures (Doc 7030) as approved by the ICAO Council. The States' PBN implementation plan will include a concise and detailed schedule of implementation for all phases of flight which will be endorsed through Regional agreement processes and considered by the Council as requirements for incorporated the Air Navigation Plan (ANP).

## 5. PBN OPERATIONAL REQUIREMENTS AND 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 be supported by ICAO Global Plan Initiatives.

5.2 In November 2006 the ICAO Council accepted the second amendment to the Global Air Navigation Plan for the CNS/ATM System, which has been renamed the Global Air Navigation Plan (Doc 9750), referred to as the Global Plan. A key part of the Global Plan framework are Global Plan Initiatives (GPIs), which are options for air navigation system improvements that when implemented, result in direct performance enhancements. The GPIs include implementation of performance based navigation (PBN) and navigation system. 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 It is envisaged that for the short term and medium term implementation of PBN, the establishment of a backup system in case of GNSS failure or the development of contingency procedures will be necessary.

**En-route**

5.4 Considering the traffic characteristic and CNS/ATM capability of the Region, the en-route operation can be classified as Oceanic, Remote continental, Continental, and local/domestic. In principle, each classification of the en-route operations should adopt, but not be limited to single RNAV or RNP navigation specification. This implementation strategy will be applied by the States and international organizations themselves, as coordinated at Regional level to ensure harmonization.

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

**Terminal**

5.6 Terminal operations have their own characteristics, taking into account the applicable separation minima between aircraft and between aircraft and obstacles. It also involves 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.

5.7 In this context, the States should develop their own national plans for the implementation of PBN in TMAs, based on the MID PBN Regional Plan, seeking the harmonization of the application of PBN and avoiding the need for multiple operational approvals for intra- and inter-regional operations, and the applicable aircraft separation criteria.

**Approaches**

5.8 During early implementation of PBN, IFR Approaches based on PBN should be designed to accommodate 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. States should phase-out non-precision approach procedures at a certain point when deemed operational suitable and taking in consideration GNSS integrity requirements.

**Implementation Strategy**

5.9 In order to address the operational requirements, the following PBN Implementation & Harmonisation Strategy for the ICAO MID Region is formulated as follows:

a) Implementation of any RNAV or RNP application shall be in compliance with ICAO PBN Manual (Doc 9613).

b) Implementation of RNAV5/RNAV1 depending on operation requirements for continental en-route and local/domestic en-route applications at least until 2016.

*Note: All current RNP-5 applications shall be redefined as RNAV-5 or RNAV-1 depending on operational needs.*

c) Implementation of RNAV1/Basic-RNP-1 depending on operation requirements for terminal applications at least until 2016.

d) Implementation of RNAV-10 for oceanic/remote continental until at least 2016.

e) Replacement of RNAV 5/RNAV-1 specification by RNP specifications (e.g. advanced-RNP-1) for the use in the en-route and terminal airspace to commence by 2016.

f) The target date for the completion of implementation for the Approach procedures with vertical guidance (APV) (APV/Baro-VNAV and/or APV/SBAS) for all instrument runway ends is 2016: The development of new conventional non-precision approach procedures should be discouraged. Existing conventional non-precision approach procedures should be phased not later than 2016, pending readiness of stand-alone GNSS.

g) The use of NDB for approach operations shall be terminated not later than 2012.

*Note: Although SBAS APV-I and II is currently not referenced in ICAO Doc9613, in accordance with the general Assembly resolution (A36-23) it is included in this Strategy as part of APV.*

## 6. CURRENT STATUS AND FORECAST

### MID Traffic Forecast

6.1 The GEN part of FASID (Part II) provides the information and data of the following traffic forecasts and trends:

- air traffic demand for air navigation systems planning
- Passenger traffic
- Aircraft movements
- Major city-pairs traffic

6.2 The forecast data as well as the figures contained in the FASID document are the results of the regular meetings of, MIDANPIRG Traffic Forecasting Sub-group, which had in last meeting in April 2007. Notably however, in the past two years, air traffic growth trend for the MID Region has signalled a significantly higher aircraft fleet and traffic growth than was previously forecast.

6.3 World scheduled traffic measured in terms of Passenger-kilometers Performed (PKPs) is forecast to increase at a “most likely” average annual rate at 4.6 per cent for the period 2005-2025. International traffic is expected to increase at 5.3 per cent per annum.

6.4 The airlines of the Middle East regions are expected to experience the highest growth in passenger traffic at 5.8 per cent per annum through to the year 2025 compared to the world average of 4.6%.

6.5 World scheduled freight traffic measured in terms of tonne-kilometres performed is forecast to increase at a “most likely” average annual rate of 6.6 per cent for the period 2005-2025. International freight traffic is expected to increase at an average annual growth rate of 6.9 per cent.

6.6 Air freight traffic of the airlines of Middle East region is expected to remain higher than the world average at 7.8 per annum.

6.7 The following major route groups to, from and within the Middle East Region have been identified:

- Between Middle East - Europe
- Between Middle East - Africa
- Between Middle East - Asia/Pacific
- Between Middle East - North America
- Intra Middle East

6.8 Movement forecasts for the major route groups for the 2007-2025 periods are depicted in **Table 1**.

**TABLE 1**

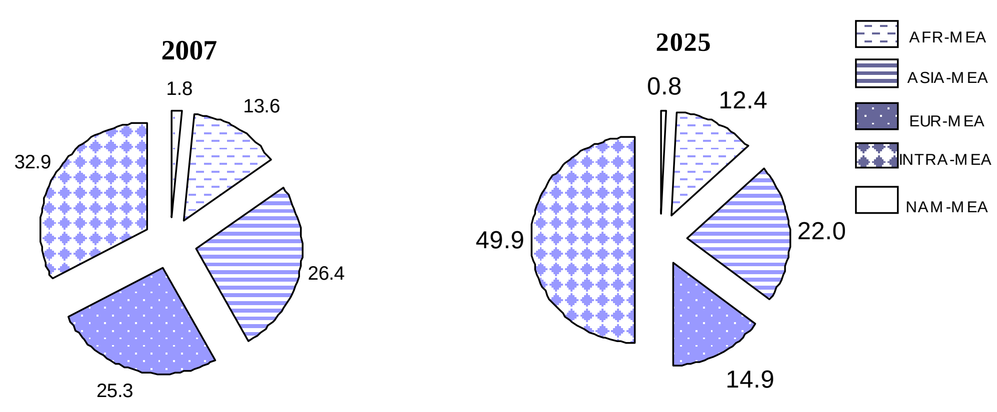
**AIRCRAFT MOVEMENTS FORECAST TO THE YEAR 2025**

| | Actual 2007 | Forecast 2025 | Average Annual Growths (per cent) 2007-2025 |
|---|---|---|---|
| **AFR-MEA** | 84933 | 291159 | 7.1 |
| **ASIA-MEA** | 165364 | 514979 | 6.5 |
| **EUR-MEA** | 158346 | 350380 | 4.5 |
| **INTRA MEA** | 205769 | 1170709 | 10.1 |
| **NAM-MEA** | 11075 | 18703 | 3.0 |
| **TOTAL** | 625487 | 2345929 | 7.6 |

6.9 The total aircraft movements to/from and within the Middle East region are estimated to increase from some 625000 in 2007 to around 2346000 in 2025 at an average annual growth rate of 7.6 per cent. The resulting movements' shares for the year 2025 are depicted in **Figure 1**.

**FIGURE 1**

**SHARES OF SELECTED ROUTE GROUPS IN AIRCRAFT MOVEMENTS**



**Aircraft Fleet Readiness**

6.10 IATA had circulated survey and will be compiling the results in report which could be referred to for details …..

**CNS Infrastructure**

**Navigation infrastructure**

**Global Navigation Satellite System (GNSS)**

6.11 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.

6.12 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.

6.13 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 Infrastructure**

6.14 Other navigation infrastructure that supports PBN applications includes INS, VOR/DME, DME/DME, and DME/DME/IRU. These navigation infrastructures may satisfy the requirements pf RNAV navigation specifications, but not those of RNP.

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

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

6.17 Uses of DME/DME and DME/DME/IRU may support PBN en-route and terminal area operations based on RNAV-5, and 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.

*Note.- The conventional Navaid infrastructure should be maintained to support non-equipped aircraft during a transition period until at least 2016.*

**Surveillance Infrastructure**

6.18 For RNAV operations, States should ensure that sufficient surveillance coverage is provided to assure the safety of the operations. Because of the on-board performance monitoring and alerting requirements 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 surveillance infrastructure in the MID can be found in ICAO FASID table.

**Communication Infrastructure**

6.19 Implementation of RNAV and 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 communication infrastructure in the MID can also be found in ICAO FASID table.

## 7. IMPLEMENTATION ROADMAP OF PBN

**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) Uniform 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

7.3 The above programmes should conform to the performance objectives and regional action plan supporting the regional implementation plan (roadmap).

**Short Term (2008-2012)**

***En-route***

7.4 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.

7.5 In this phase, the current application of RNAV-10 is expected to continue for Oceanic and Remote continental routes.

7.6 For Continental routes, the applications of RNAV-5 and RNAV-1 navigation specifications are expected. Before the PBN concept was established , the MID Region adopted the Regional implementation of RNP-5. Under the PBN concept it is now required that RNP 5 will change into RNAV-5. Based on operational requirements, States may choose to implement RNAV-1 routes to enhance efficiency of airspace usages and support closer route spacing, noting that appropriate communication and surveillance coverage is provided. Details of these requirements are provided in the PBN manual (Doc 9613) and PANS-ATM (Doc 4444).

7.7 **Operational approval**. Operators are required to have operational approval for RNAV-5. Depending on operational requirement RNAV-1 for terminal operations and RNAV-10 for Oceanic/Remote Continental operations.

7.8 Application of RNAV-5 or RNAV-1 for continental en-route will be mandated by the end of 2012.

***Terminal***

7.9 In selected TMAs, the application of RNAV-1 in a surveillance environment can be supported through 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.

7.10 In a non- surveillance environment and/or in an environment without adequate ground navigation infrastructure, the SID/STAR application of Basic-RNP-1 is expected in selected TMAs with exclusive application of GNSS.

7.11 **Operational approval**. Operators are required to have operational approval for RNAV-1. In addition, operators are required to have Basic RNP-1 approval when operating in procedural control TMAs.

*Note: In order to avoid unnecessary approvals, operators equipped with GNSS should apply for combined RNAV-1 and Basic RNP-1.*

***Approach***

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

7.13 States should promote the use of APV operations (Baro-VNAV or SBAS) to enhance safety of RNP approaches and accessibility of runways.

7.14 The application of RNP AR APCH procedures should be limited to selected airports, where obvious operational benefits can be obtained due to the existence of significant obstacles.

7.15 **Operational approval requirements**. Operators shall plan to have operational approval for RNP APCH with VNAV operations (Baro-VNAV). Depending on operational need, aircraft shall also meet the RNP AR APCH specification.

**SUMMARY TABLE AND IMPLEMENTATION TARGETS**

| **SHORT TERM (2008-2012)** | |
|---|---|
| ***Airspace*** | ***Navigation Specification*** |
| En-route – Oceanic | RNAV-10 |
| En-route - Remote continental | RNAV-10 |
| En-route – Continental | RNAV-5, RNAV-1 |
| En-route - Local / Domestic | RNAV-5, RNAV-1 |
| TMA – Arrival | RNAV-1 in surveillance environment and with adequate navigation infrastructure. Basic RNP-1 in non-surveillance environment |
| TMA – Departure | RNAV-1 in surveillance environment and with adequate navigation infrastructure. Basic RNP-1 in non-surveillance environment |
| Approach | RNP APCH with Baro-VNAV in most possible airports;<br>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 most significant operational benefits
- RNAV-1 SIDs/STARs for 30% of international airports by 2010 and 50% by 2012 and priority should be given to airports with RNP Approach
- RNP-5 and B-RNAV which is implemented in MID Region to be redefined as per ICAO PBN terminology by 2009 (MIDANPIRG/11), full implementation of PBN by 2012 for continental en-route.

**Medium Term (2013-2016)**

***En-route***

7.16 Noting the current development of route spacing standards for RNAV-1, in this phase, it is expected that the implementations of all existing RNAV/RNP routes are consistent with PBN standards. However, in order to ensure implementation harmonization, States are urged to implement their RNAV/RNP routes based on a Regional agreements and consistent PBN navigation specifications and separation standards.

7.17 With regard to oceanic remote operations, it is expected that with the additional surveillance capability, the requirement for RNAV-10 will disappear, and be replaced by navigation specifications for continental en-route applications.

7.18 **Operational approval**. Operators are required to have operational approval for RNAV-5 and RNAV-1.

***Terminal***

7.19 RNAV-1 or Basic RNP-1 will be fully implemented in all TMAs by the end of this term.

7.20 **Operational approval**. Operators are required to have operational approval for RNAV-1/Basic RNP-1 approval.

*Note: In order to avoid unnecessary approvals, operators equipped with GNSS should apply for combined RNAV-1 and Basic RNP-1*

***Approach***

7.21 In this phase, full implementation of RNP APCH with Baro-VNAV or APV SBAS for all instrument runways is expected. These applications may also serve as a back-up to precision approaches.

7.22 The extended application of RNP AR Approaches should continue for airports where there are operational benefits.

7.23 The introduction of application of landing capability using GNSS is expected to guarantee a smooth transition toward high-performance approach and landing capability.

7.24 **Operational approval requirements**. Operators are required to have operational approval for RNP APCH with VNAV operations (Baro-VNAV). Depending on operations, aircraft shall also meet RNP AR specification.

7.25 Application of RNAV-1 or Basic RNP-1 for all terminal areas and APV/Baro-VNAV or APV/SBAS for all instrument runway ends, either as the primary approach or as a back-up for precision approaches will be mandated by 2016.

**SUMMARY TABLE AND IMPLEMENTATION TARGETS**

| **MEDIUM TERM (2013-2016)** | |
|---|---|
| ***Airspace*** | ***Navigation Specification (preferred/acceptable)*** |
| En-route – Oceanic | Nil |
| En-route - Remote continental | Nil |
| En-route – Continental | RNAV-1, RNAV-5 |
| En-route - Local / Domestic | RNAV-1 , RNAV-5 |
| TMA – (Arrival, Departure) | RNAV-1 or RNP-1 application |
| Approach | 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 Basic RNP-1 SID/STAR at busy domestic airports where there are operational benefits
- Implementation additional RNAV/RNP routes

**Long Term (2016 and Beyond)**

7.26 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 (R&D) programs on GNSS implementation and operation.

7.27 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.

7.28 Noting the current development of Advanced RNP-1 navigation specification, it is expected that this navigation specification will play an important role in the long term implementation of PBN for enroute and terminal operations.

7.29 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.

7.30 During this term the use of Advanced RNP-1 for terminal and en-route will be mandated by a date to be determined.

## 8. TRANSITIONAL STRATEGIES

8.1 During the transitional phases of PBN implementation, sufficient ground infrastructure for conventional navigation systems must remain available. Before existing ground infrastructure is considered for removal, users should be consulted and 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, such as by performance of safety assessment, consultation with users through regional air navigation planning process and national consultative forums. Moreover, noting that navigation systems located in a particular State/FIR may be supporting air navigation in airspaces in other States/FIRs States are required to cooperate and coordinate bilaterally, multilaterally and within the framework of Regional agreements, in the phasing out of conventional ground based navigation systems and maintaining the serviceability of required navigation aids for area navigation (e.g. DME).

8.2 States should ensure that harmonized separation standards and procedures are developed and introduced concurrently in all flight information regions 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 R&D programs 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 need of State/Military aircraft.

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

8.6 ICAO MID Region Regional Office should provide leadership supporting implementation and transition towards PBN.

## 9. SAFETY ASSESSMENT AND MONITORS

### Methodology

#### *Need for Safety Assessment*

9.1 To ensure that the introduction of PBN en-route applications within the MID Region is undertaken in a safe manner and in accordance with relevant ICAO provisions, implementation shall only take place following conduct of a safety assessment that has demonstrated that an acceptable level of safety will be met. This assessment may also need to demonstrate levels of risk associated with specific PBN en-route implementation. Additionally, ongoing periodic safety reviews shall be undertaken where required in order to establish that operations continue to meet the target levels of safety.

#### *Roles and Responsibilities*

9.2 To demonstrate that the system is safe, it will be necessary that the implementing agency – a State or group of States - ensures that a safety assessment and, where required, ongoing monitoring of the PBN en-route implementation are undertaken. The implementing agency may have the capability to undertake such activities or may seek assistance from the Middle East Regional Monitoring Agency (MID RMA). The latter course of action is preferred as the MID RMA would be in a position to establish the necessary monitoring and data collection activity in an effective manner. Furthermore, the MIDANPIRG/10 meeting in April 2007 adopted the revised terms of reference of the MID RMA, whose scope includes safety monitoring of RNP/RNAV.

9.3 In undertaking a safety assessment to enable en-route implementation of PBN, a State, implementing agency or the MID RMA shall:

(a) Establish and maintain a database of PBN approvals;

(b) Monitor aircraft horizontal-plane navigation performance and the occurrence of large navigation errors and report results appropriately to the MID RMA;

(c) Conduct safety and readiness assessments and report results appropriately to the MID RMA;

(d) Monitor operator compliance with State approval requirements after PBN implementation; and

(e) Initiate necessary remedial actions if PBN requirements are not met.

9.4 The duties and responsibilities of the MID RMA as well as the agreed principles for its establishment are available from the ICAO MID Regional Office.

## 10. PERIODIC REVIEW OF IMPLEMENTATION ACTIVITIES

### Procedures to Modify the Regional Plan

10.1 Whenever a need is identified for a change to this document, the Request for Change (RFC) Form (to be developed) should be completed and submitted to the ICAO MID Regional Office. The Regional Office will collate RFCs for consideration by the PBN/GNSS Task Force (ATM/SAR/AIS Sub-group of MIDANPIRG).

10.2 When an amendment has been agreed by a meeting of the PBN/GNSS Task Force, 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, to enable a reader to note the origin of the change. If the change is in a table cell, the outside edges of the table will be highlighted. Final approval for publication of an amendment to the PBN Regional Plan will be the responsibility of MIDANPIRG.

**Appendix A – Practical Examples of tangible benefits (living document)**

***(To be Developed)***

**Appendix B – Reference documentation for developing operational and airworthiness approval regulations/procedures**

***(To be Developed)***

**------------------------**

PBN/GNSS TF/2
Appendix 4B to the Report on Agenda Item 4

| No. | ICAO Strategic Objective | Associated GPI | Tasks PBN/GNSS/2 | Objective | Deliverables | Target Date | To be delivered by | Supporting Parties | Status |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | Draft **Current Status & Forecast: Aircraft fleet readiness status** Section of PBN Regional Plan | To facilitate the development of the Regional Plan | Draft document | PBN/GNSS/2 | IATA | States, States | Ongoing |
| 2 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | Draft **Appendix A – Practical Example of tangible benefits** Section of PBN Regional Plan | To facilitate the development of the Regional Plan | Draft document | PBN/GNSS/2 | MID Office | – | Ongoing |
| 3 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Study and assess the Region RNAV and RNP requirements** | To facilitate the development of the Regional Plan | Draft document | PBN/GNSS/2 | ARN TF | – | Reassigned |
| 4 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Initially focus assistance on States that may require support on development of State PBN implementation plans** | To facilitate timely harmonized implementation | Draft provided | PBN/GNSS/2 | PBN/GNSS Task Force | States | Done during TF/2 Ongoing |
| 5 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Identify priority runways for Approach Procedures with Vertical Guidance (APV) to be implemented based on the ICAO RNP APCH navigation specification (APV/Baro-VNAV)** | To facilitate implementation efficiency and early operational benefits | Draft document | PBN/GNSS/2 | States | IATA | Ongoing |
| 6 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Develop an amendment proposal to the MID Regional Supplementary Procedures concerning the implementation of PBN in the Region** | To facilitate harmonized implementation | Doc 7030 amendment proposal | Mar 2010 | ARN and MID Regional Office | – | Ongoing |

| No. | ICAO Strategic Objective | Associated GPI | Tasks PBN/GNSS/2 | Objective | Deliverables | Target Date | To be delivered by | Supporting Parties | Status |
|---|---|---|---|---|---|---|---|---|---|
| 7 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Follow up on the developments in ICAO affecting the Global Plan and PBN in particular, in order to update the Regional plans accordingly** | To facilitate planning updates and global harmonization | Information and action items for PBN/GNSS Task Force | Ongoing | MID Regional Office | - | Ongoing |
| 8 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Coordinate with other ICAO Regions as necessary to address implementation interface issues** | To facilitate harmonized implementation | Information and action items for PBN/ GNSS Task Force | Ongoing | MID Regional Office | – | Ongoing |
| 9 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Undertake other functions relevant to implementation of PBN as assigned by the ATM/SAR/AIS SG or MIDANPIRG** | To facilitate implementation of PBN | As per assignments | Ongoing | PBN/ GNSS Task Force | - | Ongoing |
| 10 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Report to the ATM/SAR/AIS SG and keep the CNS SG closely briefed** | To facilitate efficiency and effectiveness | Task Force reports | Ongoing | PBN/GNSS Task Force | – | Ongoing |
| 11 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Identify guidance material and training needs/gap** | To determine required complementary guidance material | Draft document | PBN/GNSS/3 | PBN/GNSS Task Force | – | Ongoing |
| 12 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Review of Operational Approval Guidance from other Regions for use in the MID Region** | To support States' development of harmonized approvals | Draft document | PBN/GNSS/3 | IATA | | ongoing |

| No. | ICAO Strategic Objective | Associated GPI | **Tasks** PBN/GNSS/2 | Objective | Deliverables | Target Date | To be delivered by | Supporting Parties | Status |
|---|---|---|---|---|---|---|---|---|---|
| 13 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | **Develop PBN Implementation Action Plan** | To facilitate development of the Regional and State PBN Implementation Action Plan | Draft template | PBN/GNSS/2 | | | To be Assigned |
| 14 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | ICAO, via a State Letter, to request States to update information on CNS infrastructure in the FASID table | To obtain information necessary for regional planning | State letters, Updated FASID table | 1 Feb 2009 | ICAO MID Office | | On going |
| 15 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | Each State, which has not submit the updated FASID table to ICAO, to update the content of the FASID table and submit the updated table to ICAO Regional Office | To update information necessary for regional planning | | 1 Mar 2009 | States | | On going |
| 16 | A: Safety<br>D: Efficiency<br>C: Environment | GPI-5, GPI- 7, GPI-10, GPI-11, GPI-12, GPI-20, GPI-21 | Assess possibilities of future PBN Seminar | To assist States in their planning and implementation | Working Papers, Information Papers | On-going | PBN/GNSS TF | | On going |

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PBN/GNSS TF/2
Appendix 4C to the Report on Agenda Item 4

**PBN IMPLEMENTATION PFF**

| REGIONAL PERFORMANCE OBJECTIVE<br>OPTIMIZATION OF THE ATS ROUTE STRUCTURE EN-ROUTE AIRSPACE | | | | |
|---|---|---|---|---|
| ***Benefits*** | | | | |
| **Environment Efficiency** | ▪ reductions in fuel consumption;<br>▪ ability of aircraft to conduct flight more closely to preferred trajectories;<br>▪ increase in airspace capacity;<br>▪ facilitate utilization of advanced technologies (e.g., FMS based arrivals) and ATC decision support tools (e.g., metering and sequencing), thereby increasing efficiency. | | | |
| ***Short-term Strategy(2008-2012)*** | | | | |
| **TASK** | **DESCRIPTION** | **START-END** | **RESPONSIBILITY** | **STATUS** |
| **AOM** | ***En-route airspace*** | | | |
| | Develop regional strategic plan | 2008-2009 | MIDANPIRG/11 (PBN /GNSS TF) | done |
| | Develop regional implementation roadmap | 2008-2009 | MIDANPIRG /11 (PBN /GNSS TF) | done |
| | Develop regional action plan | 2009-2010 | MIDANPIRG /12 (PBN /GNSS TF) | done |
| | Develop Airspace Concept based in MID PBN Roadmap, in order to design and implement trunk route network, connecting major city pairs in the upper airspace and for transit to/from aerodromes, on the basis of PBN and, in particular, RNAV 5 and RNAV 1, taking into account interregional harmonization | 2009-2010 | ATM/SAR/AIS (ARN TF) | ARN TF/3 to start work |
| | update AIP to change RNP 5 to RNAV 5 | 2008-2009 | States | |
| | take necessary measures to implement RNAV 5 area in the level band FL 160 - FL460 (inclusive). | 2009-2012 | States | |
| | Develop State PBN implementation plans | 2008-2009 | MIDANPIRG/12 (ATM/SAR/AIS, States | States preparing plans |
| | Develop and update Standards and Procedures | 2010 | States | Ongoing |
| | Formulate safety plan | 2009 | ATM/SAR/AIS SG (MID RMA) | MID RMA to start work |
| | Establish collaborative decision making (CDM) process | 2008-2010 | MIDANPIRG/12 (ATM/SAR/AIS SG, CNS SG) | |
| | Publish national regulations for aircraft and operators approval using PBN manual as guidance material | 2008-2010 | States | Review and adapt available foreign approval guidance material |

| | | | | |
|---|---|---|---|---|
| | Develop and implement Training programmes | 2008-2010 | States | Identify training needs and develop corresponding guidelines |
| | Review System performance measurement | 2010-2012 | ATM/SAR/AIS (ARN TF) | ARN TF/3 to start work |
| | Implement the designed ATS route network | 2009-2012 | MIDANPIRG/12 (ATM/SAR/AIS) STATES | |
| | monitor implementation progress in accordance with MID PBN implementation roadmap and State implementation plan | 2008-2012 | MIDANPIRG/12 (ATM/SAR/AIS SG, CNS SG) | |
| **References** | GPI/5: performance-based navigation, GPI/7: dynamic and flexible ATS route management, GPI/8: collaborative airspace design and management, GPI/20: WGS-84 | | | |

**REGIONAL PERFORMANCE OBJECTIVE**
**OPTIMIZATION OF THE ATS ROUTE STRUCTURE IN TERMINAL AIRSPACE**

***Benefits***

| | |
|---|---|
| **Environment Efficiency** | ▪ reductions in fuel consumption;<br>▪ ability of aircraft to conduct flight more closely to preferred trajectories;<br>▪ increase in airspace capacity;<br>▪ facilitate utilization of advanced technologies (e.g., FMS based arrivals) and ATC decision support tools (e.g., metering and sequencing), thereby increasing efficiency. |

***Strategy***

| TASK | DESCRIPTION | START-END | RESPONSIBILITY | STATUS |
|---|---|---|---|---|
| **AOM** | ***In terminal airspace*** | | | |
| | Develop regional Implementation plan | 2008-2010 | MIDANPIRG PBN/GNSS TF | |
| | Develop regional action plan | 2008-2010 | MIDANPIRG PBN/GNSS TF | |
| | Develop State PBN implementation plan | 2008-2010 | MIDANPIRG PBN/GNSS TF | |
| | Develop Airspace Concept based on MID PBN Roadmap, in order to design and implement optimized standard instrument departures (SIDs), standard instrument arrivals (STARs), instrument flight procedures, holding, approach and associated procedures, on the basis of PBN and, in particular RNAV 1 and Basic-RNP 1 | 2009-2012 | MIDANPIRG PBN/GNSS TF States | |
| | Develop performance measurement and monitoring plan | | MIDANPIRG PBN/GNSS TF States | |
| | Formulate safety plan | 2008-2012 | States | |
| | Establish collaborative decision making (CDM) process | | MIDANPIRG (ATM/SAR/AIS SG, CNS SG) | |
| | Publish national regulations for aircraft and operators approval using PBN manual as guidance material | 2008-2012 | States | |
| | Identify training needs and develop corresponding guidelines | 2008-2012 | MIDANPIRG ATM/SAR/AIS PBN/GNSS TF States | |
| | Develop a regional work programme for implementation of SIDs and STARs | | MIDANPIRG ATM/SAR/AIS PBN/GNSS TF | |
| | Implement SIDs and STARs | 2008-2014 | States | |
| | Monitor implementation progress in accordance with MID PBN implementation roadmap and State implementation plan | 2008-2016 | MIDANPIRG ATM/SAR/AIS PBN/GNSS TF | |

| | |
|---|---|
| **References** | GPI/5: performance-based navigation, GPI/7: dynamic and flexible ATS route management, GPI/8: collaborative airspace design and management, GPI/10: terminal area design and management, GPI/11: RNP and RNAV SIDs and STARs and GPI/12: Functional integration of ground systems with airborne systems. |

| REGIONAL PERFORMANCE OBJECTIVE<br>IMPLEMENTATION OF VERTICALLY GUIDED RNP APPROACHES | | | | |
|---|---|---|---|---|
| **Benefits** | | | | |
| **Efficiency**<br>**Safety** | ▪ Improvements in capacity and efficiency at aerodromes.<br>▪ Improvements in safety at aerodromes. | | | |
| ***Strategy***<br>**(2008-2016)** | | | | |
| **TASK** | **DESCRIPTION** | **START-END** | **RESPONSIBILITY** | **STATUS** |
| | Develop regional Implementation plan | | | Done |
| | Develop regional action plan | | | Done |
| | Develop State PBN implementation plan | | | Done |
| | Develop Airspace Concept based in MID PBN Implementation Plan, in order to design and implement RNP APCH with Baro-VNAV in accordance with Assembly Resolution A36-23, and RNP AR APCH where beneficial. | **2008-2016** | MIDANPIRG ATM/SAR/AIS PBN/GNSS TF States | |
| | Develop performance measurement and monitoring plan | | MIDANPIRG ATM/SAR/AIS PBN/GNSS TF | |
| | Formulate safety plan | | | |
| | Establish collaborative decision making (CDM) process | | MIDANPIRG ATM/SAR/AIS SG, CNS SG | |
| | Publish national regulations for aircraft and operators approval using PBN manual as guidance material | 2008-2012 | States | |
| | Identify training needs and develop corresponding guidelines | 2008-2012 | MIDANPIRG ATM/SAR/AIS PBN/GNSS TF States | |
| | Implement APV procedures | 2008-2012 | States | |
| | Monitor implementation progress | 2008-2016 | MIDANPIRG ATM/SAR/AIS PBN/GNSS TF | |
| **References** | GPI/5: performance-based navigation, GPI/7: dynamic and flexible ATS route management, GPI/8: collaborative airspace design and management, GPI/10: terminal area design and management, GPI/11: RNP and RNAV SIDs and STARs and GPI/12: FMS-based arrival procedures. | | | |

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**JORDAN ATM PERFORMANCE OBJECTIVES**
**PBN IMPLEMENTATION**
**PERFORMANCE OBJECTIVES**

| OPTIMIZATION OF THE ATS ROUTE STRUCTURE EN-ROUTE AIRSPACE | | | | | |
|---|---|---|---|---|---|
| ***Benefits*** | | | | | |
| **Environment** □ reductions in fuel consumption;<br>**Efficiency** □ ability of aircraft to conduct flight more closely to preferred trajectories;<br>□ increase in airspace capacity;<br>□ facilitate utilization of advanced technologies (e.g., metering and sequencing), thereby increasing efficiency. | | | | | |
| **Performance Matrixes:** | i. PBN routes implemented<br>ii. $CO_2$ reduction of new routes | | | | |
| ***Strategy 2008-2012*** | | | | | |
| **TASK** | **DESCRIPTION** | **START** | END | **RESPONSIBILITY** | **Status** |
| AOM | ***En-route airspace*** | | | | |
| | Develop Airspace Concept, in order to design and implement a trunk route network, connecting major city pairs in the upper airspace and for transit to/from aerodromes, on the basis of PBN and, in particular, RNAV/5 and RNAV/1, taking into account interregional harmonization | 2009 | 2010 | ATM/SAR/AIS SG<br>ANSP in harmonization with the Regional plan | Start |
| | Finalize implementation of WGS | 1998 | | | Completed |
| | Develop State PBN implementation plans | 2008 | 2009 | ANSP | Completed |
| | Design and implement a trunk route network, on the basis of PBN and, in particular, RNAV/5 and RNAV/1, taking into account interregional harmonization | 2009 | 2010 | ANSP | Start |
| | | | | | |
| | Formulate safety plan | 2009 | 2010 | ATM/SAR/AIS SG | MID RMA Start |
| | Publish national regulations for aircraft and operators approval using PBN manual as guidance material<br>Standards and Procedures | 2010<br><br>2009 | 2010<br><br>2010 | CARC<br><br>CARC | Start Review and adapt available approval guidance material |
| | Identify training needs and develop training plan | 2008 | 2010 | ANSP | Completed |
| | Initiate training | 2009 | 2010 | | Start |
| | Formulate system performance monitoring plan | 2009 | 2010 | ANSP<br>ATM/SAR/AIS SG | ARN TF Start |
| | Implement the designed ATS route network | 2009 | 2012 | ATM/SAR/AIS SG<br>ANSP | ARN TF Start |
| | monitor implementation progress in accordance with the MID and CARC PBN implementation Plan | 2009 | 2012 | ATM/SAR/AIS SG<br>ANSP | ARN TF Start |
| | GPI/5: performance-based navigation,<br>GPI/7: dynamic and flexible ATS route management,<br>GPI/8: collaborative airspace design and management,<br>GPI/20: WGS-84 | | | | |

