



International Civil Aviation Organization

**The Eighth Meeting of the Performance Based Navigation Task Force
(PBN/TF/8)**

New Delhi, India, 12 – 13 May 2011

Agenda Item 2: Global PBN Implementation and PBN SG Update

PBN UPDATE

(Presented by the Secretariat)

SUMMARY

The purpose of this Working Paper is to provide an update on PBN initiatives by the ICAO PBN Programme Office in Montreal. This concerns any policy decisions, implementation support such as Go-team, workshops courses, recent outcomes of Panels, Study groups and taskforces on work related to PBN and any new publications

1. INTRODUCTION

1.1 The purpose of this Working Paper is to provide an update on PBN initiatives being worked on or coordinated by the ICAO PBN Programme Office in Montreal. This concerns any policy decisions, implementation support such as Go-teams, workshops courses, recent outcomes of Panels, Study groups and taskforces on work related to PBN and any new publications.

2. DISCUSSION

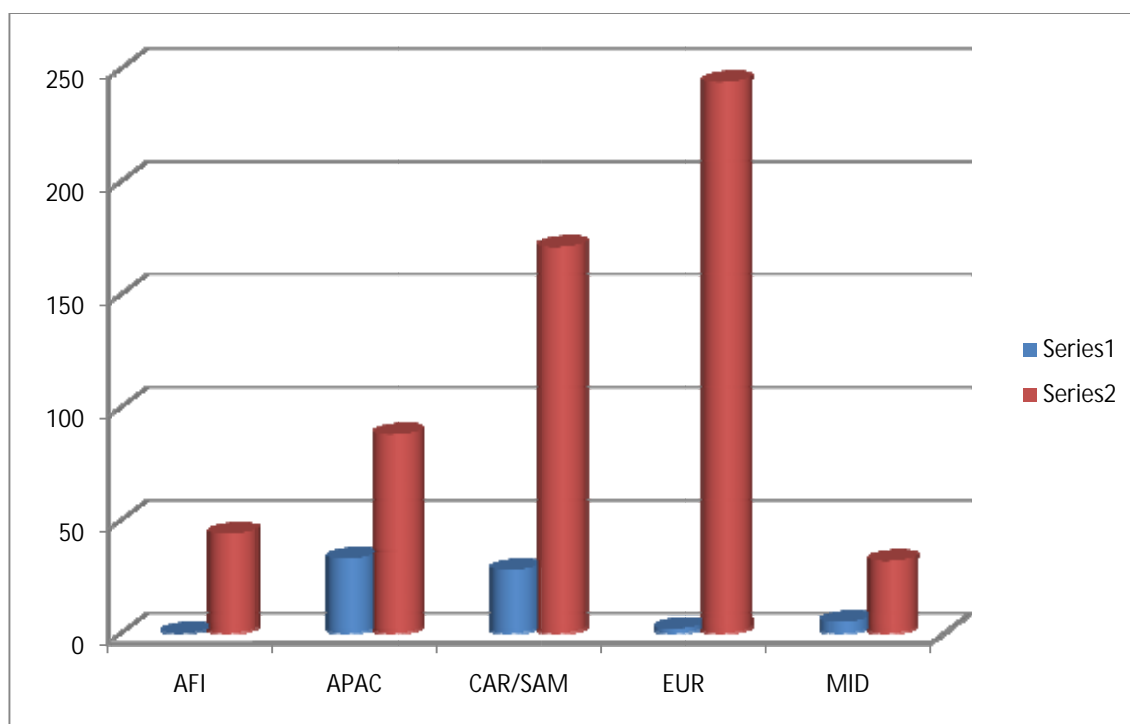
2.1 Measurement of PBN implementation

2.1.1 ICAO is undertaking a few actions to measure the PBN implementation performance

- Actual implementation database
- ATM Operational Improvement tool

2.1.2 Actual implementation database

2.1.2.1 The actual PBN implementation database is coordinated with Jeppesen. It currently contains only approach procedures. SID/