## PBN IMPLEMENTATION
## PERFORMANCE OBJECTIVES

| OPTIMIZATION OF THE ATS ROUTE STRUCTURE IN TERMINAL AIRSPACE | |
|---|---|
| ***Benefits*** | |
| **Environment**<br>**Efficiency** | reductions in fuel consumption;<br>ability of aircraft to conduct flight more closely to preferred trajectories;<br>increase in airspace capacity;<br>facilitate utilization of advanced technologies (e.g., FMS based arrivals) and ATC decision support tools (e.g., metering and sequencing), thereby increasing efficiency. |
| **Performance Matrixes:** | i. PBN routes implemented<br>ii. $CO_2$ reduction of new routes |

***Strategy 2008-2012***

| TASK | DESCRIPTION | START | END | RESPONSIBILITY | Status |
|---|---|---|---|---|---|
| AOM | ***In terminal airspace*** | | | | |
| | Develop Airspace Concept, in order to design and implement optimized standard instrument departures (SIDs), standard instrument arrivals (STARs), instrument flight procedures, holding, approach and associated procedures, on the basis of PBN and, in particular RNAV/1 and Basic-RNP1 | 2009 | 2010 | ANSP in coordination with the Regional plan | |
| | Develop PBN implementation plan | 2008 | 2009 | ANSP | Completed |
| | Finalize implementation of WGS | 1998 | 1998 | | Completed |
| | Design and implement optimized<br>- standard instrument departures (SIDs),<br>- standard instrument arrivals (STARs),<br>- instrument flight procedures, holding,<br>- approach and associated procedures,<br>on the basis of PBN and, in particular RNAV/1 and Basic-RNP1 | <br>2009<br>2009<br>2009<br>2009 | <br>2010<br>2010<br>2010<br>2010 | ANSP | Start |
| | Formulate safety plan | 2009 | 2010 | ANSP SMS unit | SMS unit Start |
| | Publish national regulations for aircraft and operators approval using PBN manual as guidance material<br>Standards and Procedures | 2010<br><br>2009 | 2010<br><br>2010 | CARC<br><br>CARC | Start Review and adapt available approval guidance material |
| | Identify training needs and develop training plan | 2008 | 2010 | ANSP | Completed |
| | Initiate training | 2009 | 2010 | | Start |
| | Formulate system performance monitoring plan | 2009 | 2010 | ANSP ATM/SAR/AIS SG | Start |
| | Implement the designed SIDs and STARs | 2009 | 2012 | ANSP | Start |
| | monitor implementation progress in accordance with the MID and CARC PBN implementation plan | 2009 | 2012 | ANSP ATM/SAR/AIS SG | Start |
| | GPI/5: performance-based navigation,<br>GPI/7: dynamic and flexible ATS route management,<br>GPI/8: collaborative airspace design and management,<br>GPI/10: terminal area design and management,<br>GPI/11: RNP and RNAV SIDs and STARs and<br>GPI/12: Functional integration of ground systems with airborne systems. | | | | |

**ATM PERFORMANCE OBJECTIVES**
**PBN IMPLEMENTATION**
**PERFORMANCE OBJECTIVES**

| IMPLEMENTATION OF VERTICALLY GUIDED RNP APPROACHES | | | | | |
|---|---|---|---|---|---|
| ***Benefits*** | | | | | |
| **Efficiency**  Improvements in capacity and efficiency at aerodromes.<br>**Safety**  Improvements in safety at aerodromes. | | | | | |
| **Performance Matrixes:** | i. PBN routes implemented<br>ii. $CO_2$ reduction of new routes | | | | |
| ***Strategy 2008-2012*** | | | | | |
| **TASK** | **DESCRIPTION** | **START** | END | **RESPONSIBILITY** | **Status** |
| AOM AO | ***At Airports*** | | | | |
| | Develop Airspace Concept Implementation Plan, in order to design and implement RNP APCH with Baro-VNAV and RNP AR APCH where beneficial. | 2009 | 2012 | ANSP in coordination with the Regional plan | |
| | Develop PBN implementation plans | 2008 | 2009 | ANSP | Completed |
| | Design and implement RNP APCH with Baro-VNAV and RNP AR APCH. | 2011 | 2016 | ANSP | |
| | Finalize implementation of WGS | 1998 | 1998 | ANSP | Completed |
| | Develop performance measurement plan | 2009 | 2012 | ATM/SAR/AIS SG | ARN TF Start |
| | Formulate safety plan | 2009 | 2012 | ANSP SMS unit | SMS unit Start |
| | Publish national regulations for aircraft and operators approval using PBN manual as guidance material<br>Standards and Procedures | 2010<br><br><br>2009 | 2010<br><br><br>2010 | CARC<br><br><br>CARC | Start Review and adapt available approval guidance material |
| | Identify training needs and develop training plan | 2008 | 2010 | ANSP | Completed |
| | Initiate training | 2009 | 2010 | | Start |
| | Formulate system performance monitoring plan | 2009 | 2012 | ANSP | Start |
| | Implement APV procedures | 2009 | 2012 | ANSP | Start |
| | monitor implementation progress in accordance with MID and CARC PBN implementation plan | 2009 | 2012 | ANSP ATM/SAR/AIS SG | Start |
| | GPI/5: performance-based navigation,<br>GPI/7: dynamic and flexible ATS route management,<br>GPI/8: collaborative airspace design and management,<br>GPI/10: terminal area design and management,<br>GPI/11: RNP and RNAV SIDs and STARs and<br>GPI/12: FMS-based arrival procedures. | | | | |

## PERFORMANCE FRAMEWORK FORM - EXPLANATORY NOTES

1. **Performance framework form:** This form is an output and management form which is applicable to both regional and national planning and includes references to the Global Plan. Other formats may be appropriate but should contain as a minimum the elements described below
2. **Performance objective:** Regional /national performance objectives should be developed using a performance based approach that best reflects the necessary activities needed to support regional/national ATM systems. During their life cycle, performance objectives may change depending on the ATM system's evolution; therefore, throughout the implementation process, these should be coordinated with and be available to all interested parties within the ATM Community. The establishment of collaborative decision making processes ensures that all stakeholders are involved in and concur with the requirements, tasks and timelines.
3. **Regional performance objective:** Regional performance objectives are the improvements required to the air navigation system in support of the global performance objectives, and are related to the operating environments and priorities applicable at the regional level.
4. **National performance objective:** National performance objectives are the improvements required to the air navigation system in support of the regional performance objectives, and are related to the operating environments and priorities applicable at the State level.
5. **Benefits:** The regional/national performance objectives should meet the expectations of the ATM community as described in the operational concept and should lead to benefits for stakeholders and be achieved through operational and technical activities aligned with each performance objective.
6. **Strategy:** ATM evolution requires a clearly defined progressive strategy including tasks and activities which best represent the national and regional planning processes in accordance with the global planning framework. The goal is to achieve a harmonized implementation process evolving toward a seamless global ATM system. For this reason, it is necessary to develop short (1 to 5 years) and medium term (6 to 10 years) work programmes, focusing on improvements to the system indicating a clear work commitment for the parties involved.
7. **ATM operational concept components:** Each strategy or set of tasks should be linked with associated components of the ATM operational concept. The designators for ATM components are as follows:

- AOM – Airspace organization and management
- DCB – Demand and capacity management
- AO – Aerodrome operations
- TS – Traffic synchronization
- CM – Conflict management
- AUO – Airspace user operations
- ATM SDM – ATM service delivery management.

8. Tasks: The regional/national work programmes, using these PFF templates, should define tasks in order to achieve the said performance objective and at the same time maintain a direct relation with ATM system components. The following principles should be considered when developing work programme:

The work should be organized using project management techniques and performance-based objectives in alignment with the strategic objectives of ICAO.

All tasks involved in meeting the performance objectives should be developed using strategies, concepts, action plans and roadmaps which can be shared among parties with the fundamental objective of achieving seamlessness through interoperability and harmonization.

The planning of tasks should include optimizing human resources as well as encouraging dynamic use of electronic communication between parties such as the Internet, videoconferences, teleconferences, e-mail, telephone and facsimile. Additionally, resources should be efficiently used, avoiding any duplication or unnecessary work.

The work process and methods should ensure that performance objectives can be measured against timelines and the national and regional progress achieved can be easily reported to PIRGs and ICAO Headquarters respectively.

9. Timeframe: Indicates start and end time period of that particular task(s).
10. Responsibility: Indicates the organization/entity/person accountable for the execution or management of the related tasks.
11. Status: The status is mainly focused on monitoring the progress of the implementation of that task(s) as it progresses toward the completion date.
12. Linkage to global plan initiatives (GPIs): The 23 GPIs, as described in the Global Plan, provide a global strategic framework for planning for air navigation systems and are designed to contribute to achieving the regional/national performance objectives. Each performance objective should be mapped to the corresponding GPIs. The goal is to ensure that the evolutionary work process at the State and regional levels will be integrated into the global planning framework.

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PBN/GNSS TF/2
Report on Agenda Item 5

**REPORT ON AGENDA ITEM 5: DEVELOPMENT OF STATES PBN IMPLEMENTATION PLAN AND IMPLEMENTATION ISSUES.**

5.1 The meeting was apprised on the 36th Session of the ICAO Assembly, Montreal 18 to 28 September 2007, where on the subject of continued evolution of a performance-based global air traffic management (ATM) system, the assembly acknowledged the benefits of PBN as well the responsibility of States in its implementation. The Assembly then adopted Resolution A36-13: *Performance based navigation global goals*, which outlines global goals for implementation of PBN to be addressed by States, as well as follow up action by the Council and the Planning and Implementation Regional Groups (PIRGs).

5.2 The meeting recalled that States are ultimately responsible for the safe and efficient operation of their national airspace systems including the provision for safe instrument flight procedures and safety oversight of their service providers and operators, and noting the benefits of PBN as well as other implications, States need to ensure that all RNAV and RNP operations and procedures are in accordance with the PBN concept.

5.3 The meeting also noted that A36th Assembly agreed that there should be a globally harmonized and coordinated transition to PBN, noting that in addition to the safety benefits, it was a key enabler towards a performance-based global air traffic management (ATM) system, furthermore the meeting noted that Assembly Resolution A36-23, amongst others, requests the Planning and Implementation Regional Groups (PIRG) to include in their work programme the review of status of implementation of PBN by States according to the defined implementation plans and report to ICAO any deficiencies that may occur.

5.4 The meeting noted that PBN/GNSS TF/1 developed the first version of the MID Regional PBN Implementation strategy and plan in order to allow sufficient time for the MID states to complete the development of their National PBN implementation plans by 2009 as called by the Assembly resolution A36:23.

5.5 Furthermore the meeting also noted that in order to further assist the MID States to develop their National PBN Implementation plan a common template with the List of content of the National PBN implementation plan was also developed and made available on the ICAO PBN web site: http://www2.icao.int/en/pbn/Pages/Documentation.aspx which was also endorsed by MIDANPIRG/11 in Feb 2009, in this regard the meeting was informed that only one MID State (Jordan) had submitted their National State PBN Implementation plan.

5.6 The meeting was apprised on the importance of development of the National State PBN implementation plan, in accordance with ICAO Assembly resolution A36:23, consequently the delegates of the participating States were asked to develop their own State PBN Implementation plans with the assistance of the ICAO secretariat and present them to the meeting for comments. The following States PBN Implementation plans were presented:

- Bahrain presented the draft PBN Implementation plan that was developed during the meeting which is at **Appendix 5A** to the Report on the Agenda Item 5, the meeting noted that in accordance with the ISO and SMS the control of the documents, the distribution list and other fundamental details are being part of the documentation in Bahrain.

- Egypt presented the plan that was developed during the meeting which is at **Appendix 5B** to the Report on the Agenda Item 5, the meeting noted that Egypt would benefit by implementation of PBN procedures by local expertise in order to build in-house expertise and knowledge on procedures design.

- Iran presented the draft PBN Implementation plan that was developed during the meeting which is at **Appendix 5C** to the Report on the Agenda Item 5, the meeting noted that the new PBN implementation will be enabler tool for improving the air space capacity in light of the expected traffic growth in Iran.

- Jordan presented the draft PBN Implementation plan that was sent to the ICAO MID Regional office which is as **at Appendix 5D** to the Report on the Agenda Item 5, the meeting appreciated the efforts done by Jordan to comply with the Assembly resolution target and noted that it highlighted many good ideas that could be utilized by the other States in the MID Region.

- Kuwait presented the draft PBN Implementation plan that was developed during the meeting which is at **Appendix 5E** to the Report on the Agenda Item 5, the meeting noted that Kuwait highlighted the benefits to the environment.

- Saudi Arabia presented the draft PBN Implementation plan that was developed during the meeting which is at **Appendix 5F** to the Report on the Agenda Item 5, the meeting noted that that Saudi Arabia highlighted the need for developing the flight procedures for helicopter. In this regard the meeting was informed that the new amendment to PANS-OPS document will include provisions for helicopter flight procedures and consequently alignment of the national plan will be needed.

5.7 The meeting was presented with task list used by Egypt for the development of the RNAV approach procedures and noted with appreciation that Egypt had developed new RNAV approach procedure for Cairo and Sharm El Shaikh using local expertise

5.8 The meeting noted with interest UAE achievement in implementing the first RNAV1 route within the UAE FIR, further developments are in process to implement RNAV 1 routes in UAE, furthermore the meeting noted that the implementation of these routes are results of the good cooperation and coordination between civil and Military authorities. The meeting encourage UAE and all States to submit major achievement to ICAO for publishing in the WAYPOINTS news letter.

5.9 Based on the above and noting the capability of the States and the requirement to submit their State's PBN Implementation plans to ICAO according to assembly resolution A36:23, the meeting agreed to the following Draft Conclusion:

***DRAFT CONCLUSION 2/5: STATE PBN IMPLEMENTATION PLANS***

*That, MID States which have not submitted their State PBN Implementation plans to ICAO MID Regional office are requested to do so before 30 December 2009.*

5.10 The meeting noted that ICAO MID Regional office sent State letter AN 6/28 – 293 dated 10 August 2008, requesting the appointment of PBN Implementation focal points, in this regard the meeting noted the updated list of PBN focal points as shown in **Appendix 5G** to the Report on Agenda Item 5 and urged the States who didn't appoint focal points to do so urgently.

5.11 The meeting further noted that MID States were requested to provide on a spreadsheet template information on the status of PBN implementation, in this regard the replies received by ICAO MID Regional Office are reflected as in **Appendix 5H** to the Report on Agenda Item 5.

5.12 The meeting also noted the experience in other ICAO Regions were progress report is used. Consequently the meeting developed a progress report as at **Appendix 5I** to the Report on Agenda Item 5 and urged all MID States to keep ICAO MID Regional office updated using the spreadsheet and the progress report , which is generic Template that requires States to provide information on their Designated PBN Focal Point; details on its PBN Implementation Plan; information on its development of Approach Procedures with Vertical Guidance (APV) for all instrument runway ends against the target dates agreed to in the MID Regional Implementation Plan and information on implementation of RNAV and RNP operations for en route and terminal areas against the established timelines and intermediate milestones.

5.13 Based on the above the meeting agreed to the following Draft Conclusion:

***DRAFT CONCLUSION 2/6: PBN IMPLEMENTATION PROGRESS REPORT***

*That, States are requested to use the excel sheet as at **Appendix 5H** and PBN Implementation Progress Report Template as at **Appendix 5I** to the Report on Agenda Item 5 for future reporting on the status of PBN implementation and submit progress reports to ICAO MID Regional Office every six months or whenever major progress is achieved.*

**------------------**

**KINGDOM OF BAHRAIN**

مملكة البحرين

*Civil Aviation Affairs*

شئون الطيران المدني

*Air Navigation*

إدارة الملاحة الجوية

# Performance Based Navigation (PBN) Implementation Plan

## Kingdom of Bahrain

Version 1

Draft



October 2009

**Distribution List**

| Q ty | Name | Title | Signature |
|---|---|---|---|
| 1 | Ali Ahmed Mohammed | Air Navigation Director | |
| 2 | Saleem M. Hasan | Chief ATM | |
| 3 | ICAO-MIDANPIRG | HQ | CAIRO |
| 4 | ATM Section | All staff | BCAA |
| 5 | | | |
| 6 | | | |
| 7 | | | |
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# RECORD OF AMENDMENTS

**Record the incorporation of an amendment, the date of inserting the amendment and signature as indicated below.**

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## About the Plan

### Requirement for PBN

ICAO Assembly Resolution A36-23 calls for each State to develop a national PBN implementation plan by December 2009. By elaborating this plan, Bahrain wants to meet the intent of the resolution and to show his engagement (commitment) for the implementation of PBN.

Why is a PBN implementation plan needed?

With RVSM implemented in most of the world, the main tool for optimising the airspace structure is the implementation of performance-based navigation (PBN), which will foster the necessary conditions for the utilization of RNAV and RNP capabilities by a significant portion of airspace users in the Regions and States.

Current planning by the Regional Planning and Implementation Groups is based on the Air Navigation Plans and the Regional CNS/ATM Plans. Currently, these plans are mostly made up of tables that do not contain the necessary details for the implementation of each of the CNS and ATM elements. For this reason, the Regions will be developing Regional PBN implementation plans. The aim of this national implementation PBN plan is to implement the MID regional plan at the State level and address PBN implementation strategy at the national level.

The national PBN implementation plan wants also to provide proper guidance and direction to the air navigation service provider(s), airspace operators and users, regulating agency, as well as foreign operators who operate or plan to operate in Bahrain. This plan will address the planned evolution of navigation, as one of the key systems supporting air traffic management, and describe the RNAV and RNP navigation applications that will be implemented in at least the short and medium term, in Bahrain.

### What are the objectives of the PBN Implementation Plan?

The PBN implementation plan meets the following strategic objectives:

a) provide a high-level strategy for the evolution of the navigation applications to be implemented in Bahrain in the short term (2010-2012) and medium term (2013-2016). This strategy is based on the concepts of PBN, Area Navigation (RNAV) and Required Navigation Performance (RNP), which will be applied to aircraft operations involving instrument approaches, standard departure (SID) routes, standard arrival (STAR) routes, and ATS routes in continental areas in accordance with the implementation goals in the Assembly resolution;

b) ensure that the implementation of the navigation portion of the CNS/ATM system is based on clearly established operational requirements;

c) avoid unnecessarily imposing the mandate for multiple equipment on board or multiple systems on the ground;

d) avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations;

e) prevent commercial interests from outdoing ATM operational requirements, generating unnecessary costs for Bahrain as well as for airspace users.

### What is the intent of the PBN Implementation Plan?

The PBN Implementation Plan will be developed by Bahrain Civil Aviation Authority together with the stakeholders concerned. The main stakeholders of the aviation community that benefit from this roadmap and are therefore included in the development process are:

- Airlines and operators
- Air navigation service providers
- Regulating agencies (MINISTRY OF TRANSPORT)

• National and international organizations (MILITARY)

The PBN Implementation Plan is intended to assist those stakeholders of the aviation community plan a gradual transition to the RNAV and RNP concepts and their investment strategies.

Airlines and operators will use this roadmap to plan future equipage and additional navigation capability investments;

Air navigation service providers will plan a gradual transition for the evolving ground infrastructure.

The Ministry of transport and the Bahrain Civil Aviation Authority will anticipate and plan for the criteria that will be needed in the future as well as the future regulatory workload and associated training requirements for their work force.

## What principles should be applied in development of the PBN Implementation Plan?

The implementation of PBN in Bahrain is based on the following principles:

a) Continued application of conventional air navigation procedures during the transition period, to guarantee availability by users that are not RNAV- and/or RNP-equipped;
b) Development of airspace concepts, applying airspace modeling tools as well as real-time and accelerated simulations, which identify the navigation applications that are compatible with the aforementioned concept;
c) Conduct of cost-benefit analyses to justify the implementation of the RNAV and/or RNP concepts in each particular airspace;
d) Conduct of pre- and post-implementation safety assessments to ensure the application and maintenance of the established target levels of safety.
e) Must not conflict with the MID regional PBN implementation plan.

## Table of contents

## 1. Introduction

The MID Region Performance Based Navigation (PBN) Roadmap details the framework within which the ICAO PBN concept will be implemented in the MID Region for the foreseeable future. The MID Region Roadmap for PBN is guided by ICAO Doc. 9613 and relevant SARPs. The primary driver for this plan is to maintain and increase safety, air traffic demand and capacity, and services and technology in consultation with relevant stakeholders. The MID Region Roadmap also supports national and international interoperability and global harmonization.

## 2. Background

The continuing growth of aviation places increasing demands on airspace capacity and emphasizes the need for the optimum utilization of the available airspace.

Growth in scheduled and General Aviation aircraft is expected to increase point-to-point and direct routings. The increasing cost of fuel also presents a significant challenge to all segments of the aviation community. This anticipated growth and higher complexity of the air transportation system could result in increased flight delays, schedule disruptions, choke points, inefficient flight operations, and passenger inconvenience, particularly when unpredictable weather and other factors constrain airport capacity. Without improvements in system efficiency and workforce productivity, the aviation community and cost of operations will continue to increase. Upgrades to the air transportation system must leverage current and evolving capabilities in the near term, while building the foundation to address the future needs of the aviation community stakeholders. These circumstances can be partially alleviated by efficiencies in airspace and procedures through the implementation of PBN concepts.

In setting out requirements for navigation applications on specific routes or within a specific airspace, it is necessary to define requirements in a clear and concise manner. This is to ensure that both flight crew and ATC are aware of the on-board area navigation (RNAV) system capabilities and to ensure that the performance of the RNAV system is appropriate for the specific airspace requirements.

The early use of RNAV systems arose in a manner similar to conventional ground-based routes and procedures. A specific RNAV system was identified and its performance was evaluated through a combination of analysis and flight testing. For domestic operations the initial systems used VOR and DME for their position estimation. For oceanic operations, inertial navigation systems (INS) were employed.

These 'new' systems were developed, evaluated and certified. Airspace and obstacle clearance criteria were developed on the basis of available equipment performance. Requirements specifications were based upon available capabilities and, in some implementations, it was necessary to identify the individual models of equipment that could be operated within the airspace concerned.

Such prescriptive requirements result in delays to the introduction of new RNAV system capabilities and higher costs for maintaining appropriate certification. To avoid such prescriptive specifications of requirements, the PBN concept introduces an alternative method for defining equipage requirements by specification of the performance requirements. This is termed Performance Based Navigation (PBN).

## 3. Performance Based Navigation (PBN)

Performance based navigation (PBN) is a concept that encompasses both area navigation (RNAV) and required navigation performance (RNP) and revises the current RNP concept. Performance based navigation is increasingly seen as the most practical solution for regulating the expanding domain of navigation systems.

Under the traditional approach, each new technology is associated with a range of system-specific requirements for obstacle clearance, aircraft separation, operational aspects (e.g. arrival and approach procedures), aircrew operational training and training of air traffic controllers. However, this system-specific approach imposes an unnecessary effort and expense on States, airlines and air navigation services (ANS) providers.

Performance based navigation eliminates the need for redundant investment in developing criteria and in operational modifications and training. Rather than build an operation around a particular system, under performance based navigation the operation is defined according to the operational goals, and the available systems are then evaluated to determine whether they are supportive.

The advantage of this approach is that it provides clear, standardized, operational approvals which enables harmonized and predictable flight paths which result in more efficient use of existing aircraft capabilities, as well as improved safety, greater airspace capacity, better fuel efficiency, and resolution of environmental issues.

The PBN concept specifies aircraft RNAV 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. 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.

Under PBN, generic navigation requirements are defined based on the operational requirements. Operators are then able to evaluate options in respect of available technologies and navigation services that could allow these requirements to be met. The chosen solution would be the most cost effective for the operator, rather than a solution being imposed as part of the operational requirements. Technologies can evolve over time without requiring the operation itself to be revisited, as long as the requisite performance is provided by the RNAV system. As part of the future work of the ICAO, it is anticipated that other means for meeting the requirements of the Navigation Specifications will be evaluated and may be included in the applicable Navigation Specifications, as appropriate.

ICAO's Performance Based Navigation (PBN) concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use worldwide. It is a new concept based on the use of Area Navigation (RNAV) systems. Significantly, it is a move from a limited statement of required performance accuracy to more extensive statements for required performance in terms of accuracy, integrity, continuity and availability, together with descriptions of how this performance is to be achieved in terms of aircraft and flight crew requirements.

### 3.1. RNAV Current status in Bahrain

RNAV-5 (Refer to Bahrain AIP ENR 6.2.1)

### 3.1.1 RNAV, ATS routes, SIDs, STARs and approaches

RNAV SIDs & STARs will be implemented in early 2010

3.1.2 User equipage in Bahrain airspace excluding overfly (Awaiting information from Licensing Directorate )

e.g:

a) Aircrafts registered in Bahrain

| Manufacturer & Type | Variant | Registration. No. | Build Year | Operator |
|---|---|---|---|---|
| Boeing 727 | 200 Advanced | | | Government of Bahrain |
| Boeing 767 | 300ER (P&W) | | | Government of Bahrain |
| Boeing 747 | SP | | | Government of Bahrain |
| Boeing 747 | 400 | | | Government of Bahrain |
| Gulfstream Aerospace Gulfstream | G4 | | | Government of Bahrain |
| Gulfstream Aerospace Gulfstream | G5 | | | Government of Bahrain |
| | | | | Government of Bahrain |
| | | | | |
| | | | | |

All aircraft are RNAV equipped. One aircraft is not RNAV approved G4

### 3.2 Benefits of PBN and global harmonization

PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. These include:

- Reduces need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.
- Avoids need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.
- Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).
- Clarifies the way in which RNAV systems are used.
- Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects. Specifically, RNAV and RNP may:

- Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.
- Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.
- Improve efficiency and flexibility by increasing use of operator-preferred trajectories airspace-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.
- Reduce workload and improve productivity of air traffic controllers.

Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of aviation stakeholders and service providers.

## 3.3 Stakeholders

Coordination is critical with the aviation community through collaborative forums. This will assist aviation stakeholders in understanding operational goals, determining requirements, and considering future investment strategies. This, in turn, enables the aviation stakeholders to focus on addressing future efficiency and capacity needs while maintaining or improving the safety of flight operations by leveraging advances in navigation capabilities on the flight deck. RNAV and RNP have reached a sufficient level of maturity and definition to be included in key plans and strategies, such as this State PBN plan.

The stakeholders who will benefit from the concepts in this State PBN plan include airspace operators, air traffic service providers, regulators, and standards organizations. As driven by business needs, airlines and operators can use the State PBN roadmap to plan future equipage and capability investments. Similarly, air traffic service providers can determine requirements for future automation systems, and more smoothly modernize ground infrastructure. Finally, regulators and standards organizations can anticipate and develop the key enabling criteria needed for implementation.

This plan is a work in progress and will be amended through collaborative MID Region States, industry efforts and consultations that establish a joint aviation community/government/industry strategy for implementing performance-based navigation. Critical initiative strategies are required to accommodate the expected growth and complexity over the next two decades. These strategies have five key features:

- Expediting the development of performance-based navigation criteria and standards.
- Introducing airspace and procedure improvements in the near term.
- Providing benefits to operators who have invested in existing and upcoming capabilities.
- Establishing target dates for the introduction of navigation mandates for selected procedures and airspace, with an understanding that any mandate must be rationalized on the basis of benefits and costs.
- Defining new concepts and applications of performance-based navigation for the mid term and Long term and building synergy and integration among other capabilities toward the realization of the MID Region PBN goals.

# 4. Challenges

## 4.1 Increasing Demands

Our two national airlines Gulf Air and Bahrain Air are planned to increase their fleets in 2010 with new aircrafts. That will increase …………………

## 4.2 Efficient Operations

### 4.2.1 En route (continental)

- Optimization of traffic routes by made them routes as direct as possible

### 4.2.2 Terminal Areas (Departures and Arrivals)

- Provides an efficient link to the TMA and en-route structure.
- Provide for increase operations in a single runway environment.
- Reduced ATC controller workload.
- Controlled paths to and from

### 4.2.3 Approach

- Reduce radar separation from 5 nm to 3 nm to increase capi
- Provides an efficient link to the TMA and en-route structure.
- Provide for increase operations in a single runway environment.
- Reduced ATC controller workload.
- Better Aerodrome operating minim
- Redundancy to landing navigation aids

## 4.3 Environment

- Implement recommendations of the ongoing environment study.

# 5. Implementation strategy

This plan provides a high-level strategy for the evolution of navigation capabilities to be implemented in three timeframes: near term (2008-2012), mid term (2013-2016), and Long term (2017 and Beyond). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en-route continental, oceanic and remote operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.

To avoid proliferation of new navigation standards, Bahrain will communicate any new operational requirements with ICAO HQ, so that it can be taken into account by the ICAO Study Group in charge of PBN.

## 5.1 Near Term (2008-2012) Mid Term (2013-2016) and Long Term (2017 and Beyond) Key Tasks

The key tasks involved in the transition to performance-based navigation are:

- Establish navigation service needs through the Long term that will guide infrastructure decisions and specify needs for navigation system infrastructure, and ensure funding for managing and transitioning these systems.
- Define and adopt a national policy enabling additional benefits based on RNP and RNAV.
- Identify operational and integration issues between navigation and surveillance, air-ground communications, and automation tools that maximize the benefits of RNP.
- Support mixed operations throughout the term of this Roadmap, in particular considering navigation system variations during the near term until appropriate standards are developed and implemented.
- To support Civil/Military coordination and develop the policies needed to accommodate the unique missions and capabilities of military aircraft operating in civil airspace.
- Harmonize the evolution of capabilities for interoperability across airspace operations.
- Increase emphasis on human factors, especially on training and procedures as operations increase reliance on appropriate use of flight deck systems.

- Facilitate and advance environmental analysis efforts required to support the development of RNAV and RNP procedures.
- Maintain consistent and harmonized global standards for RNAV and RNP operations.

## 5.2 Near term strategy (2008-2012)

In the near-term, initiatives focus on investments by operators in current and new aircraft acquisitions, in satellite-based navigation and conventional navigation infrastructure as well as Bahrain investments. Key components include wide-scale RNAV implementation and the introduction of RNP for en route, terminal, and approach procedures.

The near-term strategy will also focus on expediting the implementation and proliferation of RNAV and RNP procedures. As demand for air travel continues at healthy levels, choke points will develop and delays at the major airports will continue to climb. RNAV and RNP procedures will help alleviate those problems. Continued introduction of RNAV and RNP procedures will not only provide benefits and savings to the operators but also encourage further equipage.

ANSPs as a matter of urgency must adapt new flight plan procedures to accommodate PBN operations. This particularly addresses fields 10 and 18.

Operators will need to plan to obtain operational approvals for the planned Navigation Specifications for this period. Operators shall also review Regional PBN Implementation Plans from other Regions to assess if there is a necessity for additional Operational approvals.

### 5.2.1 En route

#### *5.2.1.1 Remote Continental*

RNAV-5

#### *5.2.1.2 Continental*

All routes in Bahrain FIR are PBN RNAV-5 and currently are reviewing existing conventional and RNAV routes to transition to PBN RNAV-1 or where operationally required RNAV-1.

### 5.2.2 Terminal Areas (Departures and Arrivals)

RNAV reduces conflict between traffic flows by consolidating flight tracks. RNAV-1/Basic RNP-1 SIDs and STARs improve safety, capacity, and flight efficiency and also lower communication errors.

Bahrain will plan, develop and implement RNP-1 SIDs and STARs, at *Douala, Yaoundé-Nsimalen, Garoua international airports, Maroua, Ngaoundéré, Bafoussam, Bamenda and Bertoua national airports* and make associated changes in airspace design. RNAV-1 will be implemented in airspace where there is sufficient surveillance coverage and Basic RNP-1 where there is no such coverage.

*Where operationally feasible*, Bahrain will develop operational concepts and requirements for continuous descent arrivals (CDAs) based on FMS Vertical Guidance and for applying time of arrival control based on RNAV and RNP procedures. This would reduce workload for pilots and controllers as well as increase fuel efficiency.

PBN SIDs and STARS would allow the following:

- Reduction in controller-pilot communications;
- Reduction of route lengths to meet environmental and fuel efficiency requirements;
- Seamless transition from and to en-route entry/exit points;
- Sequence departures to maximize benefits of RNAV and identify automation requirements for traffic flow management, sequencing tools, flight plan processing, and tower data entry activities.

### 5.2.3 Approach

The application of RNP APCH will be implemented in Douala, Yaoundé, Garoua international airports. To facilitate a transitional period, conventional approach procedures and conventional navigation aids will be maintained for non PBN equipped aircraft during *this term*.

Bahrain will promote the use of APV Operations (Baro-VNAV ) to enhance safety of RNP Approaches and accessibility of runways.

The application of RNP AR Approach will be limited to selected runways where obvious operational benefits can be obtained due to the existence of significant obstacles.

RNP approaches include:

- APV implemented at all instrument runways at major regional airports and all non-instrument runways serving aircraft weighing greater than 5,700kg.

### 5.2.5 Summary near term strategy

| **Airspace** | **Nav. Specifications** | **Nav. Specifications where operationally required** |
|---|---|---|
| En-Route | RNAV-5 | RNP-5 |
| En-Route Remote Continental | RNAV-5 | RNP-10 |
| En-Route Continental | RNAV-5 | RNAV-1 |
| TMA Arrival/Departure | RNAV-1 in a surveillance environment<br>Basic RNP-1 in non-surveillance environment | |
| Approach | GNSS RNAV APP<br>or RNP APCH with Baro-VNAV if required | |

Implementation Targets

- RNP APCH (with Baro-VNAV) by 2012 and priority given to airports with operational benefits
- RNAV-1 SID/ airports by 2010.
- Review existing conventional and RNAV routes to transition to PBN RNAV-1 by 2012.

## 5.3 Medium term strategy (2013-2016)

In the mid term, increasing demand for air travel will continue to challenge the efficiencies of the air traffic management system.

While the hub-and-spoke system will remain largely the same as today for major airline operations, the demand for more point-to-point service will create new markets and spur increases in low-cost carriers, air taxi operations, and on-demand services. Additionally, the emergence of VLJs is expected to create new markets in the general and business aviation sectors for personal, air taxi, and point-to-point passenger operations. Many airports will thus experience significant increases in unscheduled traffic. In addition, many destination airports that support scheduled air carrier traffic are forecast to grow and to experience congestion or delays if efforts to increase their capacity fall short. As a result, additional airspace flexibility will be necessary to accommodate not only the increasing growth, but also the increasing air traffic complexity.

The mid term will leverage these increasing flight capabilities based on RNAV and RNP, with a commensurate increase in benefits such as fuel-efficient flight profiles, better access to airspace and airports, greater capacity, and reduced delay. These incentives, which should provide an advantage over non-RNP operations, will expedite propagation of equipage and the use of RNP procedures.

*To achieve efficiency and capacity gains partially enabled by RNAV and RNP, Bahrain and aviation industry will pursue use of data communications (e.g., for controller-pilot communications) and enhanced surveillance functionality, e.g. ADS-Broadcast (ADS-B).* Data communications will make it possible to issue complex clearances easily and with minimal errors. ADS-B will expand or augment surveillance coverage so that track spacing and longitudinal separation can be optimized where needed (e.g., in non-radar airspace). Initial capabilities for flights to receive and confirm 3D clearances and time of arrival control based on RNP will be demonstrated in the mid term. With data link implemented, flights will begin to transmit 4D trajectories (a set of points defined by latitude, longitude, altitude, and time.) Stakeholders must therefore develop concepts that leverage this capability.

## 5.3.1 En route

### *5.3.1.1 Oceanic and Remote Continental*

In the midterm, Bahrain will endeavour to work with international air traffic service providers to promote the application of RNP 10 and RNP 4 in additional sub-regions of the oceanic environment.

### *5.3.1.2 Continental*

The review of en-route airspace will be completed by 2016.

**Implementation**

By the end of the mid term other benefits of PBN will have been enabled, such as flexible procedures to manage the mix of faster and slower aircraft in congested airspace and use of less conservative PBN requirements.

**Automation for RNAV and RNP Operations**

By the end of the mid term enhanced en route automation will allow the assignment of RNAV and RNP routes based upon specific knowledge of an aircraft's RNP capabilities. En route automation will use collaborative routing tools to assign aircraft priority, since the automation system can rely upon the aircraft's ability to change a flight path and fly safely around problem areas. This functionality will enable the controller to recognize aircraft capability and to match the aircraft to dynamic routes or procedures, thereby helping appropriately equipped operators to maximize the predictability of their schedules.

Conflict prediction and resolution in most en route airspace must improve as airspace usage increases. Path repeatability achieved by RNAV and RNP operations will assist in achieving this goal. Mid-term automation tools will facilitate the introduction of RNP offsets and other forms of dynamic tracks for maximizing the capacity of airspace. By the end of the mid term, *en route automation* will have evolved to incorporate more accurate and frequent surveillance reports through ADS-B, and to execute problem prediction and conformance checks that enable offset manoeuvres and closer route spacing (e.g., for passing other aircraft and manoeuvring around weather).

### 5.3.2 Terminal Areas (Departures and Arrivals)

During this period, either Basic RNP-1 or RNAV-1 will become a required capability for flights arriving and departing major airports based upon the needs of the airspace, such as the volume of traffic and complexity of operations. This will ensure the necessary throughput and access, as well as reduced controller workload, while maintaining safety standards.

With RNAV-1 operations as the predominant form of navigation in terminal areas by the end of the mid term, Bahrain will have the option of removing conventional terminal procedures that are no longer expected to be used.

**Terminal Automation**

Terminal automation will be enhanced with tactical controller tools to manage complex merges in busy terminal areas. As data communications become available, the controller tools will apply knowledge of flights' estimates of time of arrival at upcoming waypoints, and altitude and speed constraints, to create efficient maneuvers for optimal throughput.

Terminal automation will also sequence flights departing busy airports more efficiently than today. This capability will be enabled as a result of PBN and flow management tools. Flights arriving and departing busy terminal areas will follow automation-assigned PBN routes.

### 5.3.3 Approach

In the mid term, implementation priorities for instrument approaches will still be based on RNP APCH and RNP AR APCH and full implementation is expected at the end of this term.

*The introduction of the application of landing capability, using GBAS (currently non PBN)* is expected to guarantee a smooth transition towards high performance approach and landing capability.

### 5.3.4 Helicopter operations (To be developed by State)

### 5.3.5 Medium term strategy summary

| Airspace | Nav. Specifications | Nav. Specifications where operationally required |
|---|---|---|
| En-Route Continental | RNAV-1, RNAV-5 | |
| TMA Arrival/Departure | Expand RNAV-1, or basic RNP-1 application<br>Mandate RNAV-1, or basic RNP-1 | |
| Approach | Expand RNP APCH with (Baro-VNAV) and APV<br>Expand RNP AR APCH where there are operational benefits | |

**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 as required

## 5.4 Long term strategy (2017 and beyond)

The Long-term environment will be characterized by continued growth in air travel and increased air traffic complexity.

No one solution or simple combination of solutions will address the inefficiencies, delays, and congestion anticipated to result from the growing demand for air transportation. Therefore, Bahrain and key Stakeholders need an operational concept that exploits the full capability of the aircraft in this time frame.

### 5.4.1 Long Term Key Strategies (2017 and Beyond)

Airspace operations in the Long term will make maximum use of advanced flight deck automation that integrates CNS capabilities. RNP, RCP, and RSP standards will define these operations. Separation assurance will remain the principal task of air traffic management in this time frame. This task is expected to leverage a combination of aircraft and ground-based tools. Tools for conflict detection and resolution, and for flow management, will be enhanced significantly to handle increasing traffic levels and complexity in an efficient and strategic manner.

Strategic problem detection and resolution will result from better knowledge of aircraft position and intent, coupled with automated, ground-based problem resolution. In addition, pilot and air traffic controller workload will be lowered by substantially reducing voice communication of clearances, and furthermore using data communications for clearances to the flight deck. Workload will also decrease as the result of automated confirmation (via data communications) of flight intent from the flight deck to the ground automation.

With the necessary aircraft capabilities, procedures, and training in place, it will become possible in certain situations to delegate separation tasks to pilots and to flight deck systems that depict traffic and conflict resolutions. Procedures for airborne separation assurance will reduce reliance on ground infrastructure and minimize controller workload. As an example, in IMC an aircraft could be instructed to follow a leading aircraft, keeping a certain distance. Once the pilot agreed, ATC would transfer responsibility for maintaining spacing (as is now done with visual approaches).

Performance-based operations will exploit aircraft capabilities for “electronic” visual acquisition of the external environment in low-visibility conditions, which may potentially increase runway capacity and decrease runway occupancy times.

Improved wake prediction and notification technologies may also assist in achieving increased runway capacity by reducing reliance on wake separation buffers.

System-wide information exchange will enable real-time data sharing of NAS constraints, airport and airspace capacity, and aircraft performance. Electronic data communications between the ATC automation and aircraft, achieved through data link, will become widespread—possibly even mandated in the busiest airspace and airports. The direct exchange of data between the ATC automation and the aircraft FMS will permit better strategic and tactical management of flight operations.

Aircraft will downlink to the ground-based system their position and intent data, as well as speed, weight, climb and descent rates, and wind or turbulence reports. The ATC automation will uplink clearances and other types of information, for example, weather, metering, choke points, and airspace use restrictions.

To ensure predictability and integrity of aircraft flight path, RNP will be mandated in busy en route and terminal airspace. RNAV operations will be required in all other airspace (except oceanic). Achieving standardized FMS functionalities and consistent levels of crew operation of the FMS is integral to the success of this Long-term strategy.

The most capable aircraft will meet requirements for low values of RNP (RNP 0.3 or lower en route). Flights by such aircraft are expected to benefit in terms of airport access, shortest routes during IMC or convective weather, and the ability to transit or avoid constrained airspace, resulting in greater efficiencies and fewer delays operating into and out of the busiest airports.

Enhanced ground-based automation and use of real-time flight intent will make time-based metering to terminal airspace a key feature of future flow management initiatives. This will improve the sequencing and spacing of flights and the efficiency of terminal operations.

Uniform use of RNP for arrivals and departures at busy airports will optimize management of traffic and merging streams. ATC will continue to maintain control over sequencing and separation; however, aircraft arriving and departing the busiest airports will require little controller intervention. Controllers will spend more time monitoring flows and will intervene only as needed, primarily when conflict prediction algorithms indicate a potential problem.

More detailed knowledge of meteorological conditions will enable better flight path conformance, including time of arrival control at key merge points. RNP will also improve management of terminal arrival and departure with seamless routing from the en route and transition segments to the runway threshold. Enhanced tools for surface movement will provide management capabilities that synchronize aircraft movement on the ground; for example, to coordinate taxiing aircraft across active runways and to improve the delivery of aircraft from the parking areas to the main taxiways.

### 5.4.2 Summary of Long Term Key Strategies (2017 and Beyond)

The key strategies for instituting performance-based operations employ an integrated set of solutions.

- Airspace operations will take advantage of aircraft capabilities, i.e. aircraft equipped with data communications, integrated displays, and FMS.
- Aircraft position and intent information directed to automated, ground-based ATM systems, strategic and tactical flight deck-based separation assurance in selected situations (problem detection and resolution).
- Strategic and tactical flow management will improve through use of integrated airborne and ground information exchange.
- Ground-based system knowledge of real-time aircraft intent with accurate aircraft position and trajectory information available through data link to ground automation.
- Real-time sharing of National Air Space (NAS) flight demand and other information achieved via ground-based and air-ground communication between air traffic management and operations planning and dispatch.
- Overall system responsiveness achieved through flexible routing and well-informed, distributed decision-making.
- Systems ability to adapt rapidly to changing meteorological and airspace conditions.

- System leverages through advanced navigation capabilities such as fixed radius transitions, RF legs, and RNP offsets.
- Increased use of operator-preferred routing and dynamic airspace.
- Increased collaboration between service providers and operators.

Operations at the busiest airports will be optimized through an integrated set of capabilities for managing pre-departure planning information, ground-based automation, and surface movement.

- RNP-based arrival and departure structure for greater predictability.
- Ground-based tactical merging capabilities in terminal airspace.
- Integrated capabilities for surface movement optimization to synchronize aircraft movement on the ground. Improved meteorological and aircraft intent information shared via data link.

### 5.4.3 Key Research Areas

The aviation community must address several key research issues to apply these strategies effectively. These issues fall into several categories:

**Navigation**

- To what extent can lower RNP values be achieved and how can these be leveraged for increased flight efficiency and access benefits?
- Under what circumstances RNAV should be mandated for arriving/departing satellite airports to enable conflict-free flows and optimal throughput in busy terminal areas?

**Flight Deck Automation**

- What FMS capabilities are required to enable the future concepts and applications?
- How can performance-based communication and surveillance be leveraged in the flight deck to enable Long-term strategies such as real-time exchange of flight deck data?

**Automation**

- To what extent can lateral or longitudinal separation assurance be fully automated, in particular on final approach during parallel operations?
- To what extent can surface movement be automated, and what are the cost-benefit trade-offs associated with different levels of automation?
- To what extent can conflict detection and resolution be automated for terminal ATC operations?

**Procedures**

- How can time of arrival control be applied effectively to maximize capacity of arrival or departure operations, in particular during challenging wind conditions?
- In what situations is delegation of separation to the flight crews appropriate?
- What level of onboard functionality is required for flight crews to accept separation responsibility within a manageable workload level?

**Airspace**

- To what extent can airspace be configured dynamically on the basis of predicted traffic demand and other factors?
- What separation standards and procedures are needed to enable smoother transition between en route and terminal operations?
- How can fuel-efficient procedures such as CDAs be accomplished in busy airspace?

## Glossary

| | |
|---|---|
| 3D | Three-Dimensional |
| 4D | Four-Dimensional |
| ADS-B | Automatic Dependent Surveillance-Broadcast |
| ADS-C | Automatic Dependent Surveillance-Contract |
| ATC | Air Traffic Control |
| CDA | Continuous Descent Arrival |
| CNS | Communications, Navigation, Surveillance |
| EFVS | Enhanced Flight Visibility System |
| GA | General Aviation |
| GBAS | Ground-Based Augmentation System |
| GLS | GNSS (Global Navigation Satellite System) Landing System |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| ICAO | International Civil Aviation Organization |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| LNAV | Lateral Navigation |
| LPV | Localizer Performance with Vertical Guidance |
| NAS | National Airspace System |
| NAVAID | Navigation Aid |
| NM | Nautical Miles |
| PBN | Performance Based Navigation |
| RCP | Required Communications Performance |
| RF | Radius-to-Fix |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RNPSORSG | Required Navigation Performance and Special Operational Requirements Study Group |
| RSP | Required Surveillance Performance |
| SAAAR | Special Aircraft and Aircrew Authorization Required |
| SID | Standard Instrument Departure |
| STAR | Standard Instrument Arrival |
| VLJ | Very Light Jet |
| VNAV | Vertical Navigation |
| WAAS | Wide Area Augmentation System |

## Appendix A – National Action plan for PBN implementation

## Appendix B – En route continental implementation schedule by area or city pair (will be done in collaboration with ASECNA )

## Appendix C – Terminal area and approach implementation schedule by aerodrome (to be developed by State)

| Navigation Specification | Airspace Application | Short Term | | | | Medium Term | | | | Long Term |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017…. |
| RNAV10 | NA | Will not be used | | | | | | | | |
| RNP4 | NA | Will not be used | | | | | | | | |
| RNAV2 | NA | Will not be used | | | | | | | | |
| RNP5 into RNAV5 | Enroute | | | | | | | | | |
| RNAV1 | Enrout | | | | | | | | | |
| RNAV1 | TMA Dep. and Arr. Sur | | | | | | | | | |
| Basic RNP1 | TMA Dep. and Arr. Non sur | | | | | | | | | |
| RNP APCH | Approach | | | | | | | | | |
| RNP AR APCH | Approach KHIA | | | | | | | | | |
| RNAV1 | SIDs / STARs | | | | | | | | | |
| Basic RNP1 | Enrout | | | | | | | | | |
| advanced-RNP-1 | en-route | | | | | | | | | |
| advanced-RNP-1 | terminal airspace | | | | | | | | | |
| Use of NDB | Approach operations | | | | | Stop using the NDB for approach operations | | | | |
| Conventional NPA procedures | | | | | | | | | | Stop the conver procedures |

| Navigation Specification | Airspace Application | Short Term | | | | Medium Term | | | | Long Term |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017…. |
| RNAV10 | NA | Will not be used | | | | | | | | |
| RNP4 | NA | Will not be used | | | | | | | | |
| RNAV2 | NA | Will not be used | | | | | | | | |
| RNP5 into RNAV5 | Enroute | | | | | | | | | |
| RNAV1 | Enrout | | | | | | | | | |
| RNAV1 | TMA Dep. and Arr. Sur | | | | | | | | | |
| Basic RNP1 | TMA Dep. and Arr. Non sur | | | | | | | | | |
| RNP APCH | Approach | | | | | | | | | |
| RNP AR APCH | Approach | | | | | | | | | |
| RNAV1 | SIDs / STARs | | | | | | | | | |
| Basic RNP1 | Enrout | | | | | | | | | |
| advanced-RNP-1 | en-route | | | | | | | | | |
| advanced-RNP-1 | terminal airspace | | | | | | | | | |
| Use of NDB | Approach operations | | | | | Stop using the NDB for approach operations | | | | |
| Conventional NPA procedures | | | | | | | | | | Stop the convent procedures |

# Performance Based Navigation (PBN) Implementation Plan

# **EGYPT**

DRAFT 1

December 2008

**MID State PBN Plan Template**

## About the Plan

### Requirement for PBN

1.1 ICAO Assembly Resolution A36-23 calls for each State to develop a national PBN implementation plan by December 2009. This is a template developed by the ICAO PBN Programme as an example for use by the ICAO Contracting States as they each develop their own plans. This is only one example of what subjects a "National PBN Implementation Plan" that meets the intent of the resolution might include. States are encouraged to tailor their plans to meet their needs. This may mean that the "PBN Implementation Plan" is not stand-alone, but part of a broader plan for development of aviation in the State. This is a determination that only the State can make. It should be pointed out that if the State has not yet met its obligations with regard to conversion to the WGS-84 coordinate system, this should be included in the plan, as all RNAV and RNP operations are conducted solely with reference to WGS-84 coordinates.

### Why is a PBN implementation plan or roadmap needed?

1.2 With RVSM implemented or soon to be implemented in most of the world, the main tool for optimising the airspace structure is the implementation of performance-based navigation (PBN), which will foster the necessary conditions for the utilization of RNAV and RNP capabilities by a significant portion of airspace users in the Regions and State s.

1.3 Current planning by the Regional Planning and Implementation Groups is based on the Air Navigation Plans and the Regional CNS/ATM Plans. Currently, these plans are mostly made up of tables that do not contain the necessary details for the implementation of each of the CNS and ATM elements. For this reason, the Regions will be developing Regional PBN implementation plans. The necessary concurrent and follow-on step is to develop national plans that implement the regional plans at the State level and address PBN implementation strategy at the national level.

1.4 In view of the need for detailed navigation planning, it was deemed advisable to call for preparation of a national PBN Implementation Plan by each State, to provide proper guidance and direction to the domestic air navigation service provider(s), airspace operators and users, regulating agency, as well as foreign operators who operate or plan to operate in the State. This guidance should address the planned evolution of navigation, as one of the key systems supporting air traffic management, and describe the RNAV and RNP navigation applications that should be implemented in at least the short and medium term, in the State.

### What are the objectives of the PBN Implementation Plan or Roadmap?

1.5 The PBN implementation plan should meet the following strategic objectives:

a) provide a high-level strategy for the evolution of the navigation applications to be implemented in the State in the short term (2008-2012) and medium term (2013-2016). This strategy is based on the concepts of PBN, Area Navigation (RNAV) and Required Navigation Performance (RNP), which 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 in accordance with the implementation goals in the Assembly resolution;

b) ensure that the implementation of the navigation portion of the CNS/ATM system is based on clearly established operational requirements;

c) avoid unnecessarily imposing the mandate for multiple equipment on board or multiple systems on the ground;

d) avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations;

e) prevent commercial interests from outdoing ATM operational requirements, generating unnecessary costs for the State as well as for airspace users.

**What is the intent of the PBN Implementation Plan or Roadmap?**

1.6 The PBN Implementation Plan should be developed by the State together with the stakeholders concerned 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 roadmap and should therefore be included in the development process are:

- Airspace operators and users
- Air navigation service providers
- Regulating agencies
- National and international organizations

1.7 The PBN Implementation 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 roadmap to plan 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 as well as the future regulatory workload and associated training requirements for their work force.

**What principles should be applied in development of the PBN Implementation Plan or Roadmap?**

1.8 The implementation of PBN in the State should be based on the following principles:

a) Continued application of conventional air navigation procedures during the transition period, to guarantee availability by users that are not RNAV- and/or RNP-equipped;

b) Development of airspace concepts, applying airspace modeling tools as well as real-time and accelerated simulations, which identify the navigation applications that are compatible with the aforementioned concept;

c) Conduct of cost-benefit analyses to justify the implementation of the RNAV and/or RNP concepts in each particular airspace;

d) Conduct of pre- and post-implementation safety assessments to ensure the application and maintenance of the established target levels of safety.

e) Must not conflict with the regional PBN implementation plan.

**Table of contents**

**MID State PBN Plan Template**

## 1. Introduction

The MID Region Performance Based Navigation (PBN) Roadmap details the framework within which the ICAO PBN concept will be implemented in the MID Region for the foreseeable future. The MID Region Roadmap for PBN is guided by ICAO Doc. 9613 and relevant SARPs. The primary driver for this plan is to maintain and increase safety, air traffic demand and capacity, and services and technology in consultation with relevant stakeholders. The MID Region Roadmap also supports national and international interoperability and global harmonization.

## 2. Background

The continuing growth of aviation places increasing demands on airspace capacity and emphasizes the need for the optimum utilization of the available airspace.

Growth in scheduled and General Aviation aircraft is expected to increase point-to-point and direct routings. The increasing cost of fuel also presents a significant challenge to all segments of the aviation community. This anticipated growth and higher complexity of the air transportation system could result in increased flight delays, schedule disruptions, choke points, inefficient flight operations, and passenger inconvenience, particularly when unpredictable weather and other factors constrain airport capacity. Without improvements in system efficiency and workforce productivity, the aviation community and cost of operations will continue to increase. Upgrades to the air transportation system must leverage current and evolving capabilities in the near term, while building the foundation to address the future needs of the aviation community stakeholders. These circumstances can be partially alleviated by efficiencies in airspace and procedures through the implementation of PBN concepts.

In setting out requirements for navigation applications on specific routes or within a specific airspace, it is necessary to define requirements in a clear and concise manner. This is to ensure that both flight crew and ATC are aware of the on-board area navigation (RNAV) system capabilities and to ensure that the performance of the RNAV system is appropriate for the specific airspace requirements.

The early use of RNAV systems arose in a manner similar to conventional ground-based routes and procedures. A specific RNAV system was identified and its performance was evaluated through a combination of analysis and flight testing. For domestic operations the initial systems used VOR and DME for their position estimation. For oceanic operations, inertial navigation systems (INS) were employed.

These ‘new’ systems were developed, evaluated and certified. Airspace and obstacle clearance criteria were developed on the basis of available equipment performance. Requirements specifications were based upon available capabilities and, in some implementations, it was necessary to identify the individual models of equipment that could be operated within the airspace concerned.

Such prescriptive requirements result in delays to the introduction of new RNAV system capabilities and higher costs for maintaining appropriate certification. To avoid such prescriptive specifications of requirements, the PBN concept introduces an alternative method for defining equipage requirements by specification of the performance requirements. This is termed Performance Based Navigation (PBN).

## 3. Performance Based Navigation (PBN)

Performance based navigation (PBN) is a concept that encompasses both area navigation (RNAV) and required navigation performance (RNP) and revises the current RNP concept. Performance based navigation is increasingly seen as the most practical solution for regulating the expanding domain of navigation systems.

Under the traditional approach, each new technology is associated with a range of system-specific requirements for obstacle clearance, aircraft separation, operational aspects (e.g. arrival and approach procedures), aircrew operational training and training of air traffic controllers. However, this system-specific approach imposes an unnecessary effort and expense on States, airlines and air navigation services (ANS) providers.

Performance based navigation eliminates the need for redundant investment in developing criteria and in operational modifications and training. Rather than build an operation around a particular system, under performance based navigation the operation is defined according to the operational goals, and the available systems are then evaluated to determine whether they are supportive.

The advantage of this approach is that it provides clear, standardized operational approvals which enables harmonized and predictable flight paths which result in more efficient use of existing aircraft capabilities, as well as improved safety, greater airspace capacity, better fuel efficiency, and resolution of environmental issues.

The PBN concept specifies aircraft RNAV 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. 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.

Under PBN, generic navigation requirements are defined based on the operational requirements. Operators are then able to evaluate options in respect of available technologies and navigation services that could allow these requirements to be met. The chosen solution would be the most cost effective for the operator, rather than a solution being imposed as part of the operational requirements. Technologies can evolve over time without requiring the operation itself to be revisited, as long as the requisite performance is provided by the RNAV system. As part of the future work of the ICAO, it is anticipated that other means for meeting the requirements of the Navigation Specifications will be evaluated and may be included in the applicable Navigation Specifications, as appropriate.

ICAO's Performance Based Navigation (PBN) concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use worldwide. It is a new concept based on the use of Area Navigation (RNAV) systems. Significantly, it is a move from a limited State ment of required performance accuracy to more extensive State ments for required performance in terms of accuracy, integrity, continuity and availability, together with descriptions of how this performance is to be achieved in terms of aircraft and flight crew requirements.

### 3.1. RNAV Current status in [EGYPT]

#### 3.1.1 RNAV, ATS routes, SIDs, STARs and approaches for 13 aerodromes

#### 3.1.2 Fleet equipage

(To be developed )

### 3.2 Benefits of PBN and global harmonization

PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. These include:

- Reduces need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.
- Avoids need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.
- Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).
- Clarifies the way in which RNAV systems are used.
- Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects. Specifically, RNAV and RNP may:

- Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.
- Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.
- Improve efficiency and flexibility by increasing use of operator-preferred trajectories airspace-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.
- Reduce workload and improve productivity of air traffic controllers.

Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of aviation stakeholders and service providers.

### 3.3 Stakeholders

Coordination is critical with the aviation community through collaborative forums. This will assist aviation stakeholders in understanding operational goals, determining requirements, and considering future investment strategies. This, in turn, enables the aviation stakeholders to focus on addressing future efficiency and capacity needs while maintaining or improving the safety of flight operations by leveraging advances in navigation capabilities on the flight deck. RNAV and RNP have reached a sufficient level of maturity and definition to be included in key plans and strategies, such as this State PBN plan.

The stakeholders who will benefit from the concepts in this State PBN plan include airspace operators, air traffic service providers, regulators, and standards organizations. As driven by business needs, airlines and operators can use the State PBN roadmap to plan future equipage and capability investments. Similarly, air traffic service providers can determine requirements for future automation systems, and more smoothly modernize ground infrastructure. Finally, regulators and standards organizations can anticipate and develop the key enabling criteria needed for implementation.

This plan is a work in progress and will be amended through collaborative MID Region States, industry efforts and consultations that establish a joint aviation community/government/industry strategy for implementing performance-based navigation. Critical initiative strategies are required to accommodate the expected growth and complexity over the next two decades. These strategies have five key features:

- Expediting the development of performance-based navigation criteria and standards.
- Introducing airspace and procedure improvements in the near term.
- Providing benefits to operators who have invested in existing and upcoming capabilities.
- Establishing target dates for the introduction of navigation mandates for selected procedures and airspace, with an understanding that any mandate must be rationalized on the basis of benefits and costs.
- Defining new concepts and applications of performance-based navigation for the mid term and Long term and building synergy and integration among other capabilities toward the realization of the MID Region PBN goals.

## 4. Challenges

### 4.1 Increasing Demands

- Traffic projection (scheduled, non-scheduled, GA)
- New aerodromes

#### 4.1.1 En route

##### 4.1.1.1 Oceanic and Remote Continental

(N/A)

##### 4.1.1.2 Continental

(RNAV-5 )

#### 4.1.2 Terminal Areas (Departures and Arrivals)

(RNAV-1 in surveillance environment and with adequate navigation infrastructure.)

#### 4.1.3 Approach

(RNP APCH with Baro-VNAV in most possible airports;)

### 4.2 Efficient Operations

#### 4.2.1 En route

##### 4.2.1.1 Oceanic and remote continental

(N/A )

##### 4.2.1.2 Continental

- Optimization of traffic routes by made them routes as direct as possible

#### 4.2.2 Terminal Areas

- Provides an efficient link to the TMA and en-route structure.
- Provide for increase operations in a single runway environment.
- Reduced ATC controller workload.

#### 4.2.3 Approach

- Provides an efficient link to the TMA and en-route structure.
- Provide for increase operations in a single runway environment.
- Reduced ATC controller workload.
- Better Aerodrome operating minim
- Redundancy to landing navigation aids

### 4.3 Environment

**Implement recommendations of the ongoing environment study.**

## 5. Implementation strategy

This plan provides a high-level strategy for the evolution of navigation capabilities to be implemented in three timeframes: near term (2008-2012), mid term (2013-2016), and Long term (2017 and Beyond). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en-route continental, oceanic and remote operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.

To avoid proliferation of new navigation standards, [EGYPT] and other aviation stakeholders in the MID region should communicate any new operational requirements with ICAO HQ, so that it can be taken into account by the ICAO Study Group in charge of PBN.

**Near Term (2008-2012) Mid Term (2013-2016) and Long Term (2017 and Beyond) Key Tasks**

The key tasks involved in the transition to performance-based navigation are:

- Establish navigation service needs through the Long term that will guide infrastructure decisions and specify needs for navigation system infrastructure, and ensure funding for managing and transitioning these systems.
- Define and adopt a national policy enabling additional benefits based on RNP and RNAV.
- Identify operational and integration issues between navigation and surveillance, air-ground communications, and automation tools that maximize the benefits of RNP.
- Support mixed operations throughout the term of this Roadmap, in particular considering navigation system variations during the near term until appropriate standards are developed and implemented.
- To support Civil/Military coordination and develop the policies needed to accommodate the unique missions and capabilities of military aircraft operating in civil airspace.
- Harmonize the evolution of capabilities for interoperability across airspace operations.
- Increase emphasis on human factors, especially on training and procedures as operations increase reliance on appropriate use of flight deck systems.
- Facilitate and advance environmental analysis efforts required to support the development of RNAV and RNP procedures.
- Maintain consistent and harmonized global standards for RNAV and RNP operations.

**5.2 Near term strategy (2008-2012)**

In the near-term, initiatives focus on investments by operators in current and new aircraft acquisitions, in satellite-based navigation and conventional navigation infrastructure as well as [EGYPT] investments. Key components include wide-scale RNAV implementation and the introduction of RNP for en route, terminal, and approach procedures.

The near-term strategy will also focus on expediting the implementation and proliferation of RNAV and RNP procedures. As demand for air travel continues at healthy levels, choke points will develop and delays at the major airports will continue to climb. RNAV and RNP procedures will help alleviate those problems. Continued introduction of RNAV and RNP procedures will not only provide benefits and savings to the operators but also encourage further equipage.

ANSPs as a matter of urgency must adapt new flight plan procedures to accommodate PBN operations. This particularly addresses fields 10 and 18.

Operators will need to plan to obtain operational approvals for the planned Navigation Specifications for this period. Operators shall also review Regional PBN Implementation Plans from other Regions to assess if there is a necessity for additional Operational approvals.

### 5.2.1 En route

#### 5.2.1.1 Oceanic and Remote Continental

To promote global harmonization, [ EGYPT] continues to work closely with its international partners in implementing RNAV–10 and where operationally required RNP-4 by 2010. Safety assessment shall be undertaken to evaluate reduced oceanic and remote longitudinal/lateral separation minima between aircraft approved for RNAV-10 and RNP-4 operations.

For Oceanic and Remote Areas where high density traffic operations occur, a review of the airspace concept must be undertaken to convert to Continental En-Route Operation where sufficient, surveillance is available so as to allow RNAV-5 operations.

#### 5.2.1.2 Continental

For airspace and corridors requiring structured routes for flow management, [EGYPT] will review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV-2/1.

### 5.2.2 Terminal Areas (Departures and Arrivals)

RNAV reduces conflict between traffic flows by consolidating flight tracks. RNAV-1/Basic RNP-1 SIDs and STARs improve safety, capacity, and flight efficiency and also lower communication errors.

[EGYPT] will continue to plan, develop and implement RNAV-1 SIDs and STARs, at major airports and make associated changes in airspace design. In addition, [EGYPT] will implement Basic RNP-1 SIDs and STARs. RNAV-1 will be implemented in airspace where there is sufficient surveillance coverage and Basic RNP-1 where there is no such coverage.

Where operationally feasible, [EGYPT] should develop operational concepts and requirements for continuous descent arrivals (CDAs) based on FMS Vertical Guidance and for applying time of arrival control based on RNAV and RNP procedures. This would reduce workload for pilots and controllers as well as increase fuel efficiency.

PBN SIDs and STARS would allow the following:

- Reduction in controller-pilot communications;
- Reduction of route lengths to meet environmental and fuel efficiency requirements;.
- Seamless transition from and to en-route entry/exit points;
- Sequence departures to maximize benefits of RNAV and identify automation requirements for traffic flow management, sequencing tools, flight plan processing, and tower data entry activities.

### 5.2.3 Approach

The application of RNP APCH is expected to be implemented in the maximum possible number of aerodromes. To facilitate a transitional period, conventional approach procedures and conventional navigation aids should be maintained for non PBN equipped aircraft during this term.

[EGYPT] should promote the use of APV Operations (Baro-VNAV or SBAS) to enhance safety of RNP Approaches and accessibility of runways.

The application of RNP AR Approach should be limited to selected runways where obvious operational benefits can be obtained due to the existence of significant obstacles.

RNP approaches include:

- APV implemented at all instrument runways at major regional airports and all non-instrument runways serving aircraft weighing greater than 5,700kg.

### 5.2.5 Summary near term strategy

| Airspace | Nav. Specifications | Nav. Specifications where operationally required |
|---|---|---|
| En-Route Oceanic | N/A | N/A |
| En-Route Remote Continental | N/A | N/A |
| En-Route Continental | RNAV-5 | RNAV-1 |
| TMA Arrival/Departure | RNAV-1 in a surveillance environment | |
| Approach | RNP APCH with Baro-VNAV | |

### 1.9 Implementation Targets

- RNP APCH (with Baro-VNAV) in 30% of instrument runways by 2010 and 50% by 2012 and priority given to airports with operational benefits
- RNAV-1 SID/STAR for 30% of international airports by 2010 and 50% by 2012 and priority given to airports with RNP Approach
- Review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV-2/1 by 2012.

### 5.3 Medium term strategy (2013-2016)

In the mid term, increasing demand for air travel will continue to challenge the efficiencies of the air traffic management system.

While the hub-and-spoke system will remain largely the same as today for major airline operations, the demand for more point-to-point service will create new markets and spur increases in low-cost carriers, air taxi operations, and on-demand services. Additionally, the emergence of VLJs is expected to create new markets in the general and business aviation sectors for personal, air taxi, and point-to-point passenger operations. Many airports will thus experience significant increases in unscheduled traffic. In addition, many destination airports that support scheduled air carrier traffic are forecast to grow and to experience congestion or delays if efforts to increase their capacity fall short. As a result, additional airspace flexibility will be necessary to accommodate not only the increasing growth, but also the increasing air traffic complexity.

The mid term will leverage these increasing flight capabilities based on RNAV and RNP, with a commensurate increase in benefits such as fuel-efficient flight profiles, better access to airspace and airports, greater capacity, and reduced delay. These incentives, which should provide an advantage over non-RNP operations, will expedite propagation of equipage and the use of RNP procedures.

To achieve efficiency and capacity gains partially enabled by RNAV and RNP, [EGYPT] and aviation industry will pursue use of data communications (e.g., for controller-pilot communications) and enhanced surveillance functionality, e.g. ADS-Broadcast (ADS-B). Data communications will make it possible to issue complex clearances easily and with minimal errors. ADS-B will expand or augment surveillance coverage so that track spacing and longitudinal separation can be optimized where needed (e.g., in non-radar airspace). Initial capabilities for flights to receive and confirm 3D clearances and time of arrival control based on RNP will be demonstrated in the mid term. With data link implemented, flights will begin to transmit 4D trajectories (a set of points defined by latitude, longitude, altitude, and time.) Stakeholders must therefore develop concepts that leverage this capability.

### 5.3.1 En route

#### 5.3.1.1 Oceanic and Remote Continental

In the mid term, [EGYPT] will endeavour to work with international air traffic service providers to promote the application of RNP 10 and RNP 4 in additional sub-regions of the oceanic environment.

#### 5.3.1.2 Continental

The review of en-route airspace will be completed by 2016.

**Implementation**

By the end of the mid term other benefits of PBN will have been enabled, such as flexible procedures to manage the mix of faster and slower aircraft in congested airspace and use of less conservative PBN requirements.

**Automation for RNAV and RNP Operations**

By the end of the mid term enhanced en route automation will allow the assignment of RNAV and RNP routes based upon specific knowledge of an aircraft's RNP capabilities. En route automation will use collaborative routing tools to assign aircraft priority, since the automation system can rely upon the aircraft's ability to change a flight path and fly safely around problem areas. This functionality will enable the controller to recognize aircraft capability and to match the aircraft to dynamic routes or procedures, thereby helping appropriately equipped operators to maximize the predictability of their schedules.

Conflict prediction and resolution in most en route airspace must improve as airspace usage increases. Path repeatability achieved by RNAV and RNP operations will assist in achieving this goal. Mid-term automation tools will facilitate the introduction of RNP offsets and other forms of dynamic tracks for maximizing the capacity of airspace. By the end of the mid term, en route automation will have evolved to incorporate more accurate and frequent surveillance reports through ADS-B, and to execute problem prediction and conformance checks that enable offset manoeuvres and closer route spacing (e.g., for passing other aircraft and manoeuvring around weather).

### 5.3.2 Terminal Areas (Departures and Arrivals)

During this period, either Basic RNP-1 or RNAV-1 will become a required capability for flights arriving and departing major airports based upon the needs of the airspace, such as the volume of traffic and complexity of operations. This will ensure the necessary throughput and access, as well as reduced controller workload, while maintaining safety standards.

With RNAV-1 operations as the predominant form of navigation in terminal areas by the end of the mid term, MID [EGYPT] will have the option of removing conventional terminal procedures that are no longer expected to be used.

**Terminal Automation**

Terminal automation will be enhanced with tactical controller tools to manage complex merges in busy terminal areas. As data communications become available, the controller tools will apply knowledge of flights' estimates of time of arrival at upcoming waypoints, and altitude and speed constraints, to create efficient maneuvres for optimal throughput.

Terminal automation will also sequence flights departing busy airports more efficiently than today. This capability will be enabled as a result of PBN and flow management tools. Flights arriving and departing busy terminal areas will follow automation-assigned PBN routes.

### 5.3.3 Approach

In the mid term, implementation priorities for instrument approaches will still be based on RNP APCH and RNP AR APCH and full implementation is expected at the end of this term.

The introduction of the application of landing capability, using GBAS (currently non PBN) is expected to guarantee a smooth transition towards high performance approach and landing capability.

### 5.3.4 Helicopter operations (NOT YET)

### 5.3.5 Medium term strategy summary

| **Airspace** | **Nav. Specifications** | **Nav. Specifications where operationally required** |
|---|---|---|
| En-Route Oceanic | RNAV-10, | RNP-4 |
| En-Route Remote Continental | RNAV-10, | RNP-4 |
| En-Route Continental | RNAV-2, RNAV-5 | RNAV-1 |
| TMA Arrival/Departure | Expand RNAV-1, or basic RNP-1 application<br><br>Mandate RNAV-1, or basic RNP-1 | |
| Approach | Expand RNP APCH with (Baro-VNAV) and APV<br><br>Expand RNP AR APCH where there are operational benefits | |

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 as required

### 5.4 Long term strategy (2017 and beyond)

The Long-term environment will be characterized by continued growth in air travel and increased air traffic complexity.

No one solution or simple combination of solutions will address the inefficiencies, delays, and congestion anticipated to result from the growing demand for air transportation. Therefore, [EGYPT] and key Stakeholders need an operational concept that exploits the full capability of the aircraft in this time frame.

### 5.4.1 Long Term Key Strategies (2017 and Beyond)

Airspace operations in the Long term will make maximum use of advanced flight deck automation that integrates CNS capabilities. RNP, RCP, and RSP standards will define these operations. Separation assurance will remain the principal task of air traffic management in this time frame. This task is expected to leverage a combination of aircraft and ground-based tools. Tools for conflict detection and resolution, and for flow management, will be enhanced significantly to handle increasing traffic levels and complexity in an efficient and strategic manner.

Strategic problem detection and resolution will result from better knowledge of aircraft position and intent, coupled with automated, ground-based problem resolution. In addition, pilot and air traffic controller workload will be lowered by substantially reducing voice communication of clearances, and furthermore using data communications for clearances to the flight deck. Workload will also decrease as the result of automated confirmation (via data communications) of flight intent from the flight deck to the ground automation.

With the necessary aircraft capabilities, procedures, and training in place, it will become possible in certain situations to delegate separation tasks to pilots and to flight deck systems that depict traffic and conflict resolutions. Procedures for airborne separation assurance will reduce reliance on ground infrastructure and minimize controller workload. As an example, in IMC an aircraft could be instructed to follow a leading aircraft, keeping a certain distance. Once the pilot agreed, ATC would transfer responsibility for maintaining spacing (as is now done with visual approaches).

Performance-based operations will exploit aircraft capabilities for “electronic” visual acquisition of the external environment in low-visibility conditions, which may potentially increase runway capacity and decrease runway occupancy times.

Improved wake prediction and notification technologies may also assist in achieving increased runway capacity by reducing reliance on wake separation buffers.

System-wide information exchange will enable real-time data sharing of NAS constraints, airport and airspace capacity, and aircraft performance. Electronic data communications between the ATC automation and aircraft, achieved through data link, will become widespread—possibly even mandated in the busiest airspace and airports. The direct exchange of data between the ATC automation and the aircraft FMS will permit better strategic and tactical management of flight operations.

Aircraft will downlink to the ground-based system their position and intent data, as well as speed, weight, climb and descent rates, and wind or turbulence reports. The ATC automation will uplink clearances and other types of information, for example, weather, metering, choke points, and airspace use restrictions.

To ensure predictability and integrity of aircraft flight path, RNP will be mandated in busy en route and terminal airspace. RNAV operations will be required in all other airspace (except oceanic). Achieving standardized FMS functionalities and consistent levels of crew operation of the FMS is integral to the success of this Long-term strategy.

The most capable aircraft will meet requirements for low values of RNP (RNP 0.3 or lower en route). Flights by such aircraft are expected to benefit in terms of airport access, shortest routes during IMC or convective weather, and the ability to transit or avoid constrained airspace, resulting in greater efficiencies and fewer delays operating into and out of the busiest airports.

Enhanced ground-based automation and use of real-time flight intent will make time-based metering to terminal airspace a key feature of future flow management initiatives. This will improve the sequencing and spacing of flights and the efficiency of terminal operations.

Uniform use of RNP for arrivals and departures at busy airports will optimize management of traffic and merging streams. ATC will continue to maintain control over sequencing and separation; however, aircraft arriving and departing the busiest airports will require little controller intervention. Controllers will spend more time monitoring flows and will intervene only as needed, primarily when conflict prediction algorithms indicate a potential problem.

More detailed knowledge of meteorological conditions will enable better flight path conformance, including time of arrival control at key merge points. RNP will also improve management of terminal arrival and departure with seamless routing from the en route and transition segments to the runway threshold. Enhanced tools for surface movement will provide management capabilities that synchronize aircraft movement on the ground; for example, to coordinate taxiing aircraft across active runways and to improve the delivery of aircraft from the parking areas to the main taxiways.

### 5.4.2 Summary of Long Term Key Strategies (2017 and Beyond)

The key strategies for instituting performance-based operations employ an integrated set of solutions.

- Airspace operations will take advantage of aircraft capabilities, i.e. aircraft equipped with data communications, integrated displays, and FMS.
- Aircraft position and intent information directed to automated, ground-based ATM systems, strategic and tactical flight deck-based separation assurance in selected situations (problem detection and resolution).
- Strategic and tactical flow management will improve through use of integrated airborne and ground information exchange.
- Ground-based system knowledge of real-time aircraft intent with accurate aircraft position and trajectory information available through data link to ground automation.
- Real-time sharing of National Air Space (NAS) flight demand and other information achieved via ground-based and air-ground communication between air traffic management and operations planning and dispatch.
- Overall system responsiveness achieved through flexible routing and well-informed, distributed decision-making.
- Systems ability to adapt rapidly to changing meteorological and airspace conditions.
- System leverages through advanced navigation capabilities such as fixed radius transitions, RF legs, and RNP offsets.
- Increased use of operator-preferred routing and dynamic airspace.
- Increased collaboration between service providers and operators.

Operations at the busiest airports will be optimized through an integrated set of capabilities for managing pre-departure planning information, ground-based automation, and surface movement.

- RNP-based arrival and departure structure for greater predictability.
- Ground-based tactical merging capabilities in terminal airspace.
- Integrated capabilities for surface movement optimization to synchronize aircraft movement on the ground. Improved meteorological and aircraft intent information shared via data link.

### 5.4.3 Key Research Areas

The aviation community must address several key research issues to apply these strategies effectively. These issues fall into several categories:

**Navigation**

- To what extent can lower RNP values be achieved and how can these be leveraged for increased flight efficiency and access benefits?
- Under what circumstances RNAV should be mandated for arriving/departing satellite airports to enable conflict-free flows and optimal throughput in busy terminal areas?

**Flight Deck Automation**

- What FMS capabilities are required to enable the future concepts and applications?
- How can performance-based communication and surveillance be leveraged in the flight deck to enable Long-term strategies such as real-time exchange of flight deck data?

**Automation**

- To what extent can lateral or longitudinal separation assurance be fully automated, in particular on final approach during parallel operations?
- To what extent can surface movement be automated, and what are the cost-benefit trade-offs associated with different levels of automation?
- To what extent can conflict detection and resolution be automated for terminal ATC operations?

**Procedures**

- How can time of arrival control be applied effectively to maximize capacity of arrival or departure operations, in particular during challenging wind conditions?
- In what situations is delegation of separation to the flight crews appropriate?
- What level of onboard functionality is required for flight crews to accept separation responsibility within a manageable workload level?

**Airspace**

- To what extent can airspace be configured dynamically on the basis of predicted traffic demand and other factors?
- What separation standards and procedures are needed to enable smoother transition between en route and terminal operations?
- How can fuel-efficient procedures such as CDAs be accomplished in busy airspace?

**Glossary**

| | |
|---|---|
| 3D | Three-Dimensional |
| 4D | Four-Dimensional |
| ADS-B | Automatic Dependent Surveillance-Broadcast |
| ADS-C | Automatic Dependent Surveillance-Contract |
| ATC | Air Traffic Control |
| CDA | Continuous Descent Arrival |
| CNS | Communications, Navigation, Surveillance |
| EFVS | Enhanced Flight Visibility System |
| GA | General Aviation |
| GBAS | Ground-Based Augmentation System |
| GLS | GNSS (Global Navigation Satellite System) Landing System |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| ICAO | International Civil Aviation Organization |

| | |
|---|---|
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| LNAV | Lateral Navigation |
| LPV | Localizer Performance with Vertical Guidance |
| NAS | National Airspace System |
| NAVAID | Navigation Aid |
| NM | Nautical Miles |
| PBN | Performance Based Navigation |
| RCP | Required Communications Performance |
| RF | Radius-to-Fix |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RNPSORSG | Required Navigation Performance and Special Operational Requirements Study Group |
| RSP | Required Surveillance Performance |

| | |
|---|---|
| SAAAR | Special Aircraft and Aircrew Authorization Required |
| SID | Standard Instrument Departure |
| STAR | Standard Instrument Arrival |
| VLJ | Very Light Jet |
| VNAV | Vertical Navigation |
| WAAS | Wide Area Augmentation System |

**Appendix A – Oceanic and Remote Continental implementation schedule by area or city pair** (to be developed by State )

**Appendix B – En route continental implementation schedule by area or city pair** (to be developed by State )

**Appendix C – Terminal area and approach implementation schedule by aerodrome** (to be developed by State)

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# PERFORMANCE BASED NAVIGATION (PBN) IMPLEMENTATION PLAN

## *I.R. OF IRAN (Draft)*

## Version 1.0



October 2009

## Document change record

| Version | Issue Date | Author | Change description |
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## Document Approval

| Title | Name | Date | Signature |
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## About the Plan

### Requirement for PBN

ICAO Assembly Resolution A36-23 calls for each State to develop a national PBN implementation plan by October 2009. By elaborating this plan, *I.R. of IRAN* wants to meet the intent of the resolution and to show his engagement (commitment) for the implementation of PBN.

Why is a PBN implementation plan needed?

With RVSM implemented in most of the world, the main tool for optimizing the airspace structure is the implementation of performance-based navigation (PBN), which will foster the necessary conditions for the utilization of RNAV and RNP capabilities by a significant portion of airspace users in the Regions and States.

Current planning by the Regional Planning and Implementation Groups is based on the Air Navigation Plans and the Regional CNS/ATM Plans. Currently, these plans are mostly made up of tables that do not contain the necessary details for the implementation of each of the CNS and ATM elements. For this reason, the Regions will be developing Regional PBN implementation plans. The aim of this national implementation PBN plan is to implement the *MID* regional plan at the State level and address PBN implementation strategy at the national level.

The national PBN implementation plan wants also to provide proper guidance and direction to the air navigation service provider(s), airspace operators and users, regulating agency, as well as foreign operators who operate or plan to operate in *I.R. of IRAN*. This plan will address the planned evolution of navigation, as one of the key systems supporting air traffic management, and describe the RNAV and RNP navigation applications that will be implemented in at least the short and medium term, in *I.R. of IRAN*.

### What are the objectives of the PBN Implementation Plan?

The PBN implementation plan meets the following strategic objectives:

a) provide a high-level strategy for the evolution of the navigation applications to be implemented in *I.R. of IRAN* in the short term (2010-2012) and medium term (2013-2016). This strategy is based on the concepts of PBN, Area Navigation (RNAV) and Required Navigation Performance (RNP), which will be applied to aircraft operations involving instrument approaches, standard departure (SID) routes, standard arrival (STAR) routes, and ATS routes in continental areas in accordance with the implementation goals in the Assembly resolution;

b) ensure that the implementation of the navigation portion of the CNS/ATM system is based on clearly established operational requirements;

c) avoid unnecessarily imposing the mandate for multiple equipment on board or multiple systems on the ground;

d) avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations;

e) prevent commercial interests from outdoing ATM operational requirements, generating unnecessary costs for *I.R. of IRAN* as well as for airspace users.

### What is the intent of the PBN Implementation Plan?

The PBN Implementation Plan will be developed by *I.R. of IRAN* Civil Aviation Authority together with the stakeholders concerned. The main stakeholders of the aviation community that benefit from this roadmap and are therefore included in the development process are:

- Airlines (IranAir, MahanAir, KishAir, ASEMAN AirLine, … )
- Air navigation service providers (Iranian Airport Company(IAC))

•Regulating agencies (Civil Aviation Organization (CAO))

• National and international organizations

The PBN Implementation Plan is intended to assist those stakeholders of the aviation community plan a gradual transition to the RNAV and RNP concepts and their investment strategies.

Airlines and operators will use this roadmap to plan future equipage and additional navigation capability investments;

Air navigation service providers will plan a gradual transition for the evolving ground infrastructure.

The Ministry of transport and the *I.R. of IRAN* Civil Aviation Authority will anticipate and plan for the criteria that will be needed in the future as well as the future regulatory workload and associated training requirements for their work force.

## What principles should be applied in development of the PBN Implementation Plan?

The implementation of PBN in Cameroun is based on the following principles:

a) Continued application of conventional air navigation procedures during the transition period, to guarantee availability by users that are not RNAV- and/or RNP-equipped;

b) Development of airspace concepts, applying airspace modeling tools as well as real-time and accelerated simulations, which identify the navigation applications that are compatible with the aforementioned concept;

c) Conduct of cost-benefit analyses to justify the implementation of the RNAV and/or RNP concepts in each particular airspace;

d) Conduct of pre- and post-implementation safety assessments to ensure the application and maintenance of the established target levels of safety.

e) Must not conflict with the *MID* regional PBN implementation plan.

## Table of contents

## 1. Introduction

The *MID* Region Performance Based Navigation (PBN) Roadmap details the framework within which the ICAO PBN concept will be implemented in the *MID* Region for the foreseeable future. The *MID* Region Roadmap for PBN is guided by ICAO Doc. 9613 and relevant SARPs. The primary driver for this plan is to maintain and increase safety, air traffic demand and capacity, and services and technology in consultation with relevant stakeholders. The *MID* Region Roadmap also supports national and international interoperability and global harmonization.

## 2. Background

The continuing growth of aviation places increasing demands on airspace capacity and emphasizes the need for the optimum utilization of the available airspace.

Growth in scheduled and General Aviation aircraft is expected to increase point-to-point and direct routings. The increasing cost of fuel also presents a significant challenge to all segments of the aviation community. This anticipated growth and higher complexity of the air transportation system could result in increased flight delays, schedule disruptions, choke points, inefficient flight operations, and passenger inconvenience, particularly when unpredictable weather and other factors constrain airport capacity. Without improvements in system efficiency and workforce productivity, the aviation community and cost of operations will continue to increase. Upgrades to the air transportation system must leverage current and evolving capabilities in the near term, while building the foundation to address the future needs of the aviation community stakeholders. These circumstances can be partially alleviated by efficiencies in airspace and procedures through the implementation of PBN concepts.

In setting out requirements for navigation applications on specific routes or within a specific airspace, it is necessary to define requirements in a clear and concise manner. This is to ensure that both flight crew and ATC are aware of the on-board area navigation (RNAV) system capabilities and to ensure that the performance of the RNAV system is appropriate for the specific airspace requirements.

The early use of RNAV systems arose in a manner similar to conventional ground-based routes and procedures. A specific RNAV system was identified and its performance was evaluated through a combination of analysis and flight testing. For domestic operations the initial systems used VOR and DME for their position estimation. For oceanic operations, inertial navigation systems (INS) were employed.

These 'new' systems were developed, evaluated and certified. Airspace and obstacle clearance criteria were developed on the basis of available equipment performance. Requirements specifications were based upon available capabilities and, in some implementations, it was necessary to identify the individual models of equipment that could be operated within the airspace concerned.

Such prescriptive requirements result in delays to the introduction of new RNAV system capabilities and higher costs for maintaining appropriate certification. To avoid such prescriptive specifications of requirements, the PBN concept introduces an alternative method for defining equipage requirements by specification of the performance requirements. This is termed Performance Based Navigation (PBN).

## 3. Performance Based Navigation (PBN)

Performance based navigation (PBN) is a concept that encompasses both area navigation (RNAV) and required navigation performance (RNP) and revises the current RNP concept. Performance based navigation is increasingly seen as the most practical solution for regulating the expanding domain of navigation systems.

Under the traditional approach, each new technology is associated with a range of system-specific requirements for obstacle clearance, aircraft separation, operational aspects (e.g. arrival and approach procedures), aircrew operational training and training of air traffic controllers. However, this system-specific approach imposes an unnecessary effort and expense on States, airlines and air navigation services (ANS) providers.

Performance based navigation eliminates the need for redundant investment in developing criteria and in operational modifications and training. Rather than build an operation around a particular system, under performance based navigation the operation is defined according to the operational goals, and the available systems are then evaluated to determine whether they are supportive.

The advantage of this approach is that it provides clear, standardized, operational approvals which enables harmonized and predictable flight paths which result in more efficient use of existing aircraft capabilities, as well as improved safety, greater airspace capacity, better fuel efficiency, and resolution of environmental issues.

The PBN concept specifies aircraft RNAV 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. 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.

Under PBN, generic navigation requirements are defined based on the operational requirements. Operators are then able to evaluate options in respect of available technologies and navigation services that could allow these requirements to be met. The chosen solution would be the most cost effective for the operator, rather than a solution being imposed as part of the operational requirements. Technologies can evolve over time without requiring the operation itself to be revisited, as long as the requisite performance is provided by the RNAV system. As part of the future work of the ICAO, it is anticipated that other means for meeting the requirements of the Navigation Specifications will be evaluated and may be included in the applicable Navigation Specifications, as appropriate.

ICAO’s Performance Based Navigation (PBN) concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use worldwide. It is a new concept based on the use of Area Navigation (RNAV) systems. Significantly, it is a move from a limited statement of required performance accuracy to more extensive statements for required performance in terms of accuracy, integrity, continuity and availability, together with descriptions of how this performance is to be achieved in terms of aircraft and flight crew requirements.

### 3.1. RNAV Current status in *I.R. of IRAN*

#### 3.1.1 RNAV, ATS routes, SIDs, STARs and approaches

Nil

### 3.1.2 User equipage in *I.R. of IRAN* airspace excluding overfly

a) Aircrafts registered in *I.R. of IRAN*
To be Developed

| Manufacturer & Type | Variant | Registration. No. | Build Year | Operator |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
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| | | | | |
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| | | | | |

b) Aircrafts landing in *I.R. of IRAN*
(to be completed)

## 3.2 Benefits of PBN and global harmonization

PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. These include:

- Reduces need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.
- Avoids need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.
- Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).
- Clarifies the way in which RNAV systems are used.
- Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects. Specifically, RNAV and RNP may:

- Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.
- Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.

- Improve efficiency and flexibility by increasing use of operator-preferred trajectories airspace-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.
- Reduce workload and improve productivity of air traffic controllers.

Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of aviation stakeholders and service providers.

## 3.3 Stakeholders

Coordination is critical with the aviation community through collaborative forums. This will assist aviation stakeholders in understanding operational goals, determining requirements, and considering future investment strategies. This, in turn, enables the aviation stakeholders to focus on addressing future efficiency and capacity needs while maintaining or improving the safety of flight operations by leveraging advances in navigation capabilities on the flight deck. RNAV and RNP have reached a sufficient level of maturity and definition to be included in key plans and strategies, such as this State PBN plan.

The stakeholders who will benefit from the concepts in this State PBN plan include airspace operators, air traffic service providers, regulators, and standards organizations. As driven by business needs, airlines and operators can use the State PBN roadmap to plan future equipage and capability investments. Similarly, air traffic service providers can determine requirements for future automation systems, and more smoothly modernize ground infrastructure. Finally, regulators and standards organizations can anticipate and develop the key enabling criteria needed for implementation.

This plan is a work in progress and will be amended through collaborative *MID* Region States, industry efforts and consultations that establish a joint aviation community/government/industry strategy for implementing performance-based navigation. Critical initiative strategies are required to accommodate the expected growth and complexity over the next two decades. These strategies have five key features:

- Expediting the development of performance-based navigation criteria and standards.
- Introducing airspace and procedure improvements in the near term.
- Providing benefits to operators who have invested in existing and upcoming capabilities.
- Establishing target dates for the introduction of navigation mandates for selected procedures and airspace, with an understanding that any mandate must be rationalized on the basis of benefits and costs.
- Defining new concepts and applications of performance-based navigation for the mid term and Long term and building synergy and integration among other capabilities toward the realization of the *MID* Region PBN goals.

# 4. Challenges

## 4.1 Increasing Demands

- Because of increasing Demands, All IRANIAN Air career operator are planning expanding their fleet by 2011.
- Traffic projection (scheduled, non-scheduled, GA)

etc….

## 4.2 Efficient Operations

### 4.2.1 En route (continental)

- RNAV 5 Will be provided ti Optimizing of traffic routes by made them routes as direct as possible

### 4.2.2 Terminal Areas (Departures and Arrivals)

RNAV 1 /Basic RNP 1

- Provides an efficient link to the TMA and en-route structure.
- Provide for increase operations in a single runway environment.
- Reduced ATC controller workload.
- Controlled paths to and from

### 4.2.3 Approach

RNP APCH With Baro-VNAV

- Provides an efficient link to the TMA and en-route structure.
- Provide for increase operations in a single runway environment.
- Reduced ATC controller workload.
- Better Aerodrome operating minim
- Redundancy to landing navigation aids

- Vertical guided approach for 5 Airport :
- OIIE RWY 29
- OIII RWY 29 L/R
- OISS RWY 29 L/R
- OIMM RWY 31 L/R
- OIFM 26 L/R

## 4.3 Environment

- Implement recommendations of the ongoing environment study.

# 5. Implementation strategy

Education seminar will be arranged by C.A.O for all stakeholders.

This plan provides a high-level strategy for the evolution of navigation capabilities to be implemented in three timeframes: near term (2008-2012), mid term (2013-2016), and Long term (2017 and Beyond). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en-route continental, oceanic and remote operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.

To avoid proliferation of new navigation standards, *I.R. of IRAN* will communicate any new operational requirements with ICAO HQ, so that it can be taken into account by the ICAO Study Group in charge of PBN.

## 5.1 Near Term (2008-2012) Mid Term (2013-2016) and Long Term (2017 and Beyond) Key Tasks

The key tasks involved in the transition to performance-based navigation are:

- Establish navigation service needs through the Long term that will guide infrastructure decisions and specify needs for navigation system infrastructure, and ensure funding for managing and transitioning these systems.
- Define and adopt a national policy enabling additional benefits based on RNP and RNAV.
- Identify operational and integration issues between navigation and surveillance, air-ground communications, and automation tools that maximize the benefits of RNP.
- Support mixed operations throughout the term of this Roadmap, in particular considering navigation system variations during the near term until appropriate standards are developed and implemented.
- To support Civil/Military coordination and develop the policies needed to accommodate the unique missions and capabilities of military aircraft operating in civil airspace.
- Harmonize the evolution of capabilities for interoperability across airspace operations.
- Increase emphasis on human factors, especially on training and procedures as operations increase reliance on appropriate use of flight deck systems.
- Facilitate and advance environmental analysis efforts required to support the development of RNAV and RNP procedures.
- Maintain consistent and harmonized global standards for RNAV and RNP operations.

## 5.2 Near term strategy (2008-2012)

In the near-term, initiatives focus on investments by operators in current and new aircraft acquisitions, in satellite-based navigation and conventional navigation infrastructure as well as *I.R. of IRAN* investments. Key components include wide-scale RNAV implementation and the introduction of RNP for en route, terminal, and approach procedures.

The near-term strategy will also focus on expediting the implementation and proliferation of RNAV and RNP procedures. As demand for air travel continues at healthy levels, choke points will develop and delays at the major airports will continue to climb. RNAV and RNP procedures will help alleviate those problems. Continued introduction of RNAV and RNP procedures will not only provide benefits and savings to the operators but also encourage further equipage.

ANSPs as a matter of urgency must adapt new flight plan procedures to accommodate PBN operations. This particularly addresses fields 10 and 18.

Operators will need to plan to obtain operational approvals for the planned Navigation Specifications for this period. Operators shall also review Regional PBN Implementation Plans from other Regions to assess if there is a necessity for additional Operational approvals.

### 5.2.1 En route

#### *5.2.1.1 Oceanic and Remote Continental*

N/A

#### *5.2.1.2 Continental*

For airspace and corridors requiring structured routes for flow management, *I.R. of IRAN* , will review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV-2/1.

### 5.2.2 Terminal Areas (Departures and Arrivals)

RNAV reduces conflict between traffic flows by consolidating flight tracks. RNAV-1/Basic RNP-1 SIDs and STARs improve safety, capacity, and flight efficiency and also lower communication errors.

*I.R. of IRAN* will plan, develop and implement RNP-1 SIDs and STARs, at *OIIE,OIII, OISS,OIMM, OIFM, International airports* and make associated changes in airspace design. RNAV-1 will be implemented in airspace where there is sufficient surveillance coverage and Basic RNP-1 where there is no such coverage.

*Where operationally feasible*, *I.R. of IRAN* will develop operational concepts and requirements for continuous descent arrivals (CDAs) based on FMS Vertical Guidance and for applying time of arrival control based on RNAV and RNP procedures. This would reduce workload for pilots and controllers as well as increase fuel efficiency.

PBN SIDs and STARS would allow the following:

- Reduction in controller-pilot communications;
- Reduction of route lengths to meet environmental and fuel efficiency requirements;
- Seamless transition from and to en-route entry/exit points;
- Sequence departures to maximize benefits of RNAV and identify automation requirements for traffic flow management, sequencing tools, flight plan processing, and tower data entry activities.

### 5.2.3 Approach

The application of RNP APCH will be implemented in *OIIE ,OIII, OISS, OIMM, OIFM, International airports*. To facilitate a transitional period, conventional approach procedures and conventional navigation aids will be maintained for non PBN equipped aircraft during *this term*.

*I.R. of IRAN* will promote the use of APV Operations (Baro-VNAV ) to enhance safety of RNP Approaches and accessibility of runways.

The application of RNP AR Approach will be limited to selected runways where obvious operational benefits can be obtained due to the existence of significant obstacles.

RNP approaches include:

- APV implemented at all instrument runways at major regional airports and all non-instrument runways serving aircraft weighing greater than 5,700kg.

### 5.2.5 Summary near term strategy

| **Airspace** | **Nav. Specifications** | **Nav. Specifications where operationally required** | |
|---|---|---|---|
| En-Route Continental | RNAV-5 | RNAV-1 | |
| TMA Arrival/Departure | RNAV 1 In surveillance environnement<br>Basic RNP-1 In Non-surveillance environnement | | |
| Approach | RNP APCH with Baro-VNAV | | *OIIE,OIII, OISS,OIMM, OIFM, International airports* |

Implementation Targets

- RNP APCH (with Baro-VNAV) in 30% of instrument runways by 2010 (*OIIE, OISS,OIMM, International airports*) and 70% by 2012 and priority given to airports with operational benefits
- RNAV 1 / Basic RNP-1 SID/STAR of in 30% of International Airport by 2010 (*OIIE, OISS,OIMM, International airports*) and 70% by 2012 by 2012.
- Review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV 1 by 2012.

## 5.3 Medium term strategy (2013-2016)

**Medium Term (2013-2016)**

***En-route***

5.3.1Noting the current development of route spacing standards for RNAV-1, in this phase, it is expected that the implementations of all existing RNAV/RNP routes are consistent with PBN standards. However, in order to ensure implementation harmonization, States are urged to implement their RNAV/RNP routes based on a Regional agreements and consistent PBN navigation specifications and separation standards.

5.3.2With regard to oceanic remote operations, it is expected that with the additional surveillance capability, the requirement for RNAV-10 will disappear, and be replaced by navigation specifications for continental en-route applications.

5.3.3 **Operational approval**. Operators are required to have operational approval for RNAV-5 and RNAV-1..

***Terminal***

5.3.4RNAV-1 or Basic RNP-1 will be fully implemented in all TMAs by the end of this term.

5.3.5 **Operational approval**. Operators are required to have operational approval for RNAV-1/Basic RNP-1 approval.

*Note: In order to avoid unnecessary approvals, operators equipped with GNSS should apply for combined RNAV-1 and Basic RNP-1*

***Approach***

5.3.5 In this phase, full implementation of RNP APCH with Baro-VNAV or APV SBAS for all instrument runways is expected. These applications may also serve as a back-up to precision approaches.

5.3.6The extended application of RNP AR Approaches should continue for airports where there are operational benefits.

5.3.7The introduction of application of landing capability using GNSS is expected to guarantee a smooth transition toward high-performance approach and landing capability.

5.3.8**Operational approval requirements**. Operators are required to have operational approval for RNP APCH with VNAV operations (Baro-VNAV). Depending on operations, aircraft shall also meet RNP AR specification.

5,3.9Application of RNAV-1 or Basic RNP-1 for all terminal areas and APV/Baro-VNAV or APV/SBAS for all instrument runway ends, either as the primary approach or as a back-up for precision approaches will be mandated by 2016.

| MEDIUM TERM (2013-2016) | |
|---|---|
| *Airspace* | *Navigation Specification (preferred/acceptable)* |
| En-route – Oceanic | Nil |
| En-route - Remote continental | Nil |
| En-route – Continental | RNAV-1, RNAV-5 |
| En-route - Local / Domestic | RNAV-1 , RNAV-5 |
| TMA – (Arrival, Departure) | RNAV-1 or RNP-1 application |
| Approach | 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**<br>▪ RNP APCH with Baro-VNAV or APV in 100% of instrument runways by 2016<br>▪ RNAV-1 or RNP-1 SID/STAR for 100% of international airports by 2016<br>▪ RNAV-1 or Basic RNP-1 SID/STAR at busy domestic airports where there are operational benefits<br>▪ Implementation additional RNAV/RNP routes | |

## 5.3.1 En route

### *5.3.1.1 Oceanic and Remote Continental*

In the midterm, *I.R. of IRAN* will endeavour to work with international air traffic service providers to promote the application of RNP 10 and RNP 4 in additional sub-regions of the oceanic environment.

### *5.3.1.2 Continental*

The review of en-route airspace will be completed by 2016.

**Implementation**

By the end of the mid term other benefits of PBN will have been enabled, such as flexible procedures to manage the mix of faster and slower aircraft in congested airspace and use of less conservative PBN requirements.

**Automation for RNAV and RNP Operations**

By the end of the mid term enhanced en route automation will allow the assignment of RNAV and RNP routes based upon specific knowledge of an aircraft's RNP capabilities. En route automation will use collaborative routing tools to assign aircraft priority, since the automation system can rely upon the aircraft's ability to change a flight path and fly safely around problem areas. This functionality will enable the controller to recognize aircraft capability and to match the aircraft to dynamic routes or procedures, thereby helping appropriately equipped operators to maximize the predictability of their schedules.

Conflict prediction and resolution in most en route airspace must improve as airspace usage increases. Path repeatability achieved by RNAV and RNP operations will assist in achieving this goal. Mid-term automation tools will facilitate the introduction of RNP offsets and other forms of dynamic tracks for maximizing the capacity of airspace. By the end of the mid term, *en route automation* will have evolved to incorporate more accurate and frequent surveillance reports through ADS-B, and to execute problem prediction and conformance checks that enable offset manoeuvres and closer route spacing (e.g., for passing other aircraft and manoeuvring around weather).

### 5.3.2 Terminal Areas (Departures and Arrivals)

During this period, either Basic RNP-1 or RNAV-1 will become a required capability for flights arriving and departing major airports based upon the needs of the airspace, such as the volume of traffic and complexity of operations. This will ensure the necessary throughput and access, as well as reduced controller workload, while maintaining safety standards.

With RNAV-1 operations as the predominant form of navigation in terminal areas by the end of the mid term, *I.R. of IRAN* will have the option of removing conventional terminal procedures that are no longer expected to be used.

**Terminal Automation**

Terminal automation will be enhanced with tactical controller tools to manage complex merges in busy terminal areas. As data communications become available, the controller tools will apply knowledge of flights' estimates of time of arrival at upcoming waypoints, and altitude and speed constraints, to create efficient maneuvers for optimal throughput.

Terminal automation will also sequence flights departing busy airports more efficiently than today. This capability will be enabled as a result of PBN and flow management tools. Flights arriving and departing busy terminal areas will follow automation-assigned PBN routes.

### 5.3.3 Approach

In the mid term, implementation priorities for instrument approaches will still be based on RNP APCH and RNP AR APCH and full implementation is expected at the end of this term.

*The introduction of the application of landing capability, using GBAS (currently non PBN)* is expected to guarantee a smooth transition towards high performance approach and landing capability.

### 5.3.4 Helicopter operations (To be developed by State)

### 5.3.5 Medium term strategy summary

| Airspace | Nav. Specifications | Nav. Specifications where operationally required |
|---|---|---|
| En-Route Continental | RNAV-2, RNAV-5 | RNAV-1 |
| TMA Arrival/Departure | Expand RNAV-1, or basic RNP-1 application<br>Mandate RNAV-1, or basic RNP-1 | |
| Approach | Expand RNP APCH with (Baro-VNAV) and APV | |

**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 as required

## 5.4 Long term strategy (2017 and beyond)

The Long-term environment will be characterized by continued growth in air travel and increased air traffic complexity.

No one solution or simple combination of solutions will address the inefficiencies, delays, and congestion anticipated to result from the growing demand for air transportation. Therefore, *I.R. of IRAN* and key Stakeholders need an operational concept that exploits the full capability of the aircraft in this time frame.

### 5.4.1 Long Term Key Strategies (2017 and Beyond)

Airspace operations in the Long term will make maximum use of advanced flight deck automation that integrates CNS capabilities. RNP, RCP, and RSP standards will define these operations. Separation assurance will remain the principal task of air traffic management in this time frame. This task is expected to leverage a combination of aircraft and ground-based tools. Tools for conflict detection and resolution, and for flow management, will be enhanced significantly to handle increasing traffic levels and complexity in an efficient and strategic manner.

Strategic problem detection and resolution will result from better knowledge of aircraft position and intent, coupled with automated, ground-based problem resolution. In addition, pilot and air traffic controller workload will be lowered by substantially reducing voice communication of clearances, and furthermore using data communications for clearances to the flight deck. Workload will also decrease as the result of automated confirmation (via data communications) of flight intent from the flight deck to the ground automation.

With the necessary aircraft capabilities, procedures, and training in place, it will become possible in certain situations to delegate separation tasks to pilots and to flight deck systems that depict traffic and conflict resolutions. Procedures for airborne separation assurance will reduce reliance on ground infrastructure and minimize controller workload. As an example, in IMC an aircraft could be instructed to follow a leading aircraft, keeping a certain distance. Once the pilot agreed, ATC would transfer responsibility for maintaining spacing (as is now done with visual approaches).

Performance-based operations will exploit aircraft capabilities for “electronic” visual acquisition of the external environment in low-visibility conditions, which may potentially increase runway capacity and decrease runway occupancy times.

Improved wake prediction and notification technologies may also assist in achieving increased runway capacity by reducing reliance on wake separation buffers.

System-wide information exchange will enable real-time data sharing of NAS constraints, airport and airspace capacity, and aircraft performance. Electronic data communications between the ATC automation and aircraft, achieved through data link, will become widespread—possibly even mandated in the busiest airspace and airports. The direct exchange of data between the ATC automation and the aircraft FMS will permit better strategic and tactical management of flight operations.

Aircraft will downlink to the ground-based system their position and intent data, as well as speed, weight, climb and descent rates, and wind or turbulence reports. The ATC automation will uplink clearances and other types of information, for example, weather, metering, choke points, and airspace use restrictions.

To ensure predictability and integrity of aircraft flight path, RNP will be mandated in busy en route and terminal airspace. RNAV operations will be required in all other airspace (except oceanic). Achieving standardized FMS functionalities and consistent levels of crew operation of the FMS is integral to the success of this Long-term strategy.

The most capable aircraft will meet requirements for low values of RNP (RNP 0.3 or lower en route). Flights by such aircraft are expected to benefit in terms of airport access, shortest routes during IMC or convective weather, and the ability to transit or avoid constrained airspace, resulting in greater efficiencies and fewer delays operating into and out of the busiest airports.

Enhanced ground-based automation and use of real-time flight intent will make time-based metering to terminal airspace a key feature of future flow management initiatives. This will improve the sequencing and spacing of flights and the efficiency of terminal operations.

Uniform use of RNP for arrivals and departures at busy airports will optimize management of traffic and merging streams. ATC will continue to maintain control over sequencing and separation; however, aircraft arriving and departing the busiest airports will require little controller intervention. Controllers will spend more time monitoring flows and will intervene only as needed, primarily when conflict prediction algorithms indicate a potential problem.

More detailed knowledge of meteorological conditions will enable better flight path conformance, including time of arrival control at key merge points. RNP will also improve management of terminal arrival and departure with seamless routing from the en route and transition segments to the runway threshold. Enhanced tools for surface movement will provide management capabilities that synchronize aircraft movement on the ground; for example, to coordinate taxiing aircraft across active runways and to improve the delivery of aircraft from the parking areas to the main taxiways.

### 5.4.2 Summary of Long Term Key Strategies (2017 and Beyond)

The key strategies for instituting performance-based operations employ an integrated set of solutions.

- Airspace operations will take advantage of aircraft capabilities, i.e. aircraft equipped with data communications, integrated displays, and FMS.
- Aircraft position and intent information directed to automated, ground-based ATM systems, strategic and tactical flight deck-based separation assurance in selected situations (problem detection and resolution).
- Strategic and tactical flow management will improve through use of integrated airborne and ground information exchange.
- Ground-based system knowledge of real-time aircraft intent with accurate aircraft position and trajectory information available through data link to ground automation.
- Real-time sharing of National Air Space (NAS) flight demand and other information achieved via ground-based and air-ground communication between air traffic management and operations planning and dispatch.
- Overall system responsiveness achieved through flexible routing and well-informed, distributed decision-making.

- Systems ability to adapt rapidly to changing meteorological and airspace conditions.
- System leverages through advanced navigation capabilities such as fixed radius transitions, RF legs, and RNP offsets.
- Increased use of operator-preferred routing and dynamic airspace.
- Increased collaboration between service providers and operators.

Operations at the busiest airports will be optimized through an integrated set of capabilities for managing pre-departure planning information, ground-based automation, and surface movement.

- RNP-based arrival and departure structure for greater predictability.
- Ground-based tactical merging capabilities in terminal airspace.
- Integrated capabilities for surface movement optimization to synchronize aircraft movement on the ground. Improved meteorological and aircraft intent information shared via data link.

### 5.4.3 Key Research Areas

The aviation community must address several key research issues to apply these strategies effectively. These issues fall into several categories:

**Navigation**

- To what extent can lower RNP values be achieved and how can these be leveraged for increased flight efficiency and access benefits?
- Under what circumstances RNAV should be mandated for arriving/departing satellite airports to enable conflict-free flows and optimal throughput in busy terminal areas?

**Flight Deck Automation**

- What FMS capabilities are required to enable the future concepts and applications?
- How can performance-based communication and surveillance be leveraged in the flight deck to enable Long-term strategies such as real-time exchange of flight deck data?

**Automation**

- To what extent can lateral or longitudinal separation assurance be fully automated, in particular on final approach during parallel operations?
- To what extent can surface movement be automated, and what are the cost-benefit trade-offs associated with different levels of automation?
- To what extent can conflict detection and resolution be automated for terminal ATC operations?

**Procedures**

- How can time of arrival control be applied effectively to maximize capacity of arrival or departure operations, in particular during challenging wind conditions?
- In what situations is delegation of separation to the flight crews appropriate?
- What level of onboard functionality is required for flight crews to accept separation responsibility within a manageable workload level?

**Airspace**

- To what extent can airspace be configured dynamically on the basis of predicted traffic demand and other factors?
- What separation standards and procedures are needed to enable smoother transition between en route and terminal operations?
- How can fuel-efficient procedures such as CDAs be accomplished in busy airspace?

## Glossary

| | |
|---|---|
| 3D | Three-Dimensional |
| 4D | Four-Dimensional |
| ADS-B | Automatic Dependent Surveillance-Broadcast |
| ADS-C | Automatic Dependent Surveillance-Contract |
| ATC | Air Traffic Control |
| CDA | Continuous Descent Arrival |
| CNS | Communications, Navigation, Surveillance |
| EFVS | Enhanced Flight Visibility System |
| GA | General Aviation |
| GBAS | Ground-Based Augmentation System |
| GLS | GNSS (Global Navigation Satellite System) Landing System |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| ICAO | International Civil Aviation Organization |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| LNAV | Lateral Navigation |
| LPV | Localizer Performance with Vertical Guidance |
| NAS | National Airspace System |
| NAVAID | Navigation Aid |
| NM | Nautical Miles |
| PBN | Performance Based Navigation |
| RCP | Required Communications Performance |
| RF | Radius-to-Fix |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RNPSORSG | Required Navigation Performance and Special Operational Requirements Study Group |
| RSP | Required Surveillance Performance |
| SAAAR | Special Aircraft and Aircrew Authorization Required |
| SID | Standard Instrument Departure |
| STAR | Standard Instrument Arrival |
| VLJ | Very Light Jet |
| VNAV | Vertical Navigation |
| WAAS | Wide Area Augmentation System |

## Appendix A – National Action plan for PBN implementation

## Appendix B – En route continental implementation schedule by area or city pair (will be done in collaboration with ASECNA )

## Appendix C – Terminal area and approach implementation schedule by aerodrome (to be developed by State)

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# The Hashemite Kingdom of Jordan

## Civil Aviation Regulatory Commission
## CARC

# The Performance Based Navigation PBN Implementation Plan

**First edition**
**July 2009**

# Foreword

Jordan Civil Aviation Regulatory Commission CARC is the authority responsible for the provisions and management of Air Navigation Services across and within Jordan Airspace.

JCARC strategic goal is to achieve world's best practices in aviation safety, security, environmental, and aviation economic regulation, independently enforcing civil aviation regulations but doing so in ways that are consistent, fair and transparent, and that show flexibility, good judgment and accountability.

The most challenging issue, in the Air Navigation Service provisions, is to establish a new air traffic system that enhances airspace capacity to cope efficiently with the projected increase in aviation demand, while also ensuring safe and efficient operations into the future.

In view of the need for detailed navigation planning, it was necessary to prepare a Performance Based Navigation PBN implementation Plan to provide guidance to ATM stakeholders, air navigation service providers, airspace operators and user, regulating agencies, and international organization, on the evolution of performance based navigation, as one of the key systems supporting air traffic management, which describes the RNAV and RNP navigation applications that should be implemented in the short and medium term in Jordan harmonized with its implementation in the MID Region.

The CARC, committed to the Assembly resolution A36-23: Performance based navigation global goals, has established in the year 2007 a PBN National Team consisting of the aviation community and stakeholders, Airlines, Royal Jordanian Air Force, Air Navigation Service provider, Regulatory Authorities etc. for the development of the PBN implementation plan in harmonization and coordination with the regional plans and to be consistent with ICAO's Performance-Based Navigation Manual.

This Document reflects the CARC plans for the strategic objectives achievements through the RNAV applications for all types of flights and during the whole flight path enroute, terminal area, approach and SIDs and STARS procedures.

The plan provides the strategy for the development of navigation capabilities to be implemented in three timeframes: near term (2009-2010), mid term (2011-2015), and far term (2016-2025). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en route.

CONTENTS

**Historical Back Ground**

Civil Aviation Regulatory Commission

In the year 1982 Law No. 26 was approved and Civil Aviation Authority (CAA) came into being.

Civil Aviation Regulatory Commission (CARC) was established and empowered by Civil Aviation Law No. 41, year 2007 and has been effective since 31st July 2007, this Law has established the legal and operational separation between the Regulator and the service providers (ANS).

**Vision:**

Safe Skies for all operators

**Mission**

"Promote the development of Jordan's civil aviation safety, security and environmental regulatory compliance, while ensuring the economic soundness of a liberalized industry"

**Strategic Objective**

CARC is empowered by Civil Aviation Law No. 41, year 2007 to develop, implement, monitor and enforce aviation regulations and standards in the following areas:

- Safety
- Security
- Economic Regulatory
- Environment

## 1. Background

### 1.1 Future Demand on Aviation

It is expected that future demands on aviation will continue to increase, despite temporary stagnation due to certain events. Taking into consideration that the traditional approach reactions offering technical fragmented solutions will no longer be sufficient to deal with the mentioned growth which is expected to double in the next few years, and in the same time enhancing or at least maintaining the same levels of safety.

Airspace Design, restructuring and RNAV route network development for the improvement of the Air Traffic Management capability, enhancing safety, reducing the environment impact, increase efficiency and airspace capacity to increase traffic, in addition to the improvement of the security measurements for all phases of flights will be the main strategic objectives of the aviation community.

To enhance the overall Air Traffic Management (ATM) capacity, JCARC, is planning to optimize the ATS Route Network in both en-route and terminal airspace within an integrated national, regional and international airspace structure, taking into consideration the applicable navigation specifications.

### 1.2 Operational efficiency

Given the recent surge in fuel prices, economics require improvements in the efficiency of aircraft operations in all phases of flight (en route, approach, arrival and departure). The challenge is to meet the need for more efficient operations, while also accommodating increased demand and ensuring safety, through airspace restructuring and RNAV route network development and procedures design.

### 1.3 Environmental issues

Recently, environmental issues are becoming of greater importance due to political and social pressures. To help prevent global warming, aircraft operations need to produce fewer emissions of greenhouse gases ($CO_2$, etc.). Operating at reduced noise levels has also become an important requirement. To allow operations to meet both of these goals, it is necessary to establish more efficient flight paths (e.g., shorter distances with better climb and descent profiles) that do not pass over populated or other environmentally sensitive areas, especially during departure and arrival.

### 1.4 Aviation System Context

The aviation community must make diligent efforts to increase system flexibility, improve strategic management of flights, and control delays while maintaining today's safety levels.

The cost of fuel presents another significant challenge to all segments of the aviation community. This problem can be partially alleviated by efficiencies in airspace and procedures.

The anticipated growth and higher complexity of the air transportation system are likely to result in increased flight delays, schedule disruptions, choke points, inefficient flight operations, and passenger inconvenience, particularly when unpredictable weather and other factors constrain airport capacity. Upgrades to the air transportation system must leverage current and evolving capabilities in the near term, while building the foundation to address the future needs of the aviation community stakeholders.

The transition to any new system must allow to both conventional systems and new implemented one to operate for a certain time to give the opportunity to all airspace users to converge to the new requirements.

## 2. PBN Concept

2.1 PBN is a framework for defining a navigation performance specification along a route, on an instrument approach procedure, or in airspace within which an aircraft must comply with specified operational performance requirements.

2.2 It provides the basis for the design and implementation of automated flight paths and for airspace design, aircraft separation, and obstacle clearance. It also communicates the performance and operational capabilities necessary for the utilization of such paths and airspace. Once the performance level (i.e., the accuracy value) is established, the aircraft's own capability determines whether the aircraft can safely achieve the specified performance and qualify for the operation.

The PBN concept allows the setting up of a more flexible route system, shortening route lengths, establishing airspace and routes that provide a more efficient control service, and reduction of the spacing between neighbouring air routes, increasing the airspace capacity.

2.3 The PBN concept specifies aircraft RNAV 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, which also identify which navigation sensors and equipment may be used to meet the performance requirement.

2.4 It represents a shift from sensor-based to performance-based navigation. Performance requirements identify the choice of navigation sensors and equipment to be used to meet those requirements.

2.5 There are both RNP navigation specifications and RNAV navigation specifications. RNP operations introduce the requirement for onboard performance monitoring and alerting. A critical characteristic of RNP operations is the ability of the aircraft navigation system to monitor the navigation performance it achieves and to inform the crew if the requirement is not met during an operation. This onboard monitoring and alerting capability enhances the pilot's situation awareness and can enable closer route spacing without intervention by air traffic control (ATC), and is designated as a RNP X. An RNAV specification does not have such requirements and is designated as RNAV X.

2.6 Performance based navigation therefore depends on:

- The RNAV system and installation on the aircraft being approved to meet the performance and functional requirements of the navigation specification prescribed for RNAV operations in an airspace; and
- Air crew satisfying the operating requirements set out by the regulator for RNAV operations; and
- A defined airspace concept which includes RNAV operations; and
- An available Navaid infrastructure;

Within an Airspace Concept, PBN requirements will be affected by the communication, surveillance and ATM environment, as well as the Navaid infrastructure and the functional and operational capabilities needed to meet the ATM application. PBN requirements will also depend on what reversionary, non-RNAV means of navigation are available and hence what degree or redundancy is required to ensure an adequate continuity of function.

The generic navigation requirements are defined based on the operational requirements; operators are then able to evaluate options in respect of available technologies and navigation services that could allow these requirements to be met. Technologies can evolve over time without requiring the operation itself to be revised, as long as the requisite performance is provided by the RNAV system.

Other means for meeting the requirements of the Navigation Specifications will be evaluated and may be included in the applicable Navigation Specifications, as appropriate.

**3. Strategic objective**

The PBN implementation plan should meet the following objectives:

a) Provide a high-level strategy for the implementation of the navigation applications in the short term (2008-2012) and medium term (2013-2016).
b) The strategy is based on the concepts of PBN (Area Navigation (RNAV) and Required Navigation Performance (RNP)), which will be applied to aircraft operations involving instrument approaches, standard departure (SID) routes, standard arrival (STAR) routes, and ATS routes in continental areas in accordance with the implementation goals in the Assembly resolution A36-23;
c) Ensure that the implementation of the navigation portion of the CNS/ATM system is based on clearly established operational requirements;
d) Avoid unnecessarily mandating for multiple equipment on board or on the ground;
e) Avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations;
f) Prevent commercial interests from outdoing ATM operational requirements, generating unnecessary costs for the State as well as for airspace users.

## 4. Status of RNAV operations in Jordan

In the year 2002, RNP 5 was adopted in the region on route basis and on very limited routes. On the year 2003 it was adopted on area basis, but the proper benefits and advantages were not felt by members of the aviation family.

JCARC is proceeding in the implementation of RNAV approach procedures based on GNSS to be established and implemented in the year 2009 at Jordan terminal areas and Airports.

Until now, navigation accuracy specified for the current RNAV routes in Jordan, does not provide the potential benefits and cannot make use of the advanced navigation performance of modern aircraft so that more benefits can be provided from the RNAV procedures.

In Amman FIR, aircraft that do not meet the requirements for the new RNAV procedures are expected to continue flying. There will be a period during which those aircraft will coexist with aircraft that meet the new requirements.

## 5. Benefits of PBN and Global Harmonization (Safety, Efficiency, Environment)

5.1 After the RVSM implementation in most of the world, the main tool for optimizing the airspace structure is the implementation of performance based navigation (PBN), which will foster the utilization of RNAV and RNP aircraft capabilities by a significant portion of airspace users globally.

RNAV and RNP specifications shall facilitate more efficient design of airspace and procedures, which collectively should result in improved safety, access, capacity, predictability, operational efficiency, and environmental effects; Specifically, RNAV and RNP may:

- Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.
- Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.
- Improve efficiency and flexibility by increasing use of operator-preferred trajectories, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.
- Reduce workload and improve productivity of air traffic controllers.

Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of stakeholders and service providers.

5.2 To improve safety and efficiency, it is necessary to consider the whole and totality of systems:

1- the procedures and
2- increasing the number of routes to increase the airspace capacity;
3- restructuring of airspace (reviewing Area Control Centre, sectors and terminal areas);
4- improving air traffic management;
5- Increase the controller capability of aircraft number handling.

5.3 The benefits of the PBN and advantages over the conventional sensor-based specific method of developing airspace and obstacle clearance criteria:

a. Reduces need to maintain sensor-specific routes and procedures, and their associated costs.
b. Avoids need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.
c. Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).
d. Clarifies the way in which RNAV systems are used.
e. Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

f. Improves 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;
g. Reduces delays in airspaces and airports through the implementation of additional parallel routes and additional arrival and departure points in terminal areas.
h. Reduces cock-pit workload, with increase in safety through the navigation function using highly accurate and sophisticated onboard equipment.
i. The ATS routes can be straightened as it is not necessary for the routes to pass over locations marked by conventional NAVAIDS.
j. RNAV based arrival and departure routes can complement and even replace radar vectoring, thereby reducing approach and departure controllers' workload.
k. Increase of predictability of the flight path

## 6. Challenges

### 6.1 Increasing demands

En route: Measures must be introduced to increase both airspace capacity and the number of aircraft that can be handled by individual controllers without increasing workload through:

1- double-or-quadruple-tracking of routes,
2- re-structuring of airspace,
3- improving air traffic management, and
4- Introducing tools to assist air traffic controllers that can increase the number of aircraft handled by a controller without increasing their workload.

The present route network in Jordan is ground-based navigation aids such as VOR (VOR routes) and RNAV routes. These mixed routes could create complexity for ATC and increased controller workload at specific points. The ATC complexity caused by the mixed operation must be removed to increase the aircraft handled by each controller, and to reduce controller workload.

Terminal Areas: Even though flights enter a terminal area from more than one direction, they must all finally converge onto courses that correspond to landing runways. This is why; developing RNAV routes alone cannot drastically increase the airspace capacity. However at airports, introducing RNAV and RNP with navigation performance and functional requirements can increase the airspace capacity as aircraft can more precisely fly along RNAV routes.

For night flights at Amman International Airport in particular, RNAV can allow aircraft to fly tracks that better avoid noise sensitive areas, resulting in an increase in the number of aircraft that can be handled at night.

Most aircraft are expected to have the capability for advanced RNAV and RNP that includes a time of arrival control function. Aircraft can then pass over a specific point on the route precisely at the time directed by the controller. Hence, longitudinal separation can be maintained by the aircraft system, keeping separation to the minimum needed for efficiency while also ensuring safety, which increases the capacity of the air traffic system without increasing controller workload.

**6.2 Efficient operations**

In order to improve operating efficiency, both en route and terminal operations must be considered when developing routes. Since the establishment of RNAV routes does not depend on the location of ground-based navigation aids, routes for departures and arrivals in terminal areas could be more easily shortened than in en route areas, usually departure and arrival routes involve many turns depending on those navigation aids. Therefore, the development of RNAV within terminal areas should be a priority.

En route: For Jordan domestic airspace and for routes connecting departure and arrival procedures and medium distance routes, RNAV routes will be designed to increase operational efficiency and reduce environment impact.

Conditional ATS route, which go through training/testing areas, are expected to shorten flight distances significantly and increase operational efficiency.

Terminal Areas: RNAV departure and arrival routes can be made shorter than routes that use ground-based navigation aids. Analysis and coordination for the establishment of RNAV departure and arrival routes has initiated so the benefits from RNAV operations can be provided to operators as soon as possible.

Operations on the developed RNAV routes can reduce the amount of communication required between the pilot and the controller significantly, reducing their workload, resulting in an improvement in safety while also increasing the airspace capacity.

To shorten the routes to the maximum possible extent, arrival routes will be connected directly to the approach phase. To minimize fuel consumption, the routes will be designed so that an optimized profile descent can be made using the aircraft's FMS. For airports without Airport Surveillance Radar, RNAV could be very effective in shortening routes. For the approach phase, most runways in Jordan are equipped with an ILS CAT II.

However, due to limitations such as terrain and noise sensitive areas, only airports with ILS at both runway ends allow a straight-in precision approach. At king

Hussein Airport runway end where a straight-in precision approach with ILS is not possible, a study for RNP Authorization Required (AR) approaches will be made even though the traffic is less than 5% and does not justify its application for the time being.

JCARC in response to requests from operators and airspace users and to make operations more effective in general, will take into consideration all solution regarding RNAV procedures design and airspace restructuring to accommodate the expected large increase in traffic and their needs.

### 6.3 Environmental impact

With the improvements in operational efficiency that result from shortening developed routes, greenhouse gasses ($CO_2$, etc.) will also be reduced over all routes including en route, terminal, and approach procedures. Departures, arrivals, and approach procedures will be developed to reduce noise exposure by avoiding populated areas and other noise sensitive areas. Overall, noise levels may increase, especially at Amman International Airport with the increase in traffic expected after the scheduled expansion; however, implementation of RNAV and RNP operating procedures that take advantage of the more advanced features of FMS will prevent any increase in noise exposure.

## 7. Infrastructure Communication, Navigation, Surveillance.

### 7.1 Global Navigation Satellite System (GNSS) infrastructure

7.1.1 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.

7.1.2 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.

7.1.3 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).

## 7.2 Conventional PBN Infrastructure

7.2.1 Other navigation infrastructure that supports PBN applications includes INS, VOR/DME. These navigation infrastructures may satisfy the requirements of RNAV navigation specifications, but not those of RNP. Jordan airports are provided with VOR/DME systems in addition to enroute navigation aids VOR/DME systems.

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

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

The conventional Navaid infrastructure shall be maintained to support non-equipped aircraft during a transition period until at least 2016.

## 7.3 Surveillance Infrastructure

7.3.1 For RNAV operations, CARC shall ensure that sufficient surveillance coverage is provided to assure the safety of the operations. Because of the on-board performance monitoring and alerting requirements for RNP operations, surveillance coverage may not be required. Amman FIR is radar covered with a Monopulse Secondary Surveillance Radar system capable of covering 250 NM from the radar centre.

## 7.4 Communication Infrastructure

Implementation of RNAV and RNP routes includes communication requirements as per annex 10 to the convention, Amman FIR will be covered by a new VHF network covering all the airspace and beyond.

# 8. Implementation Of Performance-Based Navigation

8.1 ATM operational requirements.

8.1.1 The Global ATM System makes necessary to adopt an airspace concept able to provide an operational scenario that includes Routes Network, Minimum separation, Assessment of obstacles clearance, and CNS infrastructure that satisfies safety specific strategic objectives, capacity, efficiency, environment and technology addressed for the implementation of performance based navigation.

8.1.2 In this regard, the following programmes should be developed in different areas:

a) Traffic and cost benefit studies
b) Automation necessary update
c) Operations simulation in different scenarios
d) ATC personnel training

e) FPL processing
f) AIS support
g) WGS 84 implementation
h) Uniform classification of adjacent and regional airspaces
i) RNAV/RNP application in SIDs and STARs
j) RNAV routes implementation and coordination

**9. Implementation Strategy**

In addressing the operational requirements, the following ICAO MID Region PBN Implementation & Harmonisation Strategy was taken in consideration:

a) Implementation of any RNAV or RNP application shall be in compliance with ICAO PBN Manual (Doc 9613).

b) Implementation of RNAV5/RNAV1 depending on operation requirements for Continental en-route and local/domestic en-route applications at least until 2016.

All current RNP-5 applications shall be redefined as RNAV-5 or RNAV-1 depending on operational needs.

c) Implementation of RNAV1/Basic-RNP-1 depending on operation requirements for terminal applications at least until 2016.

d) Implementation of RNAV-10 for oceanic/remote continental until at least 2016;

e) Replacement of RNAV 5/RNAV-1 specification by RNP specifications (e.g. Advanced-RNP-1) for the use in the en-route and terminal airspace to commence by 2016.

f) The target date for the completion of implementation for the Approach procedures with vertical guidance (APV) (APV/Baro-VNAV and/or APV/SBAS) for all instrument runway ends is 2016:

The development of new conventional non-precision approach procedures shall not be implemented.

Existing conventional non-precision approach procedures shall be phased out not later than 2016, pending readiness of stand-alone GNSS.

g) The use of NDB for approach operations shall be terminated by the end of 2012.

**9.1 RNAV/RNP approval.** will cover two types of approvals: airworthiness, which will exclusively deal with aircrafts approval, and operations, which will take care of the operational aspects of air transport operators. The fulfilment of these types of approvals will permit operators to obtain RNAV/RNP approval.

**9.2 Short term (up to 2012)**

9.2.1 En-route

Taking into account air traffic density, no significant changes are expected in the present Amman airspace structure that will demand changes in applied RNAV navigation specifications.

93.1.1 Prior the planning phase of PBN implementation, CARC established a PBN National Team to gather inputs from all aviation stakeholders to obtain operational needs and requirements. These needs and requirements were translated into the selection of appropriate PBN navigation specification.

9.2.1.2 In this phase, for Continental routes, the applications of RNAV-5 and RNAV-1 navigation specifications shall be used, to replace the RNP5 already applied in Amman FIR, in line with the PBN concept requirements of changing RNP 5 into RNAV-5. Based on operational requirements, Jordan could choose to implement RNAV-1 routes to enhance efficiency of airspace usages and support closer route spacing, noting that the appropriate communication and surveillance coverage is provided, in accordance with PBN manual.

9.2.1.3 Operational approval. Operators are required to have operational approval for RNAV-5. Depending on operational requirement RNAV-1 for terminal operations

9.2.2 Terminal

9.2.2.1 In Amman TMA, surveillance environment, the application of RNAV-1 can be supported through the use of GNSS. In this phase, mixed operations (equipped and non-equipped aircraft) will be permitted.

9.2.2.2 In King Hussein International Airport KHIA, a non- surveillance environment and an environment without adequate ground navigation infrastructure, the SID/STAR application of Basic-RNP-1 shall be selected with application of GNSS.

9.2.2.3 Operational approval. Operators are required to have operational approval for RNAV 1. In addition, operators are required to have Basic RNP-1 approval when operating in procedural control TMA.

Note: In order to avoid unnecessary approvals**,** operators equipped with GNSS should apply for combined RNAV-1 and Basic RNP-1.

9.2.3 Approach

9.2.3.1 The application of RNP APCH procedures is expected to be implemented in the maximum possible number of airports, primarily international airports. To facilitate transitional period, conventional approach procedures and conventional navigation aids should be maintained for non-equipped aircraft until 2016.

9.2.3.2 CARC will promote the use of APV operations (Baro-VNAV or SBAS) to enhance safety of RNP approaches and accessibility of runways.

9.2.3.3 The application of RNP AR APCH procedures should be limited to KHIA, where obvious operational benefits can be obtained due to the existence of significant obstacles.

9.2.3.4 Operational approval requirements. Operators shall plan to have operational approval for RNP APCH with VNAV operations (Baro-VNAV). Depending on operational need, aircraft shall also meet the RNP AR APCH specification.

9.2.3.5 Application of RNAV-5 or RNAV-1 for continental en-route will be mandated by the end of 2012.

9.2.4 IFR approaches

9.2.4.1 Approach procedures for PBN should be implemented as approach procedures with vertical guidance (APV) utilizing Baro-VNAV for runways either as the primary approach or as a back-up for precision approaches for all instrument runway ends, based on the RNP APCH or RNP AR APCH navigation specifications.

9.2.4.2 The application of RNP APCH approach procedures (basic GNSS) is expected in the maximum possible of Jordan international airports, maintaining conventional approach procedures for non-equipped aircraft.

Summary Table And Implementation Targets
Short Term (2008-2012)

| **Airspace** | **Navigation Specification** |
|---|---|
| En-route | RNAV 5, RNAV 1 |
| En-route - Local / Domestic | RNAV 5, RNAV 1 |
| TMA – Arrival | RNAV 1 in surveillance environment<br>Basic RNP 1 in non surveillance environnent |
| TMA – Departure | RNAV 1 in surveillance environment<br>Basic RNP 1 in non surveillance environnent |
| Approach | RNP APCH with Baro-VNAV in most possible airports<br>RNP AR APCH King Hussein International Airport |

Implementation Targets

1- RNP APCH (with Baro-VNAV) priority should be given to airports with most significant operational benefits
2- RNAV 1 SIDs/STARs priority should be given to airports with RNP Approach
3- RNP 5 and B-RNAV which is implemented in MID Region to be redefined as per ICAO PBN terminology by 2009 full implementation for continental enroute.

**9.3 Medium Term (2013-2016)**

9.3.1 En-route

Noting the current development of route spacing standards for RNAV 1, in this phase, it is expected that the implementations of all existing RNAV/RNP routes are consistent with PBN standards. However, in order to ensure implementation harmonization, JCARC should implement the RNAV/RNP routes based on a Regional agreements and consistent with PBN navigation specifications and separation standards.

9.3.2 Operational approval. Operators are required to have operational approval for RNAV 5 and RNAV 1.

Terminal

9.3.3 RNAV 1 or Basic RNP 1 will be fully implemented in all TMAs by the end of 2016.

9.3.4 Operational approval. Operators are required to have operational approval for RNAV 1/Basic RNP 1 approval.

In order to avoid unnecessary approvals, operators equipped with GNSS should apply for combined RNAV 1 and Basic RNP 1

Approach

9.3.5 In this phase, full implementation of RNP APCH with Baro-VNAV or APV SBAS for all instrument runways is planned. These applications may also serve as a back-up to precision approaches.

9.3.6 The introduction of application of landing capability using GNSS is expected to guarantee a smooth transition toward high-performance approach and landing capability.

9.3.7 Operational approval requirements. Operators are required to have operational approval for RNP APCH with VNAV operations (Baro-VNAV). Depending on operations, aircraft shall also meet RNP AR specification.

9.3.8 Application of RNAV 1 or Basic RNP 1 for all terminal areas and APV/Baro-VNAV or APV/SBAS for all instrument runway ends, either as the primary approach or as a back-up for precision approaches will be mandated by 2016.

Summary Table and Implementation Targets
Medium Term (2013-2016)

| ***Airspace*** | ***Navigation Specification*** |
|---|---|
| En-route | RNAV 5, RNAV 1 |
| En-route - Local / Domestic | RNAV 5, RNAV 1 |
| TMA – Arrival | RNAV 1 in surveillance environment<br>Basic RNP 1 in non surveillance environnent |
| TMA – Departure | RNAV 1 in surveillance environment<br>Basic RNP 1 in non surveillance environnent |
| Approach | RNP APCH with Baro-VNAV in most possible airports<br>RNP AR APCH King Hussein International Airport |

**9.4 Long Term (2016 and Beyond)**

9.4.1 In this phase, GNSS is expected to be a primary navigation infrastructure for PBN implementation. JCARC should have been working co-operatively on a multinational basis to implement GNSS in order to facilitate seamless and inter-operable systems.

9.4.2 Moreover, during this phase, CARC shall consider segregating traffic according to navigation capability and granting preferred routes to aircraft with better navigation performance.

9.4.3 Noting the current development of Advanced RNP 1 navigation specification, it is expected that this navigation specification will play an important role in the long term implementation of PBN for enroute and terminal operations.

9.4.4 With the expectation of GNSS and its augmentation systems usage availability, CARC will explore the use of such capability where there are operational and financial benefits.

9.4.5 During this term the use of Advanced RNP 1 for terminal and en-route will be mandated.
Refer to Appendix 1 for the PBN implementation schedule

9.4.6 Applicable navigation specifications: RNAV 5 and RNAV 1 for Enroute;
- Applicable navigation specifications: RNAV 1 and Basic-RNP 1 for Terminal area.

- Applicable navigation specifications: RNP APCH, RNP AR APCH, for Approach (RNP).

## 10. Transitional Strategies

10.1 During the transitional phases of PBN implementation, sufficient ground infrastructure for conventional navigation systems must remain available. Before the removal of such systems, users shall be consulted and given reasonable transition time to allow them to equip appropriately to attain equivalent PBN-based navigation performance.

The removal of those systems shall be approached with caution to ensure that safety is not compromised, such as by safety performance assessment, users consultation through regional air navigation planning process and national consultative forums
The navigation systems located in Amman FIR supporting air navigation in airspaces of other States shall be defined and revised before their removal.

JCARC will cooperate and coordinate bilaterally, multilaterally and within the framework of Regional agreements, in the phasing out of conventional ground based navigation systems and maintaining the serviceability of required navigation aids for area navigation.

10.2 Harmonized, and coordinated separation standards and procedures should be developed and introduced concurrently with other flight information regions to allow for a seamless transition towards PBN.

10.3 JCARC shall cooperate on a multinational basis to implement PBN in order to facilitate seamless and inter-operable systems.

10.4 JCARC shall segregate traffic according to navigation capability and granting preferred routes to aircraft with better navigation performance, taking due consideration of the need of State/Military aircraft.

10.5 JCARC shall encourage operators and other airspace users to equip with PBN avionics, through early introductions of RNP approaches, preferably those with vertical guidance.
Refer to Appendix 2 PBN ENROUTE, APP, TMA Action Plan

## 11. Safety Assessment And Monitors Methodology

11.1 Safety Assessment

To ensure that the introduction of PBN en-route applications within the MID Region is undertaken in a safe manner and in accordance with relevant ICAO provisions, implementation shall only take place following conduct of a safety assessment that has demonstrated that an acceptable level of safety will be met. This assessment may also need to demonstrate levels of risk associated with specific PBN en-route implementation. Additionally, ongoing periodic safety reviews shall be undertaken where required in order to establish that operations continue to meet the target levels of safety.

## 12. ACRONYMS

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

| | |
|---|---|
| AACO | Arab Air Carrier Association |
| ABAS | Aircraft-Based Augmentation System |
| AIS | Aeronautical Information System |
| APAC | Asia and Pacific Regions |
| 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 |
| 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 |
| MIDANPIRG | Middle East Air Navigation Planning and Implementation Regional Group |
| MID RMA | Middle East Regional Monitoring Agency |
| PANS | Procedures for Air Navigation Services |
| PBN | Performance Based Navigation |
| PIRG | Planning and Implementation Regional 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 |

Appendix 1

PBN implementation time schedule

| Navigation Specification | Airspace Application | Short Term | | | | Medium Term | | | | Long Term | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017…. | 2025 |
| RNAV10 | NA | Will not be used | | | | | | | | | |
| RNP4 | NA | Will not be used | | | | | | | | | |
| RNAV2 | NA | Will not be used | | | | | | | | | |
| RNP5 into RNAV5 | Enroute | | | | | | | | | | |
| RNAV1 | Enrout | | | | | | | | | | |
| RNAV1 | TMA Dep. and Arr. Sur | | | | | | | | | | |
| Basic RNP1 | TMA Dep. and Arr. Non sur | | | | | | | | | | |
| RNP APCH | Approach | | | | | | | | | | |
| RNP AR APCH | Approach KHIA | | | | | | | | | | |
| RNAV1 | SIDs / STARs | | | | | | | | | | |
| Basic RNP1 | Enrout | | | | | | | | | | |
| advanced-RNP-1 | en-route | | | | | | | | | | |
| advanced-RNP-1 | terminal airspace | | | | | | | | | | |
| Use of NDB | Approach operations | | | | | Stop using the NDB for approach operations | | | | | |
| Conventional NPA procedures | | | | | | | | | | Stop the conventional NPA procedures | |

# Performance Based Navigation (PBN) Implementation Plan

# **State of Kuwait (draft)**

# **Version 1**

December 2008

## About the Plan

### Requirement for PBN

The Kuwait DGCA, committed to the Assembly resolution A36-23: Performance based navigation global goals, has established in the year 2007 a PBN National consisting of the aviation community and stakeholders, Airlines, Aviation Safety , Air Navigation Service provider, Regulatory Authorities etc. for the development of the PBN implementation plan in harmonization and coordination with the regional plans and to be consistent with ICAO's Performance-Based Navigation Manual.

This Document reflects the DGCA plans for the strategic objectives achievements through the RNAV applications for all types of flights and during the whole flight path enroute, terminal area, approach and SIDs and STARS procedures.

The plan provides the strategy for the development of navigation capabilities to be implemented in three timeframes: near term (2009-2010), mid term (2011-2015), and far term (2016-2025). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en route.

### Why is a PBN implementation plan or roadmap needed?

1.1 With RVSM implemented or soon to be implemented in most of the world, the main tool for optimising the airspace structure is the implementation of performance-based navigation (PBN), which will foster the necessary conditions for the utilization of RNAV and RNP capabilities by a significant portion of airspace users in the Regions and State of Kuwait.

1.2 Current planning by the Regional Planning and Implementation Groups is based on the Air Navigation Plans and the Regional CNS/ATM Plans. Currently, these plans are mostly made up of tables that do not contain the necessary details for the implementation of each of the CNS and ATM elements. For this reason, the Regions will be developing Regional PBN implementation plans. The necessary concurrent and follow-on step is to develop national plans that implement the regional plans at the State level and address PBN implementation strategy at the national level.

1.3 to provide proper guidance and direction to the domestic air navigation service provider(s), airspace operators and users, regulating agency, as well as foreign operators who operate or plan to operate in the State. This guidance should address the planned evolution of navigation, as one of the key systems supporting air traffic management, and describe the RNAV and RNP navigation applications that should be implemented in at least the short and medium term..

### What are the objectives of the PBN Implementation Plan or Roadmap?

1.4 The PBN implementation plan should meet the following strategic objectives:

a) provide a high-level strategy for the evolution of the navigation applications to be implemented in the State in the short term (2008-2012) and medium term (2013-2016). This strategy is based on the concepts of PBN, Area Navigation (RNAV) and Required Navigation Performance (RNP), which 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 in accordance with the implementation goals in the Assembly resolution;

b) ensure that the implementation of the navigation portion of the CNS/ATM system is based on clearly established operational requirements;

c) avoid unnecessarily imposing the mandate for multiple equipment on board or multiple systems on the ground;

d) avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations;

e) prevent commercial interests from outdoing ATM operational requirements, generating unnecessary costs for the State as well as for airspace users.

**What is the intent of the PBN Implementation Plan or Roadmap?**

1.5 The PBN Implementation Plan should be developed by the State of Kuwait together with the stakeholders concerned 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 roadmap and should therefore be included in the development process are:

- Airlines , Kuwait airway….
- Air Navigation Department
- Regulating agencies, DGCA ASD
- National and international organizations

List of other airlines operation to Kuwait as a appendix vvv

1.6 The PBN Implementation 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 roadmap to plan 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 as well as the future regulatory workload and associated training requirements for their work force.

**What principles should be applied in development of the PBN Implementation Plan or Roadmap?**

1.7 The implementation of PBN in the State should be based on the following principles:

a) Continued application of conventional air navigation procedures during the transition period, to guarantee availability by users that are not RNAV- and/or RNP-equipped;

b) Development of airspace concepts, applying airspace modeling tools as well as real-time and accelerated simulations, which identify the navigation applications that are compatible with the aforementioned concept;

c) Conduct of cost-benefit analyses to justify the implementation of the RNAV and/or RNP concepts in each particular airspace;

d) Conduct of pre- and post-implementation safety assessments to ensure the application and maintenance of the established target levels of safety.

e) Must not conflict with the MID regional PBN implementation plan.

**Table of contents**

## 1. Introduction

The MID Region Performance Based Navigation (PBN) Roadmap details the framework within which the ICAO PBN concept will be implemented in the MID Region for the foreseeable future. The MID Region Roadmap for PBN is guided by ICAO Doc. 9613 and relevant SARPs. The primary driver for this plan is to maintain and increase safety, air traffic demand and capacity, and services and technology in consultation with relevant stakeholders. The MID Region Roadmap also supports national and international interoperability and global harmonization.

## 2. Background

The continuing growth of aviation places increasing demands on airspace capacity and emphasizes the need for the optimum utilization of the available airspace.

Growth in scheduled and General Aviation aircraft is expected to increase point-to-point and direct routings. The increasing cost of fuel also presents a significant challenge to all segments of the aviation community. This anticipated growth and higher complexity of the air transportation system could result in increased flight delays, schedule disruptions, choke points, inefficient flight operations, and passenger inconvenience, particularly when unpredictable weather and other factors constrain airport capacity. Without improvements in system efficiency and workforce productivity, the aviation community and cost of operations will continue to increase. Upgrades to the air transportation system must leverage current and evolving capabilities in the near term, while building the foundation to address the future needs of the aviation community stakeholders. These circumstances can be partially alleviated by efficiencies in airspace and procedures through the implementation of PBN concepts.

In setting out requirements for navigation applications on specific routes or within a specific airspace, it is necessary to define requirements in a clear and concise manner. This is to ensure that both flight crew and ATC are aware of the on-board area navigation (RNAV) system capabilities and to ensure that the performance of the RNAV system is appropriate for the specific airspace requirements.

The early use of RNAV systems arose in a manner similar to conventional ground-based routes and procedures. A specific RNAV system was identified and its performance was evaluated through a combination of analysis and flight testing. For domestic operations the initial systems used VOR and DME for their position estimation. For oceanic operations, inertial navigation systems (INS) were employed.

These ‘new’ systems were developed, evaluated and certified. Airspace and obstacle clearance criteria were developed on the basis of available equipment performance. Requirements specifications were based upon available capabilities and, in some implementations, it was necessary to identify the individual models of equipment that could be operated within the airspace concerned.

Such prescriptive requirements result in delays to the introduction of new RNAV system capabilities and higher costs for maintaining appropriate certification. To avoid such prescriptive specifications of requirements, the PBN concept introduces an alternative method for defining equipage requirements by specification of the performance requirements. This is termed Performance Based Navigation (PBN).

## 3. Performance Based Navigation (PBN)

Performance based navigation (PBN) is a concept that encompasses both area navigation (RNAV) and required navigation performance (RNP) and revises the current RNP concept. Performance based navigation is increasingly seen as the most practical solution for regulating the expanding domain of navigation systems.

Under the traditional approach, each new technology is associated with a range of system-specific requirements for obstacle clearance, aircraft separation, operational aspects (e.g. arrival and approach procedures), aircrew operational training and training of air traffic controllers. However, this system-specific approach imposes an unnecessary effort and expense on State of Kuwait , airlines and air navigation services (ANS) providers.

Performance based navigation eliminates the need for redundant investment in developing criteria and in operational modifications and training. Rather than build an operation around a particular system, under performance based navigation the operation is defined according to the operational goals, and the available systems are then evaluated to determine whether they are supportive.

The advantage of this approach is that it provides clear, standardized operational approvals which enables harmonized and predictable flight paths which result in more efficient use of existing aircraft capabilities, as well as improved safety, greater airspace capacity, better fuel efficiency, and resolution of environmental issues.

The PBN concept specifies aircraft RNAV 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. 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 State of Kuwait and operators.

Under PBN, generic navigation requirements are defined based on the operational requirements. Operators are then able to evaluate options in respect of available technologies and navigation services that could allow these requirements to be met. The chosen solution would be the most cost effective for the operator, rather than a solution being imposed as part of the operational requirements. Technologies can evolve over time without requiring the operation itself to be revisited, as long as the requisite performance is provided by the RNAV system. As part of the future work of the ICAO, it is anticipated that other means for meeting the requirements of the Navigation Specifications will be evaluated and may be included in the applicable Navigation Specifications, as appropriate.

ICAO's Performance Based Navigation (PBN) concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use worldwide. It is a new concept based on the use of Area Navigation (RNAV) systems. Significantly, it is a move from a limited State ment of required performance accuracy to more extensive State ments for required performance in terms of accuracy, integrity, continuity and availability, together with descriptions of how this performance is to be achieved in terms of aircraft and flight crew requirements.

### 3.1. RNAV Current status in [State of Kuwait ]

#### 3.1.1 RNAV, ATS routes, SIDs, STARs and approaches

Runway 33L ,15R ,33R and 15LS are published …..

#### 3.1.2 Fleet equipage

(To be developed )

### 3.2 Benefits of PBN and global harmonization

PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. These include:

- Reduces need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.
- Avoids need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.
- Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).
- Clarifies the way in which RNAV systems are used.
- Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects. Specifically, RNAV and RNP may:

- Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.
- Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.
- Improve efficiency and flexibility by increasing use of operator-preferred trajectories airspace-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.

- Reduce workload and improve productivity of air traffic controllers.

Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of aviation stakeholders and service providers.

### 3.3 Stakeholders

Coordination is critical with the aviation community through collaborative forums. This will assist aviation stakeholders in understanding operational goals, determining requirements, and considering future investment strategies. This, in turn, enables the aviation stakeholders to focus on addressing future efficiency and capacity needs while maintaining or improving the safety of flight operations by leveraging advances in navigation capabilities on the flight deck. RNAV and RNP have reached a sufficient level of maturity and definition to be included in key plans and strategies..

The stakeholders who will benefit from the concepts in this State PBN plan include airspace operators, air traffic service providers, regulators, and standards organizations. As driven by business needs, airlines and operators can use the State PBN roadmap to plan future equipage and capability investments. Similarly, air traffic service providers can determine requirements for future automation systems, and more smoothly modernize ground infrastructure. Finally, regulators and standards organizations can anticipate and develop the key enabling criteria needed for implementation.

This plan is a work in progress and will be amended through collaborative MID Region States, industry efforts and consultations that establish a joint aviation community/government/industry strategy for implementing performance-based navigation. Critical initiative strategies are required to accommodate the expected growth and complexity over the next two decades. These strategies have five key features:

- Expediting the development of performance-based navigation criteria and standards.
- Introducing airspace and procedure improvements in the near term.
- Providing benefits to operators who have invested in existing and upcoming capabilities.
- Establishing target dates for the introduction of navigation mandates for selected procedures and airspace, with an understanding that any mandate must be rationalized on the basis of benefits and costs.
- Defining new concepts and applications of performance-based navigation for the mid term and Long term and building synergy and integration among other capabilities toward the realization of the MID Region PBN goals
- .

## 4. Challenges

### 4.1 Increasing Demands

- Due to limited airspace for Kuwait FIR and Military Restricted Areas to accommodate the traffic flow from South to North Kuwait FIR in coordination with MID regional plan ,more RNAV ATS routes will be established .
- Kuwait DGCA adapted Opensky police ,in addition three new national airline operators in Kuwait INL Airport which case the traffic to increase more than triple which instated the

important of interesting RNAV SID/STARS to reduce the ATC workload .

### 4.1.1 En route

RNAV 5 it is currently RNAV 5 kuwait is planning for RNAV 1 by year 2016 specially for the following routes…..and it will safe xxxx of miles

### 4.1.2 Terminal Areas (Departures and Arrivals)

Kuwait airport established RNAV SID & STARS to provide :

- efficient link to the TMA and en-route structure
- Reduced ATC controller workload.

### 4.1.3 Approach

Kuwait airport established ILS/RNAV and Baro RNAV to provide :

- Reduced ATC controller workload.
- Better Aerodrome operating minma> chance of landing
- Vertical guided approach for all RWYS .
- Redundancy to landing nav aids.

## 4.2 Efficient Operations

### 4.2.1 En route

Establishing a New RNAV to accommodate the traffic flow from South to North Kuwait FIR will improve operations efficiency.

### 4.2.2 Terminal Areas

Utilization of RNAV SID/STARS will improve operation efficiency.

### 4.2.3 Approach

Kuwait airport established ILS/RNAV and Baro RNAV as pack up in case of NAV AID failures .

### 4.3 Environment

With the improvements in operational efficiency that result from shortening developed routes, greenhouse gasses ($CO_2$, etc.) will also be reduced over all routes including en route, terminal, and approach procedures. Departures, arrivals, and approach procedures will be developed to reduce noise exposure by avoiding populated areas and other noise sensitive areas. Overall, noise levels may increase, especially at Amman International Airport with the increase in traffic expected after the scheduled expansion; however, implementation of RNAV and RNP operating procedures that take advantage of the more advanced features of FMS will prevent any increase in noise exposure.

## 5. Implementation strategy

This plan provides a high-level strategy for the evolution of navigation capabilities to be implemented in three timeframes: near term (2008-2012), mid term (2013-2016), and Long term (2017 and Beyond). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en-route continental, oceanic and remote operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.

To avoid proliferation of new navigation standards, [State of Kuwait] and other aviation stakeholders in the MID region should communicate any new operational requirements with ICAO HQ, so that it can be taken into account by the ICAO Study Group in charge of PBN.

**Near Term (2008-2012) Mid Term (2013-2016) and Long Term (2017 and Beyond) Key Tasks**

The key tasks involved in the transition to performance-based navigation are:

- Establish navigation service needs through the Long term that will guide infrastructure decisions and specify needs for navigation system infrastructure, and ensure funding for managing and transitioning these systems.

- Define and adopt a national policy enabling additional benefits based on RNP and RNAV.

- Identify operational and integration issues between navigation and surveillance, air-ground communications, and automation tools that maximize the benefits of RNP.

- Support mixed operations throughout the term of this Roadmap, in particular considering navigation system variations during the near term until appropriate standards are developed and implemented.

- To support Civil/Military coordination and develop the policies needed to accommodate the unique missions and capabilities of military aircraft operating in civil airspace.

- Harmonize the evolution of capabilities for interoperability across airspace operations.

- Increase emphasis on human factors, especially on training and procedures as operations increase reliance on appropriate use of flight deck systems.

- Facilitate and advance environmental analysis efforts required to support the development of RNAV and RNP procedures.

- Maintain consistent and harmonized global standards for RNAV and RNP operations.

**5.2 Short term strategy (up to 2012)**

**5.2.1 En route**

To accommodate the traffic flow from South to North Kuwait FIR in coordination with MID regional plan ,more RNAV ATS routes will be established .

Operational approval. Operators are required to have operational approval for RNAV-5. Depending on operational requirement RNAV-1 .

**5.2.2 Terminal**

RNAV reduces conflict between traffic flows by consolidating flight tracks. RNAV-1/Basic RNP-1 SIDs and STARs improve safety, capacity, and flight efficiency and also lower communication errors.

[State of Kuwait] will continue to plan, develop and implement RNAV-1 SIDs and STARs, at Kuwait intl airport and make associated changes in airspace design. In addition, [State of Kuwait] will implement Basic RNP-1 SIDs and STARs. RNAV-1 will be implemented in airspace where there is sufficient surveillance coverage and Basic RNP-1 where there is no such coverage.

Where operationally feasible, [State of Kuwait] should develop operational concepts and requirements for continuous descent arrivals (CDAs) based on FMS Vertical Guidance and for applying time of arrival control based on RNAV and RNP procedures. This would reduce workload for pilots and controllers as well as increase fuel efficiency.

PBN SIDs and STARS would allow the following:

- Reduction in controller-pilot communications;

- Reduction of route lengths to meet environmental and fuel efficiency requirements;.

- Seamless transition from and to en-route entry/exit points;

- Sequence departures to maximize benefits of RNAV and identify automation requirements for traffic flow management, sequencing tools, flight plan processing, and tower data entry activities.

**5.2.3 Approach**

[State of Kuwait ] established APV Operations (Baro-VNAV) for all RWYs which will enhance safety of RNP Approaches and accessibility of runways.

**5.2.5 Summary short term strategy**

| Airspace | Navigation Specifications |
|---|---|

| | |
|---|---|
| En-Route | RNAV 5 |
| TMA Arrival | RNAV5 RNAV-1 in a surveillance environment |
| TMA Departure | RNAV-1 in a surveillance environment |
| Approach | RNP APCH with Baro-VNAV for All RWYS at Kuwait Inl Airport. |

### 1.8 Implementation Targets

- RNAV-1 SID/STAR for all RWYS by 2012 .
- Review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV-2/1 by 2012.

### 5.3 Medium term strategy (2013-2016)

**En-route**

Noting the current development of route spacing standards for RNAV 5, in this phase, it is expected that the implementations of all existing RNAV/RNP routes are consistent with PBN standards. However, in order to ensure implementation harmonization, DGCA should implement the RNAV/RNP routes based on a Regional agreements and consistent with PBN navigation specifications and separation standards.

Operational approval. Operators are required to have operational approval for RNAV 5 and RNAV 1.

**Terminal**

RNAV 1 will be fully implemented in Kuwait TMA by the end of 2016.

Operational approval. Operators are required to have operational approval for RNAV 1/Basic RNP 1 approval. In order to avoid unnecessary approvals, operators equipped with GNSS should apply for combined RNAV 1 and Basic RNP 1 Approach

In this phase, full implementation of RNP APCH with Baro-VNAV or APV SBAS for all instrument runways is planned. These applications may also serve as a back-up to precision approaches.

The introduction of application of landing capability using GNSS is expected to guarantee a smooth transition toward high-performance approach and landing capability.

Operational approval requirements. Operators are required to have operational approval for RNP APCH with VNAV operations (Baro-VNAV). Depending on operations, aircraft shall also meet RNP AR specification.

Application of RNAV 1 for Kuwait terminal area and APV/Baro-VNAV or APV/SBAS for all instrument runway ends, either as the primary approach or as a back-up for precision approaches will be mandated by 2016.

**Implementation**

By the end of the mid term other benefits of PBN will have been enabled, such as flexible procedures to manage the mix of faster and slower aircraft in congested airspace and use of less conservative PBN requirements.

**Automation for RNAV and RNP Operations**

By the end of the mid term enhanced en route automation will allow the assignment of RNAV and RNP routes based upon specific knowledge of an aircraft's RNP capabilities. En route automation will use collaborative routing tools to assign aircraft priority, since the automation system can rely upon the aircraft's ability to change a flight path and fly safely around problem areas. This functionality will enable the controller to recognize aircraft capability and to match the aircraft to dynamic routes or procedures, thereby helping appropriately equipped operators to maximize the predictability of their schedules.

Conflict prediction and resolution in most en route airspace must improve as airspace usage increases. Path repeatability achieved by RNAV and RNP operations will assist in achieving this goal. Mid-term automation tools will facilitate the introduction of RNP offsets and other forms of dynamic tracks for maximizing the capacity of airspace. By the end of the mid term, en route automation will have evolved to incorporate more accurate and frequent surveillance reports through ADS-B, and to execute problem prediction and conformance checks that enable offset manoeuvres and closer route spacing (e.g., for passing other aircraft and manoeuvring around weather).

### 5.3.2 Terminal Areas (Departures and Arrivals)

During this period, either Basic RNP-1 or RNAV-1 will become a required capability for flights arriving and departing major airports based upon the needs of the airspace, such as the volume of traffic and complexity of operations. This will ensure the necessary throughput and access, as well as reduced controller workload, while maintaining safety standards.

With RNAV-1 operations as the predominant form of navigation in terminal areas by the end of the mid term, MID [State of Kuwait] will have the option of removing conventional terminal procedures that are no longer expected to be used.

**Terminal Automation**

Terminal automation will be enhanced with tactical controller tools to manage complex merges in busy terminal areas. As data communications become available, the controller tools will apply knowledge of flights' estimates of time of arrival at upcoming waypoints, and altitude and speed constraints, to create efficient maneuvres for optimal throughput.

Terminal automation will also sequence flights departing busy airports more efficiently than today. This capability will be enabled as a result of PBN and flow management tools. Flights arriving and departing busy terminal areas will follow automation-assigned PBN routes.

### 5.3.3 Approach

In the mid term, implementation priorities for instrument approaches will still be based on RNP APCH and RNP AR APCH and full implementation is expected at the end of this term.

The introduction of the application of landing capability, using GBAS (currently non PBN) is expected to guarantee a smooth transition towards high performance approach and landing capability.

### 5.3.4 Helicopter operations (To be developed )

### 5.3.5 Medium term strategy summary

| Airspace | Nav. Specifications | Nav. Specifications where operationally required |
|---|---|---|
| En-Route | RNAV-5 | RNAV-1 |
| TMA Arrival/Departure | RNAV-1 | |
| Approach | RNP APCH with (Baro-VNAV) and APV<br>Established | |

Implementation Targets

- RNAV-1 or RNP-1 SID/STAR for 100% for all RWYS by 2016.
- Implementation of additional RNAV/RNP Routes as required

## 5.4 Long term strategy (2017 and beyond)

The Long-term environment will be characterized by continued growth in air travel and increased air traffic complexity.

No one solution or simple combination of solutions will address the inefficiencies, delays, and congestion anticipated to result from the growing demand for air transportation. Therefore, [State of Kuwait] and key Stakeholders need an operational concept that exploits the full capability of the aircraft in this time frame.

### 5.4.1 Long Term Key Strategies (2017 and Beyond)

Airspace operations in the Long term will make maximum use of advanced flight deck automation that integrates CNS capabilities. RNP, RCP, and RSP standards will define these operations. Separation assurance will remain the principal task of air traffic management in this time frame. This task is expected to leverage a combination of aircraft and ground-based tools. Tools for conflict detection and resolution, and for flow management, will be enhanced significantly to handle increasing traffic levels and complexity in an efficient and strategic manner.

Strategic problem detection and resolution will result from better knowledge of aircraft position and intent, coupled with automated, ground-based problem resolution. In addition, pilot and air traffic controller workload will be lowered by substantially reducing voice communication of clearances, and furthermore using data communications for clearances to the flight deck. Workload will also decrease as the result of automated confirmation (via data communications) of flight intent from the flight deck to the ground automation.

With the necessary aircraft capabilities, procedures, and training in place, it will become possible in certain situations to delegate separation tasks to pilots and to flight deck systems that depict traffic and conflict resolutions. Procedures for airborne separation assurance will reduce reliance on ground infrastructure and minimize controller workload. As an example, in IMC an aircraft could be instructed to follow a leading aircraft, keeping a certain distance. Once the pilot agreed, ATC would transfer responsibility for maintaining spacing (as is now done with visual approaches).

Performance-based operations will exploit aircraft capabilities for “electronic” visual acquisition of the external environment in low-visibility conditions, which may potentially increase runway capacity and decrease runway occupancy times.

Improved wake prediction and notification technologies may also assist in achieving increased runway capacity by reducing reliance on wake separation buffers.

System-wide information exchange will enable real-time data sharing of NAS constraints, airport and airspace capacity, and aircraft performance. Electronic data communications between the ATC automation and aircraft, achieved through data link, will become widespread—possibly even mandated in the busiest airspace and airports. The direct exchange of data between the ATC automation and the aircraft FMS will permit better strategic and tactical management of flight operations.

Aircraft will downlink to the ground-based system their position and intent data, as well as speed, weight, climb and descent rates, and wind or turbulence reports. The ATC automation will uplink clearances and other types of information, for example, weather, metering, choke points, and airspace use restrictions.

To ensure predictability and integrity of aircraft flight path, RNP will be mandated in busy en route and terminal airspace. RNAV operations will be required in all other airspace (except oceanic). Achieving standardized FMS functionalities and consistent levels of crew operation of the FMS is integral to the success of this Long-term strategy.

The most capable aircraft will meet requirements for low values of RNP (RNP 0.3 or lower en route). Flights by such aircraft are expected to benefit in terms of airport access, shortest routes during IMC or convective weather, and the ability to transit or avoid constrained airspace, resulting in greater efficiencies and fewer delays operating into and out of the busiest airports.

Enhanced ground-based automation and use of real-time flight intent will make time-based metering to terminal airspace a key feature of future flow management initiatives. This will improve the sequencing and spacing of flights and the efficiency of terminal operations.

Uniform use of RNP for arrivals and departures at busy airports will optimize management of traffic and merging streams. ATC will continue to maintain control over sequencing and separation; however, aircraft arriving and departing the busiest airports will require little controller intervention. Controllers will spend more time monitoring flows and will intervene only as needed, primarily when conflict prediction algorithms indicate a potential problem.

More detailed knowledge of meteorological conditions will enable better flight path conformance, including time of arrival control at key merge points. RNP will also improve management of terminal arrival and departure with seamless routing from the en route and transition segments to the runway threshold. Enhanced tools for surface movement will provide management capabilities that synchronize aircraft movement on the ground; for example, to coordinate taxiing aircraft across active runways and to improve the delivery of aircraft from the parking areas to the main taxiways.

### 5.4.2 Summary of Long Term Key Strategies (2017 and Beyond)

The key strategies for instituting performance-based operations employ an integrated set of solutions.

- Airspace operations will take advantage of aircraft capabilities, i.e. aircraft equipped with data communications, integrated displays, and FMS.
- Aircraft position and intent information directed to automated, ground-based ATM systems, strategic and tactical flight deck-based separation assurance in selected situations (problem detection and resolution).
- Strategic and tactical flow management will improve through use of integrated airborne and ground information exchange.
- Ground-based system knowledge of real-time aircraft intent with accurate aircraft position and trajectory information available through data link to ground automation.
- Real-time sharing of National Air Space (NAS) flight demand and other information achieved via ground-based and air-ground communication between air traffic management and operations planning and dispatch.
- Overall system responsiveness achieved through flexible routing and well-informed, distributed decision-making.
- Systems ability to adapt rapidly to changing meteorological and airspace conditions.
- System leverages through advanced navigation capabilities such as fixed radius transitions, RF legs, and RNP offsets.
- Increased use of operator-preferred routing and dynamic airspace.
- Increased collaboration between service providers and operators.

Operations at the busiest airports will be optimized through an integrated set of capabilities for managing pre-departure planning information, ground-based automation, and surface movement.

- RNP-based arrival and departure structure for greater predictability.
- Ground-based tactical merging capabilities in terminal airspace.
- Integrated capabilities for surface movement optimization to synchronize aircraft movement on the ground. Improved meteorological and aircraft intent information shared via data link.

### 5.4.3 Key Research Areas

The aviation community must address several key research issues to apply these strategies effectively. These issues fall into several categories:

**Navigation**

- To what extent can lower RNP values be achieved and how can these be leveraged for increased flight efficiency and access benefits?
- Under what circumstances RNAV should be mandated for arriving/departing satellite airports to enable conflict-free flows and optimal throughput in busy terminal areas?

**Flight Deck Automation**

- What FMS capabilities are required to enable the future concepts and applications?
- How can performance-based communication and surveillance be leveraged in the flight deck to enable Long-term strategies such as real-time exchange of flight deck data?

**Automation**

- To what extent can lateral or longitudinal separation assurance be fully automated, in particular on final approach during parallel operations?
- To what extent can surface movement be automated, and what are the cost-benefit trade-offs associated with different levels of automation?
- To what extent can conflict detection and resolution be automated for terminal ATC operations?

**Procedures**

- How can time of arrival control be applied effectively to maximize capacity of arrival or departure operations, in particular during challenging wind conditions?
- In what situations is delegation of separation to the flight crews appropriate?
- What level of onboard functionality is required for flight crews to accept separation responsibility within a manageable workload level?

**Airspace**

- To what extent can airspace be configured dynamically on the basis of predicted traffic demand and other factors?
- What separation standards and procedures are needed to enable smoother transition between en route and terminal operations?
- How can fuel-efficient procedures such as CDAs be accomplished in busy airspace?

**Glossary**

| | |
|---|---|
| 3D | Three-Dimensional |
| 4D | Four-Dimensional |
| ADS-B | Automatic Dependent Surveillance-Broadcast |
| ADS-C | Automatic Dependent Surveillance-Contract |
| ATC | Air Traffic Control |
| CDA | Continuous Descent Arrival |
| CNS | Communications, Navigation, Surveillance |
| EFVS | Enhanced Flight Visibility System |
| GA | General Aviation |
| GBAS | Ground-Based Augmentation System |
| GLS | GNSS (Global Navigation Satellite System) Landing System |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| ICAO | International Civil Aviation Organization |

| | |
|---|---|
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| LNAV | Lateral Navigation |
| LPV | Localizer Performance with Vertical Guidance |
| NAS | National Airspace System |
| NAVAID | Navigation Aid |
| NM | Nautical Miles |
| PBN | Performance Based Navigation |
| RCP | Required Communications Performance |
| RF | Radius-to-Fix |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RNPSORSG | Required Navigation Performance and Special Operational Requirements Study Group |
| RSP | Required Surveillance Performance |

| | |
|---|---|
| SAAAR | Special Aircraft and Aircrew Authorization Required |
| SID | Standard Instrument Departure |
| STAR | Standard Instrument Arrival |
| VLJ | Very Light Jet |
| VNAV | Vertical Navigation |
| WAAS | Wide Area Augmentation System |

## Appendix B – En route continental implementation schedule by area or city pair (to be developed by State )

**Appendix C – Terminal area and approach implementation schedule by aerodrome** (to be developed by by MID PBN/GNSS /TF )

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# Performance Based Navigation (PBN) Implementation Plan

# **Saudi Arabia**

-First Draft-

October 2009

## About the Plan

### Requirement for PBN

1.1 ICAO Assembly Resolution A36-23 calls for each State to develop a national PBN implementation plan by December 2009. This is a template developed by the ICAO PBN Programme as an example for use by the ICAO Contracting States as they each develop their own plans. This is only one example of what subjects a "National PBN Implementation Plan" that meets the intent of the resolution might include. States are encouraged to tailor their plans to meet their needs. This may mean that the "PBN Implementation Plan" is not stand-alone, but part of a broader plan for development of aviation in the State. This is a determination that only the State can make. It should be pointed out that if the State has not yet met its obligations with regard to conversion to the WGS-84 coordinate system, this should be included in the plan, as all RNAV and RNP operations are conducted solely with reference to WGS-84 coordinates.

### Why is a PBN implementation plan or roadmap needed?

1.2 With RVSM implemented or soon to be implemented in most of the world, the main tool for optimising the airspace structure is the implementation of performance-based navigation (PBN), which will foster the necessary conditions for the utilization of RNAV and RNP capabilities by a significant portion of airspace users in the Regions and State s.

1.3 Current planning by the Regional Planning and Implementation Groups is based on the Air Navigation Plans and the Regional CNS/ATM Plans. Currently, these plans are mostly made up of tables that do not contain the necessary details for the implementation of each of the CNS and ATM elements. For this reason, the Regions will be developing Regional PBN implementation plans. The necessary concurrent and follow-on step is to develop national plans that implement the regional plans at the State level and address PBN implementation strategy at the national level.

1.4 In view of the need for detailed navigation planning, it was deemed advisable to call for preparation of a national PBN Implementation Plan by each State, to provide proper guidance and direction to the domestic air navigation service provider(s), airspace operators and users, regulating agency, as well as foreign operators who operate or plan to operate in the State. This guidance should address the planned evolution of navigation, as one of the key systems supporting air traffic management, and describe the RNAV and RNP navigation applications that should be implemented in at least the short and medium term, in the State.

### What are the objectives of the PBN Implementation Plan or Roadmap?

1.5 The PBN implementation plan should meet the following strategic objectives:

a) provide a high-level strategy for the evolution of the navigation applications to be implemented in the State in the short term (2008-2012) and medium term (2013-2016). This strategy is based on the concepts of PBN, Area Navigation (RNAV) and Required Navigation Performance (RNP), which 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 in accordance with the implementation goals in the Assembly resolution;

b) ensure that the implementation of the navigation portion of the CNS/ATM system is based on clearly established operational requirements;

c) avoid unnecessarily imposing the mandate for multiple equipment on board or multiple systems on the ground;

d) avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations;

e) prevent commercial interests from outdoing ATM operational requirements, generating unnecessary costs for the State as well as for airspace users.

**What is the intent of the PBN Implementation Plan or Roadmap?**

1.6 The PBN Implementation Plan should be developed by the State together with the stakeholders concerned 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 roadmap and should therefore be included in the development process are:

- Airspace operators and users
- Air navigation service providers
- Regulating agencies
- National and international organizations

1.7 The PBN Implementation 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 roadmap to plan 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 as well as the future regulatory workload and associated training requirements for their work force.

**What principles should be applied in development of the PBN Implementation Plan or Roadmap?**

1.8 The implementation of PBN in the State should be based on the following principles:

a) Continued application of conventional air navigation procedures during the transition period, to guarantee availability by users that are not RNAV- and/or RNP-equipped;

b) Development of airspace concepts, applying airspace modeling tools as well as real-time and accelerated simulations, which identify the navigation applications that are compatible with the aforementioned concept;

c) Conduct of cost-benefit analyses to justify the implementation of the RNAV and/or RNP concepts in each particular airspace;

d) Conduct of pre- and post-implementation safety assessments to ensure the application and maintenance of the established target levels of safety.

e) Must not conflict with the regional PBN implementation plan.

**Table of contents**

## 1. Introduction

The MID Region Performance Based Navigation (PBN) Roadmap details the framework within which the ICAO PBN concept will be implemented in the MID Region for the foreseeable future. The MID Region Roadmap for PBN is guided by ICAO Doc. 9613 and relevant SARPs. The primary driver for this plan is to maintain and increase safety, air traffic demand and capacity, and services and technology in consultation with relevant stakeholders. The MID Region Roadmap also supports national and international interoperability and global harmonization.

## 2. Background

The continuing growth of aviation places increasing demands on airspace capacity and emphasizes the need for the optimum utilization of the available airspace.

Growth in scheduled and General Aviation aircraft is expected to increase point-to-point and direct routings. The increasing cost of fuel also presents a significant challenge to all segments of the aviation community. This anticipated growth and higher complexity of the air transportation system could result in increased flight delays, schedule disruptions, choke points, inefficient flight operations, and passenger inconvenience, particularly when unpredictable weather and other factors constrain airport capacity. Without improvements in system efficiency and workforce productivity, the aviation community and cost of operations will continue to increase. Upgrades to the air transportation system must leverage current and evolving capabilities in the near term, while building the foundation to address the future needs of the aviation community stakeholders. These circumstances can be partially alleviated by efficiencies in airspace and procedures through the implementation of PBN concepts.

In setting out requirements for navigation applications on specific routes or within a specific airspace, it is necessary to define requirements in a clear and concise manner. This is to ensure that both flight crew and ATC are aware of the on-board area navigation (RNAV) system capabilities and to ensure that the performance of the RNAV system is appropriate for the specific airspace requirements.

The early use of RNAV systems arose in a manner similar to conventional ground-based routes and procedures. A specific RNAV system was identified and its performance was evaluated through a combination of analysis and flight testing. For domestic operations the initial systems used VOR and DME for their position estimation. For oceanic operations, inertial navigation systems (INS) were employed.

These ‘new’ systems were developed, evaluated and certified. Airspace and obstacle clearance criteria were developed on the basis of available equipment performance. Requirements specifications were based upon available capabilities and, in some implementations, it was necessary to identify the individual models of equipment that could be operated within the airspace concerned.

Such prescriptive requirements result in delays to the introduction of new RNAV system capabilities and higher costs for maintaining appropriate certification. To avoid such prescriptive specifications of requirements, the PBN concept introduces an alternative method for defining equipage requirements by specification of the performance requirements. This is termed Performance Based Navigation (PBN).

## 3. Performance Based Navigation (PBN)

Performance based navigation (PBN) is a concept that encompasses both area navigation (RNAV) and required navigation performance (RNP) and revises the current RNP concept. Performance based navigation is increasingly seen as the most practical solution for regulating the expanding domain of navigation systems.

Under the traditional approach, each new technology is associated with a range of system-specific requirements for obstacle clearance, aircraft separation, operational aspects (e.g. arrival and approach procedures), aircrew operational training and training of air traffic controllers. However, this system-specific approach imposes an unnecessary effort and expense on States, airlines and air navigation services (ANS) providers.

Performance based navigation eliminates the need for redundant investment in developing criteria and in operational modifications and training. Rather than build an operation around a particular system, under performance based navigation the operation is defined according to the operational goals, and the available systems are then evaluated to determine whether they are supportive.

The advantage of this approach is that it provides clear, standardized operational approvals which enable harmonized and predictable flight paths which result in more efficient use of existing aircraft capabilities, as well as improved safety, greater airspace capacity, better fuel efficiency, and resolution of environmental issues.

The PBN concept specifies aircraft RNAV 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. 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.

Under PBN, generic navigation requirements are defined based on the operational requirements. Operators are then able to evaluate options in respect of available technologies and navigation services that could allow these requirements to be met. The chosen solution would be the most cost effective for the operator, rather than a solution being imposed as part of the operational requirements. Technologies can evolve over time without requiring the operation itself to be revisited, as long as the requisite performance is provided by the RNAV system. As part of the future work of the ICAO, it is anticipated that other means for meeting the requirements of the Navigation Specifications will be evaluated and may be included in the applicable Navigation Specifications, as appropriate.

ICAO's Performance Based Navigation (PBN) concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use worldwide. It is a new concept based on the use of Area Navigation (RNAV) systems. Significantly, it is a move from a limited Statement of required performance accuracy to more extensive Statements for required performance in terms of accuracy, integrity, continuity and availability, together with descriptions of how this performance is to be achieved in terms of aircraft and flight crew requirements.

### 3.1. RNAV Current status in Saudi Arabia

**3.1.1 RNAV have been developed for ATS routes, SIDs, STARs and approaches for a number of airports. The plan is to apply this for all airports.**

**3.1.2 Fleet equipage**

The data will be researched and included.

### 3.2 Benefits of PBN and global harmonization

PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. These include:

- Reduces need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.
- Avoids need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.
- Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).
- Clarifies the way in which RNAV systems are used.
- Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects. Specifically, RNAV and RNP may:

- Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.
- Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.
- Improve efficiency and flexibility by increasing use of operator-preferred trajectories airspace-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.
- Reduce workload and improve productivity of air traffic controllers.

Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of aviation stakeholders and service providers.

### 3.3 Stakeholders

Coordination is critical with the aviation community through collaborative forums. This will assist aviation stakeholders in understanding operational goals, determining requirements, and considering future investment strategies. This, in turn, enables the aviation stakeholders to focus on addressing future efficiency and capacity needs while maintaining or improving the safety of flight operations by leveraging advances in navigation capabilities on the flight deck. RNAV and RNP have reached a sufficient level of maturity and definition to be included in key plans and strategies, such as this State PBN plan.

The stakeholders who will benefit from the concepts in this State PBN plan include airspace operators, air traffic service providers, regulators, and standards organizations. As driven by business needs, airlines and operators can use the State PBN roadmap to plan future equipage and capability investments. Similarly, air traffic service providers can determine requirements for future automation systems, and more smoothly modernize ground infrastructure. Finally, regulators and standards organizations can anticipate and develop the key enabling criteria needed for implementation.

This plan is a work in progress and will be amended through collaborative MID Region States, industry efforts and consultations that establish a joint aviation community/government/industry strategy for implementing performance-based navigation. Critical initiative strategies are required to accommodate the expected growth and complexity over the next two decades. These strategies have five key features:

- Expediting the development of performance-based navigation criteria and standards.
- Introducing airspace and procedure improvements in the near term.
- Providing benefits to operators who have invested in existing and upcoming capabilities.
- Establishing target dates for the introduction of navigation mandates for selected procedures and airspace, with an understanding that any mandate must be rationalized on the basis of benefits and costs.
- Defining new concepts and applications of performance-based navigation for the mid term and Long term and building synergy and integration among other capabilities toward the realization of the MID Region PBN goals.

## 4. Challenges

### 4.1 Increasing Demands

- New fleets start operations.
- New airports built and operated.
- New airports are converted to operate as international airports.
- International airports upgraded to accept new types of aircraft.
- Operators request new procedures.
- Increasing traffic.

#### 4.1.1 En route

##### 4.1.1.1 Remote Continental

(RNAV10 )

##### 4.1.1.2 Continental

(RNAV5 )

#### 4.1.2 Terminal Areas (Departures and Arrivals)

(Available but RNAV type to be checked. )

#### 4.1.3 Approach

Available but RNAV type to be checked. )

## 5. Implementation strategy

This plan provides a high-level strategy for the evolution of navigation capabilities to be implemented in three timeframes: near term (2008-2012), mid term (2013-2016), and Long term (2017 and Beyond). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en-route continental, oceanic and remote operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.

To avoid proliferation of new navigation standards, Saudi Arabia and other aviation stakeholders in the MID region should communicate any new operational requirements with ICAO HQ, so that it can be taken into account by the ICAO Study Group in charge of PBN.

**Near Term (2008-2012) Mid Term (2013-2016) and Long Term (2017 and Beyond) Key Tasks**

The key tasks involved in the transition to performance-based navigation are:

- Establish navigation service needs through the Long term that will guide infrastructure decisions and specify needs for navigation system infrastructure, and ensure funding for managing and transitioning these systems.
- Define and adopt a national policy enabling additional benefits based on RNP and RNAV.
- Identify operational and integration issues between navigation and surveillance, air-ground communications, and automation tools that maximize the benefits of RNP.
- Support mixed operations throughout the term of this Roadmap, in particular considering navigation system variations during the near term until appropriate standards are developed and implemented.

- To support Civil/Military coordination and develop the policies needed to accommodate the unique missions and capabilities of military aircraft operating in civil airspace.
- Harmonize the evolution of capabilities for interoperability across airspace operations.
- Increase emphasis on human factors, especially on training and procedures as operations increase reliance on appropriate use of flight deck systems.
- Facilitate and advance environmental analysis efforts required to support the development of RNAV and RNP procedures.
- Maintain consistent and harmonized global standards for RNAV and RNP operations.

**5.2 Near term strategy (2008-2012)**

In the near-term, initiatives focus on investments by operators in current and new aircraft acquisitions, in satellite-based navigation and conventional navigation infrastructure as well as Saudi Arabia investments. Key components include wide-scale RNAV implementation and the introduction of RNP for en route, terminal, and approach procedures.

The near-term strategy will also focus on expediting the implementation and proliferation of RNAV and RNP procedures. As demand for air travel continues at healthy levels, choke points will develop and delays at the major airports will continue to climb. RNAV and RNP procedures will help alleviate those problems. Continued introduction of RNAV and RNP procedures will not only provide benefits and savings to the operators but also encourage further equipage.

ANSPs as a matter of urgency must adapt new flight plan procedures to accommodate PBN operations. This particularly addresses fields 10 and 18.

Operators will need to plan to obtain operational approvals for the planned Navigation Specifications for this period. Operators shall also review Regional PBN Implementation Plans from other Regions to assess if there is a necessity for additional Operational approvals.

**5.2.1 En route**

**5.2.1.1 Remote Continental**

To promote global harmonization, Saudi Arabia continues to work closely with its international partners in implementing RNAV–10 and where operationally required RNP-4 by 2010. Safety assessment shall be undertaken to evaluate reduced oceanic and remote longitudinal/lateral separation minima between aircraft approved for RNAV-10 and RNP-4 operations.

For Oceanic and Remote Areas where high density traffic operations occur, a review of the airspace concept must be undertaken to convert to Continental En-Route Operation where sufficient, surveillance is available so as to allow RNAV-5 operations.

**5.2.1.2 Continental**

For airspace and corridors requiring structured routes for flow management, Saudi Arabia will review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV-2/1.

**5.2.2 Terminal Areas (Departures and Arrivals)**

RNAV reduces conflict between traffic flows by consolidating flight tracks. RNAV-1/Basic RNP-1 SIDs and

STARs improve safety, capacity, and flight efficiency and also lower communication errors.

Saudi Arabia will continue to plan, develop and implement RNAV-1 SIDs and STARs, at major airports and make associated changes in airspace design. In addition, Saudi Arabia will implement Basic RNP-1 SIDs and STARs. RNAV-1 will be implemented in airspace where there is sufficient surveillance coverage and Basic RNP-1 where there is no such coverage.

Where operationally feasible, Saudi Arabia should develop operational concepts and requirements for continuous descent arrivals (CDAs) based on FMS Vertical Guidance and for applying time of arrival control based on RNAV and RNP procedures. This would reduce workload for pilots and controllers as well as increase fuel efficiency.

PBN SIDs and STARS would allow the following:

- Reduction in controller-pilot communications;
- Reduction of route lengths to meet environmental and fuel efficiency requirements;.
- Seamless transition from and to en-route entry/exit points;
- Sequence departures to maximize benefits of RNAV and identify automation requirements for traffic flow management, sequencing tools, flight plan processing, and tower data entry activities.

### 5.2.3 Approach

The application of RNP APCH is expected to be implemented in the maximum possible number of aerodromes. To facilitate a transitional period, conventional approach procedures and conventional navigation aids should be maintained for non PBN equipped aircraft during this term.

Saudi Arabia should promote the use of APV Operations (Baro-VNAV or SBAS) to enhance safety of RNP Approaches and accessibility of runways.

The application of RNP AR Approach should be limited to selected runways where obvious operational benefits can be obtained due to the existence of significant obstacles.

RNP approaches include:

- APV implemented at all instrument runways at major regional airports and all non-instrument runways serving aircraft weighing greater than 5,700kg.

### 5.2.5 Summary near term strategy

| Airspace | Nav. Specifications | Nav Specifications where operationally required |
|---|---|---|
| En-Route Remote Continental | RNAV-10 | RNP-4 |
| En-Route Continental | RNAV-5 | RNAV-1 |
| TMA Arrival/Departure | RNAV-1 in a surveillance environment | |

| | | |
|---|---|---|
| | Basic RNP-1 in non-surveillance environment | |
| Approach | RNP APCH with Baro-VNAV<br><br>or<br><br>RNP AR APCH if required | |

### 1.9 Implementation Targets

- RNP APCH (with Baro-VNAV) in 30% of instrument runways by 2010 and 50% by 2012 and priority given to airports with operational benefits
- RNAV-1 SID/STAR for 30% of international airports by 2010 and 50% by 2012 and priority given to airports with RNP Approach
- Review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV-2/1 by 2012.

### 5.3 Medium term strategy (2013-2016)

In the mid term, increasing demand for air travel will continue to challenge the efficiencies of the air traffic management system.

While the hub-and-spoke system will remain largely the same as today for major airline operations, the demand for more point-to-point service will create new markets and spur increases in low-cost carriers, air taxi operations, and on-demand services. Additionally, the emergence of VLJs is expected to create new markets in the general and business aviation sectors for personal, air taxi, and point-to-point passenger operations. Many airports will thus experience significant increases in unscheduled traffic. In addition, many destination airports that support scheduled air carrier traffic are forecast to grow and to experience congestion or delays if efforts to increase their capacity fall short. As a result, additional airspace flexibility will be necessary to accommodate not only the increasing growth, but also the increasing air traffic complexity.

The mid term will leverage these increasing flight capabilities based on RNAV and RNP, with a commensurate increase in benefits such as fuel-efficient flight profiles, better access to airspace and airports, greater capacity, and reduced delay. These incentives, which should provide an advantage over non-RNP operations, will expedite propagation of equipage and the use of RNP procedures.

To achieve efficiency and capacity gains partially enabled by RNAV and RNP, Saudi Arabia and aviation industry will pursue use of data communications (e.g., for controller-pilot communications) and enhanced surveillance functionality, e.g. ADS-Broadcast (ADS-B). Data communications will make it possible to issue complex clearances easily and with minimal errors. ADS-B will expand or augment surveillance coverage so that track spacing and longitudinal separation can be optimized where needed (e.g., in non-radar airspace). Initial capabilities for flights to receive and confirm 3D clearances and time of arrival control based on RNP will be demonstrated in the mid term. With data link implemented, flights will begin to transmit 4D trajectories (a set of points defined by latitude, longitude, altitude, and time.) Stakeholders must therefore develop concepts that leverage this capability.

**5.3.1 En route**

**5.3.1.1 Remote Continental**

In the mid term, Saudi Arabia will endeavour to work with international air traffic service providers to promote the application of RNP 10 and RNP 4 in additional sub-regions of the oceanic environment.

**5.3.1.2 Continental**

The review of en-route airspace will be completed by 2016.

**Implementation**

By the end of the mid term other benefits of PBN will have been enabled, such as flexible procedures to manage the mix of faster and slower aircraft in congested airspace and use of less conservative PBN requirements.

**Automation for RNAV and RNP Operations**

By the end of the mid term enhanced en route automation will allow the assignment of RNAV and RNP routes based upon specific knowledge of an aircraft's RNP capabilities. En route automation will use collaborative routing tools to assign aircraft priority, since the automation system can rely upon the aircraft's ability to change a flight path and fly safely around problem areas. This functionality will enable the controller to recognize aircraft capability and to match the aircraft to dynamic routes or procedures, thereby helping appropriately equipped operators to maximize the predictability of their schedules.

Conflict prediction and resolution in most en route airspace must improve as airspace usage increases. Path repeatability achieved by RNAV and RNP operations will assist in achieving this goal. Mid-term automation tools will facilitate the introduction of RNP offsets and other forms of dynamic tracks for maximizing the capacity of airspace. By the end of the mid term, en route automation will have evolved to incorporate more accurate and frequent surveillance reports through ADS-B, and to execute problem prediction and conformance checks that enable offset manoeuvres and closer route spacing (e.g., for passing other aircraft and manoeuvring around weather).

**5.3.2 Terminal Areas (Departures and Arrivals)**

During this period, either Basic RNP-1 or RNAV-1 will become a required capability for flights arriving and departing major airports based upon the needs of the airspace, such as the volume of traffic and complexity of operations. This will ensure the necessary throughput and access, as well as reduced controller workload, while maintaining safety standards.

With RNAV-1 operations as the predominant form of navigation in terminal areas by the end of the mid term, MID Saudi Arabia will have the option to remove conventional terminal procedures that are no longer expected to be used.

**Terminal Automation**

Terminal automation will be enhanced with tactical controller tools to manage complex merges in busy terminal areas. As data communications become available, the controller tools will apply knowledge of flights' estimates of time of arrival at upcoming waypoints, and altitude and speed constraints, to create efficient maneuvers for optimal throughput.

Terminal automation will also sequence flights departing busy airports more efficiently than today. This capability will be enabled as a result of PBN and flow management tools. Flights arriving and departing busy terminal areas will follow automation-assigned PBN routes.

### 5.3.3 Approach

In the mid term, implementation priorities for instrument approaches will still be based on RNP APCH and RNP AR APCH and full implementation is expected at the end of this term.

The introduction of the application of landing capability, using GBAS (currently non PBN) is expected to guarantee a smooth transition towards high performance approach and landing capability.

### 5.3.4 Helicopter operations (To be developed)

### 5.3.5 Medium term strategy summary

| **Airspace** | **Nav. Specifications** | **Nav. Specifications where operationally required** |
|---|---|---|
| En-Route Remote Continental | RNAV-10, | RNP-4 |
| En-Route Continental | RNAV-2, RNAV-5 | RNAV-1 |
| TMA Arrival/Departure | Expand RNAV-1, or basic RNP-1 application<br><br>Mandate RNAV-1, or basic RNP-1 | |
| Approach | Expand RNP APCH with (Baro-VNAV) and APV<br><br>Expand RNP AR APCH where there are operational benefits | |

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 as required

### 5.4 Long term strategy (2017 and beyond)

The Long-term environment will be characterized by continued growth in air travel and increased air traffic complexity.

No one solution or simple combination of solutions will address the inefficiencies, delays, and congestion

anticipated to result from the growing demand for air transportation. Therefore, Saudi Arabia and key Stakeholders need an operational concept that exploits the full capability of the aircraft in this time frame.

### 5.4.1 Long Term Key Strategies (2017 and Beyond)

Airspace operations in the Long term will make maximum use of advanced flight deck automation that integrates CNS capabilities. RNP, RCP, and RSP standards will define these operations. Separation assurance will remain the principal task of air traffic management in this time frame. This task is expected to leverage a combination of aircraft and ground-based tools. Tools for conflict detection and resolution, and for flow management, will be enhanced significantly to handle increasing traffic levels and complexity in an efficient and strategic manner.

Strategic problem detection and resolution will result from better knowledge of aircraft position and intent, coupled with automated, ground-based problem resolution. In addition, pilot and air traffic controller workload will be lowered by substantially reducing voice communication of clearances, and furthermore using data communications for clearances to the flight deck. Workload will also decrease as the result of automated confirmation (via data communications) of flight intent from the flight deck to the ground automation.

With the necessary aircraft capabilities, procedures, and training in place, it will become possible in certain situations to delegate separation tasks to pilots and to flight deck systems that depict traffic and conflict resolutions. Procedures for airborne separation assurance will reduce reliance on ground infrastructure and minimize controller workload. As an example, in IMC an aircraft could be instructed to follow a leading aircraft, keeping a certain distance. Once the pilot agreed, ATC would transfer responsibility for maintaining spacing (as is now done with visual approaches).

Performance-based operations will exploit aircraft capabilities for “electronic” visual acquisition of the external environment in low-visibility conditions, which may potentially increase runway capacity and decrease runway occupancy times.

Improved wake prediction and notification technologies may also assist in achieving increased runway capacity by reducing reliance on wake separation buffers.

System-wide information exchange will enable real-time data sharing of NAS constraints, airport and airspace capacity, and aircraft performance. Electronic data communications between the ATC automation and aircraft, achieved through data link, will become widespread—possibly even mandated in the busiest airspace and airports. The direct exchange of data between the ATC automation and the aircraft FMS will permit better strategic and tactical management of flight operations.

Aircraft will downlink to the ground-based system their position and intent data, as well as speed, weight, climb and descent rates, and wind or turbulence reports. The ATC automation will uplink clearances and other types of information, for example, weather, metering, choke points, and airspace use restrictions.

To ensure predictability and integrity of aircraft flight path, RNP will be mandated in busy en route and terminal airspace. RNAV operations will be required in all other airspace (except oceanic). Achieving standardized FMS functionalities and consistent levels of crew operation of the FMS is integral to the success of this Long-term strategy.

The most capable aircraft will meet requirements for low values of RNP (RNP 0.3 or lower en route). Flights by such aircraft are expected to benefit in terms of airport access, shortest routes during IMC or convective weather, and the ability to transit or avoid constrained airspace, resulting in greater efficiencies and fewer delays operating into and out of the busiest airports.

Enhanced ground-based automation and use of real-time flight intent will make time-based metering to terminal airspace a key feature of future flow management initiatives. This will improve the sequencing and spacing of flights and the efficiency of terminal operations.

Uniform use of RNP for arrivals and departures at busy airports will optimize management of traffic and merging streams. ATC will continue to maintain control over sequencing and separation; however, aircraft arriving and departing the busiest airports will require little controller intervention. Controllers will spend more time monitoring flows and will intervene only as needed, primarily when conflict prediction algorithms indicate a potential problem.

More detailed knowledge of meteorological conditions will enable better flight path conformance, including time of arrival control at key merge points. RNP will also improve management of terminal arrival and departure with seamless routing from the en route and transition segments to the runway threshold. Enhanced tools for surface movement will provide management capabilities that synchronize aircraft movement on the ground; for example, to coordinate taxiing aircraft across active runways and to improve the delivery of aircraft from the parking areas to the main taxiways.

### 5.4.2 Summary of Long Term Key Strategies (2017 and Beyond)

The key strategies for instituting performance-based operations employ an integrated set of solutions.

- Airspace operations will take advantage of aircraft capabilities, i.e. aircraft equipped with data communications, integrated displays, and FMS.
- Aircraft position and intent information directed to automated, ground-based ATM systems, strategic and tactical flight deck-based separation assurance in selected situations (problem detection and resolution).
- Strategic and tactical flow management will improve through use of integrated airborne and ground information exchange.
- Ground-based system knowledge of real-time aircraft intent with accurate aircraft position and trajectory information available through data link to ground automation.
- Real-time sharing of National Air Space (NAS) flight demand and other information achieved via ground-based and air-ground communication between air traffic management and operations planning and dispatch.
- Overall system responsiveness achieved through flexible routing and well-informed, distributed decision-making.
- Systems ability to adapt rapidly to changing meteorological and airspace conditions.
- System leverages through advanced navigation capabilities such as fixed radius transitions, RF legs, and RNP offsets.
- Increased use of operator-preferred routing and dynamic airspace.
- Increased collaboration between service providers and operators.

Operations at the busiest airports will be optimized through an integrated set of capabilities for managing pre-departure planning information, ground-based automation, and surface movement.

- RNP-based arrival and departure structure for greater predictability.
- Ground-based tactical merging capabilities in terminal airspace.
- Integrated capabilities for surface movement optimization to synchronize aircraft movement on the ground. Improved meteorological and aircraft intent information shared via data link.

### 5.4.3 Key Research Areas

The aviation community must address several key research issues to apply these strategies effectively. These issues fall into several categories:

**Navigation**

- To what extent can lower RNP values be achieved and how can these be leveraged for increased flight efficiency and access benefits?
- Under what circumstances RNAV should be mandated for arriving/departing satellite airports to enable conflict-free flows and optimal throughput in busy terminal areas?

**Flight Deck Automation**

- What FMS capabilities are required to enable the future concepts and applications?
- How can performance-based communication and surveillance be leveraged in the flight deck to enable Long-term strategies such as real-time exchange of flight deck data?

**Automation**

- To what extent can lateral or longitudinal separation assurance be fully automated, in particular on final approach during parallel operations?
- To what extent can surface movement be automated, and what are the cost-benefit trade-offs associated with different levels of automation?
- To what extent can conflict detection and resolution be automated for terminal ATC operations?

**Procedures**

- How can time of arrival control be applied effectively to maximize capacity of arrival or departure operations, in particular during challenging wind conditions?
- In what situations is delegation of separation to the flight crews appropriate?
- What level of onboard functionality is required for flight crews to accept separation responsibility within a manageable workload level?

**Airspace**

- To what extent can airspace be configured dynamically on the basis of predicted traffic demand and other factors?

- What separation standards and procedures are needed to enable smoother transition between en route and terminal operations?
- How can fuel-efficient procedures such as CDAs be accomplished in busy airspace?

**Glossary**

| | |
|---|---|
| 3D | Three-Dimensional |
| 4D | Four-Dimensional |
| ADS-B | Automatic Dependent Surveillance-Broadcast |
| ADS-C | Automatic Dependent Surveillance-Contract |
| ATC | Air Traffic Control |
| CDA | Continuous Descent Arrival |
| CNS | Communications, Navigation, Surveillance |
| EFVS | Enhanced Flight Visibility System |
| GA | General Aviation |
| GBAS | Ground-Based Augmentation System |
| GLS | GNSS (Global Navigation Satellite System) Landing System |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| ICAO | International Civil Aviation Organization |

| | |
|---|---|
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| LNAV | Lateral Navigation |
| LPV | Localizer Performance with Vertical Guidance |
| NAS | National Airspace System |
| NAVAID | Navigation Aid |
| NM | Nautical Miles |
| PBN | Performance Based Navigation |
| RCP | Required Communications Performance |
| RF | Radius-to-Fix |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RNPSORSG | Required Navigation Performance and Special Operational Requirements Study Group |
| RSP | Required Surveillance Performance |

| | |
|---|---|
| SAAAR | Special Aircraft and Aircrew Authorization Required |
| SID | Standard Instrument Departure |
| STAR | Standard Instrument Arrival |
| VLJ | Very Light Jet |
| VNAV | Vertical Navigation |
| WAAS | Wide Area Augmentation System |

**Appendix A –Remote Continental implementation schedule by area or city pair** (to be developed)

**Appendix B – En route continental implementation schedule by area or city pair** (to be developed)

**Appendix C – Terminal area and approach implementation schedule by aerodrome** (to be developed)



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PBN/GNSS TF/2
Appendix 5G to the Report on Agenda Item 5

## PBN IMPLEMENTATION FOCAL POINT

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UPDATED 08-12-09

## <STATE> PBN APPROACH and TERMINAL IMPLEMENTATION STATUS

| NO | ICAO REGION | ICAO DESIG | AIRPORT NAME[5] | COUNTRY | INTL (Y/N)[1] | RUNWAY | INST RWY Y/N | RESTRICTIONS | APPROACH TYPE[2, 7] | APPR EFF DATE[6] | RNAV/RNP SID[3] | SID EFF DATE[6] | RNAV/RNP STAR[4] | STAR EFF DATE[6] | COMMENTS[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MID | | | | | | | | | | | | RNAV-1 | | |
| 2 | | | | | | | Y | | | | | | RNAV | | |

**ABOVE IS ONLY AN EXAMPLE. IT IS NOT MEANT TO SHOW THE ACTUAL RUNWAY CONFIGURATION OR PBN IMPLEMENTATION AT THAT AIRPORT**

Notes:

1. If the aerodrome is used for international operations, including as an alternate, enter 'Y', if not, enter 'N'
2. If RNP APCH only, enter RNP APCH. If RNP APCH with Baro-VNAV only, enter RNP APCH-VNAV. If both enter BOTH. If RNP AR APCH, enter RNP AR APCH. If there is an RNP AR to the same runway that also has an RNP APCH and/or RNP APCH-VNAV then enter the RNP AR on a separate line for that runway. If this block is filled out "RNP APCH", then provide some explanation in the comment block, e.g. either, "planning to upgrade to RNP APCH-VNAV by [date] or APV not feasible for [reason].
3. If RNAV or RNP SID exists for this runway, note navigation specification, RNAV 1, RNAV 2, or Basic-RNP 1. If not based on a PBN navigation specification, enter RNAV.
4. If RNAV or RNP STAR exists for this aerodrome note navigation specification, RNAV-1, RNAV 2, or Basic-RNP 1. If not based on a PBN navigation specification, enter RNAV.
5. Should list all instrument aerodromes and runway ends in the State, as well as non-instrument runway ends that are used by aircraft in excess of 5700 kg MTOW. Leave blank blocks J-O as appropriate, if PBN or RNAV approaches, SIDs or STARs are not implemented or planned to be implemented yet for that runway as part of the State PBN Implementation Plan.
6. Enter actual effective date or proposed future effective date as 3-letter month-2-digit year: Oct-07
7. Provide any relevant comments

ISLAMIC REPUBLIC OF **IRAN** PBN APPROACH and TERMINAL IMPLEMENTATION STATUSLNAV

| NO | ICAO REGION | ICAO DESIG | AIRPORT NAMES | C O U N T R Y | INTL (Y/N) | RUNWAY | INST RWY Y/N | RESTRICTIONS | APPROACH LNAV/VNAV | APP R EFF DATE | RNAV/RNP SID` | S I D EFF DATE | RNAV /RNP STAR | STAR EFF DATE | MMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | MID | OIIE | IMAM KHOMAINI | ISLAMIC REPUBLIC OF IRAN | Y | 29<br>11 | Y<br>Y | | LNAV | OCT-09 | RNAV-1 | OCT-09 | RNAV | OCT-09 | |
| **2** | MID | OIII | MEHRABAD | ISLAMIC REPUBLIC OF IRAN | Y | 29L<br>29R<br>11L<br>11R | Y<br>Y<br>Y<br>Y | | LNAV | OCT-10 | RNAV-1 | OCT- 10 | RNAV | OCT-10 | |
| **3** | MID | OIMM | MASHHAD (SHAHID HASHEMI NEJAD) | ISLAMIC REPUBLIC OF IRAN | Y | 31L<br>31R<br>13L<br>13R | Y<br>Y<br>Y<br>Y | | LNAV | OCT-10 | RNAV-1 | OCT- 10 | RNAV | OCT-10 | |
| **4** | MID | OISS | SHIRAZ (SHAHID DASTGHAIB) | ISLAMIC REPUBLIC OF IRAN | Y | 29L<br>29R<br>11L<br>11R | Y<br>Y<br>Y<br>Y | | LNAV | OCT-10 | RNAV-1 | OCT- 10 | RNAV | OCT-10 | |
| **5** | MID | OIFM | ESFAHAN (SHAHID BEHESHTI) | ISLAMIC REPUBLIC OF IRAN | Y | 26L<br>26R<br>08L<br>08R | Y<br>Y<br>Y<br>Y | | LNAV | OCT-10 | RNAV-1 | OCT- 10 | RNAV | OCT-10 | |

LEBANON PBN APPROACH &TERMINAL IMPLMENTATION STATUS

| NO | ICAO REGION | ICAO DESIG | AIRPORT NAME[5] | COUNTRY | INTL (Y/N)[1] | RUNWA | INST RWY Y/N | RESTRICTIONS IF ANY | APPROACH TYPE[2,7] | APPR EFF DATE[6] | RNAV/RNP SID[3] | SID EFF DATE[6] | RNAV/RNP STAR[4] | STAR EFF DATE[6] | COMMENTS[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MID | OLBA | BEIRUT INTL AIRPORT | LEBANON | Y | 16 | Y | LANDING ONLY | RNAV(GNSS) | 11APR08 | NIL | NIL | RNAV | 11APR08 | |
| 2 | MID | OLBA | BEIRUT INTL AIRPORT | LEBANON | Y | 34 | Y | TAKEOFF ONLY | NIL | NIL | NIL | NIL | NIL | NIL | |
| 3 | MID | OLBA | BEIRUT INTL AIRPORT | LEBANON | Y | 03 | Y | NIL. | RNAV(GNSS) | 11APR08 | NIL | NIL | RNAV | 11APR08 | |
| 4 | MID | OLBA | BEIRUT INTL AIRPORT | LEBANON | Y | 21 | Y | NOT USED FOR LANDING DURING NIGHT | RNAV(GNSS) | 11APR08 | NIL | NIL | RNAV | 11APR08 | |
| 5 | MID | OLBA | BEIRUT INTL AIRPORT | LEBANON | Y | 17 | Y | SECODARY RWY | RNAV(GNSS) | 11APR08 | NIL | NIL | RNAV | 11APR08 | |
| 5 | MID | OLBA | BEIRUT INTL AIRPORT | LEBANON | Y | 35 | Y | NOT USED FOR LANDING | NIL | NIL | NIL | NIL | NIL | NIL | |
| 7 | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | |

**1.** If the aerodrome is used for international operations, including as an alternate, enter 'Y', if not, enter 'N' **2.** If RNP APCH only, enter RNP APCH. If RNP APCH with Baro-VNAV only, enter RNP APCH-VNAV. If both enter BOTH. If RNP AR, enter RNP AR AP

Appendix 1

Jordan

PBN implementation time schedule

| Navigation Specification | Airspace Application | Short Term | | | | Medium Term | | | | Long Term | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017…. | 2025 |
| RNAV10 | NA | Will not be used | | | | | | | | | |
| RNP4 | NA | Will not be used | | | | | | | | | |
| RNAV2 | NA | Will not be used | | | | | | | | | |
| RNP5 into RNAV5 | Enroute | | | | | | | | | | |
| RNAV1 | Enrout | | | | | | | | | | |
| RNAV1 | TMA Dep. and Arr. Sur | | | | | | | | | | |
| Basic RNP1 | TMA Dep. and Arr. Non sur | | | | | | | | | | |
| RNP APCH | Approach | | | | | | | | | | |
| RNP AR APCH | Approach KHIA | | | | | | | | | | |
| RNAV1 | SIDs / STARs | | | | | | | | | | |
| Basic RNP1 | Enrout | | | | | | | | | | |
| advanced-RNP-1 | en-route | | | | | | | | | | |
| advanced-RNP-1 | terminal airspace | | | | | | | | | | |
| Use of NDB | Approach operations | | | | | Stop using the NDB for approach operations | | | | | |
| Conventional NPA procedures | | | | | | | | | | Stop the conventional NPA procedures | |

**PBN IMPLEMENTATION PROGRESS REPORT**

**State: (Name of State)** Date: (DD/MM/YY)

**Designation of PBN Focal Point**
*Reference:* MID State Letter Ref AN 6/28 – 149 dated 21 April 2008 and follow up letter Ref AN6/28 – 293 dated 10 August " in order to facilitate necessary follow-up and coordination, to provide a PBN Implementation Focal Point by 21 August 2008 "

*Status:* (Nominated/ To be Nominated)
*Focal Point:* (Name, Designation, Mailing Address, Email, Phone, Fax)

**State PBN Implementation Plan**
*Reference:* MIDANPIRG Conclusion 11/74 – PBN State implementation Plan
*"That, That, in order to give effect to Assembly Resolution A36-23: Performance based navigation global goals, MID States are urged to complete development of their individual State Implementation plans based on the regional PBN implementation plan by 30 September 2009 so that it may be reviewed by the ATM/SAR/AIS SG as part of the Regional agreement process.*

*Status:* (Adopted / To be adopted) by (name of a national body) and (Reviewed / To be reviewed) by ICAO *PBN/GNSS* TF
*Note(s):* (States may include information on publication date and location for State PBN Implementation Plan and other relevant information.)

**Approach Operations**
*Reference:* ICAO Assembly Resolution A36-23
*"States and planning and implementation regional groups (PIRGs) complete a PBN implementation plan by 2009 to achieve: implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS) for all instrument runway ends, either as the primary approach or as back up for precision approaches by 2016 with intermediate milestones as follows: 30 percent by 2010, 70 percent by 2014."*
*Status:*

| **Implementation Targets** (# of RWY Ends) | | | **Completed** (# of RWY Ends) | | **On Progress** (# of RWY Ends) | |
|---|---|---|---|---|---|---|
| Y2010 | Y2014 | Y2016 | LNAV | LNAV/VNAV | LNAV | LNAV/VNAV |
| | | | | | | |

*Note(s):* (States may include information on recent publications of new PBN approach procedures.)

**Arrival and Departure Operations**
*Reference:* 1) ICAO Assembly Resolution A36-23
*"States and planning and implementation regional groups (PIRGs) complete a PBN implementation plan by 2009 to achieve: implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones."*
2) MID PBN Regional Implementation Plan and Strategy
*"Short-term 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 most significant operational benefits RNAV-1 SIDs/STARs for 30% of international airports by 2010 and 50% by 2012 and priority should be given to airports with RNP Approach RNP-5 and B-RNAV which is implemented in MID Region to be redefined as per ICAO PBN terminology by 2009 (MIDANPIRG/11), full implementation of PBN by 2012 for continental en-route.."*

- *"Medium-term 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 and RNAV-1 or Basic RNP-1 SID/STAR at busy domestic airports where there are operational benefits*

| **Implementation Targets** (# of Int'l Airports) | | | **Completed** (# of Int'l Airports) | | **On Progress** (# of Int'l Airports) | |
|---|---|---|---|---|---|---|
| Y2010 | Y2014 | Y2016 | Arrival | Departure | Arrival | Departure |
| | | | | | | |

*Note(s):* (States may include information on recent publications with new PBN arrival/departure procedures.)

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## REPORT ON AGENDA ITEM 6: GNSS SPECIFIC ISSUES

6.1 The meeting noted that frequency Interference-free operation of GNSS is essential for the GNSS operation, in this regards the meeting was apprised that MIDANPIRG/11 agreed that good coordination with the radio regulators and/or operators and civil aviation experts is essential and that the Civil Aviations experts are required to educate the regulator and operators on the importance of civil aviation frequency spectrum requirements, as well as States are required to delete their States names from foot note 5.362C *( Egypt, Iraq ,Israel Jordan, Qatar, Sudan, Syria and Yemen ),*

6.2 The meeting further noted that MIDANPIRG/11 adopted conclusion 11/65 urging MID States to take measure for the protection of the GNSS signal, and conclusion 11/56 urging MID States Civil Aviation Authorities to participate in related activities of the Aviation spectrum utilization and work with their associated frequency management authorities to ensure that the GNSS band is protected.

6.3 The meeting further noted that all frequency spectrum management and coordination issues for the MID Region are handled among others are handled through the ICAO CNS SG.

6.4 The meeting noted that GNSS supports all the Navigation specification as explained in the PBN Manual Doc 9613, where the PBN main three components are: navigation aid infrastructure, navigation specification and navigation application, the below table is an extract from the PBN manual and reflects the GNSS position with respect to various navigation specification.

***Table1 Overview of navigation specification and supporting infrastructure***

| | GNSS | IRU | D/D | D/D/IRU | D/VOR |
|---|---|---|---|---|---|
| RNAV 10 | √ | √ | | | |
| RNAV 5 | √ | √ | √ | √ | √ |
| RNAV 2/1 | √ | | √ | √ | |
| RNP 4 | √ | | | | |
| Basic-RNP 1 | √ | | | | |
| RNP APCH | √ | | | | |
| RNP AR APCH | √ | | | | |

6.5 Based on the above, the meeting noted that the PBN concept was incorporated into the Strategy for the Implementation of GNSS in the MID Region, by the GNSS TF/7 where it developed a revised Strategy for the implementation of GNSS in MID Region which was endorsed by MIDANPIRG/11 meeting, under conclusion 11/67 *STRATEGY FOR THE IMPLEMENTATION OF GNSS IN THE MID REGION.*

6.6 The meeting was of the view that with the transition to performance based planning, ICAO will no longer specify the GNSS systems (or combination of the systems) that should be used to support PBN requirements **-** this is left to the States or groups of States.

6.7 In light of this new approach, the meeting reviewed the GNSS implementation strategy and developed revised version at **Appendix 6A** to the Report on Agenda Item 6 and agreed that where indicating "RNP APCH with Baro-VNAV", should simply indicate "RNP APCH APV" in order to be consistent with the PBN concept, and to reduce or eliminate sensor specific requirements.

6.8 Based on the above the meeting agreed to the following draft conclusion which will replace and supersede MIDANPIRG/11 Draft Conclusion :

***DRAFT CONCLUSION 2/7: STRATEGY FOR THE IMPLEMENTATION OF* GNSS *IN THE MID REGION***

*That, the updated Strategy for implementation of GNSS in the MID Region is adopted as at **Appendix 6A** to the Report on Agenda Item 6.*

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PBN/GNSS TF/2
Appendix 6A to the Report on Agenda Item 6

**REVISED STRATEGY FOR THE IMPLEMENTATION OF GNSS IN THE MID REGION**

The following is the Strategy for the implementation of GNSS aligned with PBN in the MID Region:

Considering that:

a) Safety is the highest priority.

b) Elements of Global Air Navigation Plan on GNSS and requirements for the GNSS implementation will be incorporated into the CNS part of FASID.

c) GNSS Standards and Recommended Practices (SARPs), PANS and guidance material for GNSS implementation are available.

d) Human, environmental and economic factors will affect the implementation.

e) The availability of avionics, their capabilities and the level of user equipage.

f) The development of GNSS systems including satellite constellations, augmentation systems and improvement in system performance.

g) The airworthiness and operational approvals allowing the current GNSS applied for en-route and non-precision approach phases of flight without the need for augmentation services external to the aircraft.

h) The effects of ionosphere on GNSS and availability of mitigation techniques;

i) The PBN concept and the availability of PBN guidance material

j) The monitoring of the GNSS signal according to ICAO Document 9849 (GNSS Manual).

k) States pay fair cost for GNSS to service providers (according to ICAO provisional policy guidance on GNSS cost allocation

The general strategy for the implementation of GNSS in the MID Region is detailed below:

1) Introduction of GNSS Navigation Capability should be consistent with the Global Air Navigation Plan.

2) Implementation of GNSS and Augmentations should be in full compliance with ICAO Standards and Recommended Practices and PANS.

3) Assessment of the extent to which the GNSS system accessible in the Region can meet the navigational requirements of ATM service providers and aircraft operators in the Region.

4) Introduce the use of GNSS with appropriate augmentation systems, as required, for en-route navigation and Implementation of approach procedures with vertical guidance A 36-23 (APV), 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.

5) States, in their planning and introduction of GNSS services, take full advantage of future benefits accrued from using independent core satellite constellations, other GNSS elements and their combinations, and avoid limitations on the use of specific system elements.

6) Facilitate the use of GNSS; as enabler for PBN for en-route, terminal, approach and departure navigation. States should coordinate to ensure that harmonized separation standards and procedures are developed and introduced concurrently in adjacent flight information regions along major traffic flows to allow for a seamless transition to GNSS based navigation.

7) States should to the extent possible work co-operatively on a multinational basis under ICAO MID Office Guidance to implement GNSS in order to facilitate seamless and inter-operable systems and undertake coordinated R&D programmes on GNSS implementation and operation.

8) States consider segregating traffic according to navigation capability and granting preferred routes to aircraft that are appropriately equipped for PBN to realize the benefits of such equipage taking due consideration of the need of State aircraft.

9) ICAO and States should undertake education and training programs to provide necessary knowledge in AIM concept, PBN, GNSS theory and operational application.

10) States establish multidisciplinary GNSS implementation teams, using section 5.2.2 and Appendix C of ICAO Document 9849, GNSS Manual.

11) States, in their planning for implementation of GNSS services, provide effective spectrum management and protection of GNSS frequencies to reduce the possibility of unintentional interference.

12) During transition to GNSS, sufficient ground infrastructure for current navigation systems must remain available. Before existing ground infrastructure is considered for removal, users should be given reasonable transition time to allow them to equip accordingly.

13) States should approach removal of existing ground infrastructure with caution to ensure that safety is not compromised, such as by performance of safety assessment, consultation with users through regional air navigation planning and plan for Complete decommissioning of NDBs by 2015.

14) Implement GNSS with augmentation as required for APV where operationally required in accordance with the MID Regional and National PBN Implementation plans.

15) States continue their efforts to implement GNSS applications for en-route, APV and TMA operations. Attention should be accorded to meeting all GNSS implementation requirements, including establishment of GNSS legislation, regulatory framework, and approval procedure.

***Notes:***

GNSS (and ABAS using RAIM in particular) is available on a worldwide basis, not much needs to be done in terms of infrastructure assessment. Nonetheless, the responsibility for providing services based on GNSS within the airspace of a particular State remains within that State.

A decision on whether or not to develop a status monitoring and NOTAM system for ABAS operations should be made by taking into account the nature of PBN approvals. In many cases ABAS operations are predicated on having a full complement of traditional NAVAIDs available for back-up when ABAS cannot support service.

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## REPORT ON AGENDA ITEM 7: FUTURE WORK PROGRAMME/ACTION PLAN

7.1 The meeting recalled that MIDANPIRG/11, under Decision 11/66, approved the revised Terms of Reference (TOR) and Work Programme of the PBN/GNSS Task Force.

7.2 Taking into consideration the latest development of the PBN/GNSS, and recognizing that PBN and GNSS implementations are at various stages, the meeting reviewed and updated the TOR and Work Programme of the PBN/GSS Task Force and agreed to the following Draft Decision, which is proposed to replace and supersede MIDANPIRG/11 Decision 11/66:

***DRAFT DECISION 2/8: TERMS OF REFERENCE OF THE PBN/GNSS TASK FORCE***

*That, the Terms of Reference and Work Programme of the PBN/GNSS Task Force be updated as at **Appendix 7A** to the Report on Agenda Item 7.*

7.3 Taking into consideration the Work Programme of the Task Force, and noting that MIDANPIRG/12 is tentatively scheduled to be held in October 2010, the meeting agreed that the PBN/GNSS meeting be held after MIDANPIRG/12, the exact date will be determined by the ICAO MID Regional Office, in coordination the Chairman and the venue will be Cairo, unless a State is willing to host the meeting.

7.4 In accordance with the ICAO Business plan and the requirements for performance monitoring, the meeting developed a follow-up action plan as at **Appendix 7B** to the Report on Agenda Item 7.

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PBN/GNSS TF/2
Appendix 7A to the Report on Agenda Item 7

**PROPOSED TERMS OF REFERENCE FOR
PBN/GNSS TASK FORCE**

## 1. TERMS OF REFERENCE

a) Carry out specific studies to support the implementation of Performance Based Navigation (PBN) in the MID, in accordance with the ICAO Strategic Objectives and Global Plan Initiative (GPI5) and other related GPIs (GPIs 7, 10, 11, 12, 20, 21).

b) Identify issues/actions arising from the work of ICAO or for consideration by ICAO in order to facilitate regional and global harmonization of existing applications as well as future implementation of Performance Based Navigation operations.

c) Determine and recommend, on the basis of the study, the PBN strategy and Implementation Plan for the MID Region, based on the ICAO PBN Implementation goals as reflected in assembly resolution 36-23.

d) Assist States that may require support in the implementation of PBN.

e) Monitor the progress of studies, projects, trials and demonstrations by the MID Region States, and other ICAO Regions.

f) Provide a forum for active exchange of information between States related to the implementation of GNSS.

g) Identify deficiencies and constraints that would impede implementation of GNSS, and propose solutions that would facilitate the rectification of such problems.

h) Identify and address, to the extent possible, institutional, financial and legal matters related to the GNSS implementation in the MID Region.

i) Develop a system of post-implementation reviews to ensure the effective and safe introduction of PBN and non-PBN GNSS operation.

## 2. WORK PROGRAMME

a) Study and assess the Regional RNAV and RNP (PBN) requirements.

b) Initially focus assistance to States that may require support on development of the State PBN implementation plans.

c) Identify priority routes and terminal areas where RNAV and RNP should be implemented.

d) Identify priority runways for Approach Procedures with Vertical Guidance (APV) to be implemented based on the ICAO RNP APCH navigation specification (APV/Baro-VNAV).

e) Develop amendment proposal to the Regional Supplementary Procedures concerning the implementation of PBN in the MID Region.

f) Identify guidance material and training needs.

g) Follow up on the global developments in ICAO in order to update the Regional plans and PBN in particularly for PBN

h) Coordinate with other ICAO Regions as necessary to address implementation interface issues.

i) Undertake other functions relevant to implementation of PBN as assigned by the ATM/SAR/AIS SG or MIDANPIRG.

j) Report to CNS/ATM/IC SG and keep ATM/SAR/AIS SG and CNS SG closely briefed.

k) Monitor and follow-up the studies pertaining to the possible use of GNSS, and different augmentation systems in the MID Region.

l) Monitor the progress of the NAVISAT study.

m) Review and identify intra and inter regional co-ordination issues related to the implementation of GNSS and where appropriate recommend actions to address those issues.

n) Examine to what extent the GNSS system accessible in the Region can meet the navigational requirements of ATM service providers and aircraft operators in the Region.

o) Identify and co-ordinate GNSS implementation priorities in the MID Region.

p) Provide assistance to MID States in planning and implementation of GNSS, including the development of GNSS procedures.

q) Suggest ways and means for rectifying the problems as they arise related to the implementation of GNSS.

r) Provide necessary knowledge in GNSS operational application.

**3. THE TASK FORCE SHALL IN ITS WORK BE GUIDED BY THE FOLLOWING PRINCIPLES**

a) Implementation of PBN shall follow the ICAO PBN goals and milestones.

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

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

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

e) The first regional PBN Implementation Strategy and Plan should address the short term (2008-2012), medium term (2013-2016) and take into account long term global planning issues.

f) Cognizance that the primary objective of ICAO is that of ensuring the safe and efficient performance of the global Air Navigation System, ensure that pre- and post-implementation safety assessments will be conducted to ensure the application and maintenance of the established target levels of safety.

g) Take into account the introduction of new technologies, encourage implementation and development in GNSS.

h) Apply ICAO guidance material and information as may be applicable to the Region to facilitate the implementation of PBN.

## 4. COMPOSITION OF THE TASK FORCE

**STATES**

MID Region States

**ORGANIZATIONS *(AS OBSERVERS)***

IATA, IFALPA, IFATCA, EUROCONTROL, ACAC and additional representative from International/Regional Organizations may be invited when required.

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PBN/GNSS TF/2
Appendix 7B to the Report on Agenda Item 7

## PBN/GNSS TF/2 FOLLOW-UP ACTION PLAN

| CONCLUSION/DECISION | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 2/1: IMPLEMENTATION OF CONTINUOUS DESCENT OPERATIONS**<br><br>That, recognizing the efficiency and environmental benefits of Continuous Descent operations, and the need to harmonize these operations in the interest of safety, MID States are encouraged to include implementation of Continuous Descent operations (CDO) as part of their PBN implementation plans and to implement CDO in accordance with the ICAO CDO Manual. | Implement the Conclusion | ICAO HQ<br><br>States | CDO Manual<br><br>PBN Plans<br><br>CDO procedures published | 2010<br><br>Dec. 2009<br><br>2014 | |
| **CONC. 2/2: MID REGION PBN IMPLEMENTATION STRATEGY AND PLAN**<br><br>That, the revised MID Region PBN Implementation strategy and Plan be updated as at Appendix 4A to the Report on Agenda Item 4. | Implement Strategy and plan | PBN/GNSS TF<br>States<br>ICAO | Updated Regional Plan | Jan. 2010<br><br>Oct .2010 | |
| **CONC. 2/3: PBN IMPLEMENTATION TASK LIST**<br><br>That PBN Implementation Task List be updated with new task assignment as at Appendix 4B to the Report on Agenda Item 4. | Follow up the update of Task List | PBN/GNSS TF<br>States<br>ICAO | PBN/GNNS TF/ 3 Report<br>Updated Task List | Oct. 2010 | |

| CONCLUSION/DECISION | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **CONC. 2/4: PBN IMPLEMENTATION SUPPORT**<br><br>That, in order to address challenges in PBN implementation, stakeholders in the PBN implementation (air navigation services providers(ANSP's), aircraft operators, user communities, etc.) be encouraged to continue providing support including resources to States and ICAO PBN programme. | Communicate and Follow up with Stake holders | PBN/GNSS TF<br>States<br>ICAO | State Letter<br><br>Inputs from Stake holders | Oct. 2010<br><br>ongoing | |
| **CONC. 2/5: STATE PBN IMPLEMENTATION PLAN**<br><br>That, MID States which have not submitted their State PBN Implementation plans to ICAO MID Regional office are requested to do so, before 30 December 2009. | Prepare State plan | States | State PBN Implementation plans | Dec. 2009 | |
| **CONC. 2/6: PBN IMPLEMENTATION PROGRESS REPORT**<br><br>That, States are requested to use the excel sheet as at Appendix 5H and PBN Implementation Progress Report Template as at Appendix 5I to the Report on Agenda Item 5 for future reporting on the status of PBN implementation and submit progress reports to ICAO MID Regional Office every six months or whenever major progress is achieved. | Implement Conclusion | States | Updated progress reports | May 2010 | |
| **CONC. 2/7: STRATEGY FOR THE IMPLEMENTATION OF GNSS IN THE MID REGION**<br><br>That, the updated Strategy for implementation of GNSS in the MID Region is adopted as at Appendix 6A to the Report on Agenda Item. | Implement strategy | PBN/GNSS TF | adoption by MIDANPIRG/12<br><br>PBN/GNSS TF/3 Report | Dec. 2010 | |

| CONCLUSION/DECISION | FOLLOW-UP | TO BE INITIATED BY | DELIVERABLE | TARGET DATE | REMARKS |
|---|---|---|---|---|---|
| **Dec. 2/8: Revised Terms of Reverence (TOR) for PBN/GNSS TF**<br><br>That, the Terms of Reference of the PBN/GNSS TF be updated as at **Appendix 7A** to the Report on Agenda Item 8. | ICAO<br>PBN/GNSS TF<br>Follow on the work programme | PBN/GNSS TF | adoption by MIDANPIRG/12<br><br>PBN/GNSS TF/3 Report | Dec. 2010 | |

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**REPORT ON AGENDA ITEM 8: ANY OTHER BUSINESS**

8.1 The meeting extended it congratulations to all Air traffic controllers and especially for the Air traffic controllers attending the meeting on this day of 20th of October, and wished all the ATC a happy day.

8.2 The meeting thanked UAE for hosting the meeting and for the good hospitality received and arrangement especially the transportation and other supports.

8.3 On third day after completing the work programme the participants visited the new Shiekh Zayed Air Navigation Center where tour and briefing was provided to the participants on the construction and the latest technologies used in the center.

8.4 At the end of the meeting, on behalf of the other members of the Task Force, participants from Bahrain, Kuwait and Saudi Arabia expressed their thanks to UAE and the secretariat for the considerable efforts in arrangement and organization that made this meeting a success.

8.5 In adjourning the meeting, the Chairperson recalled the intensive activities of the past days of the meeting, and noted with appreciation the hard work by the participants to arrive at concrete outcomes.

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PBN/GNSS TF/2-REPORT
Attachment A to the Report

| NAME | TITLE & ADDRESS |
|---|---|
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| Mr. Salah Mohamed Alhumood | Head, Aeronautical Information & Airspace Planning<br>Civil Aviation Affairs<br>Bahrain International Airport<br>P.O. Box 586<br>KINGDOM OF BAHRAIN<br>Fax: (973) 17 321 992<br>Tel: (973) 17 321 180<br>Mobile: (973) 3640 0424<br>Email: shumood@caa.gov.bh |
| Mr. Saleem Mohamed Hassan | Chief Air Traffic Management<br>Civil Aviation Affairs<br>P.O. Box 586<br>KINGDOM OF BAHRAIN<br>Fax: (973) 17 321 992<br>Tel: (973) 17 321 117<br>Mobile: (973) 39 608 860<br>Email: saleemmh@caa.gov.bh |
| **EGYPT**<br>Mr. Ahmed A. El Gawad Olwan | Manager of Airways Dept/Procedure Designer<br>Cairo Airport<br>NANSC<br>Cairo - EGYPT<br>Mobile: (010) 753 4733<br>Email: ahmed.gwad@yahoo.com |

| NAME | TITLE & ADDRESS |
|---|---|
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| Mr. Mahmoud M. El Ashmawy | General Manager Safety & Standards of Air Navaids Facilities<br>Ministry of Civil Aviation<br>Cairo Airport Road<br>Cairo - EGYPT<br>Fax: (202) 22268 332<br>Tel: (202) 2268 1347<br>Mobile: (2010) 332 4210<br>Email: engmahd@hotmail.com<br>mahdspd@yahoo.com |
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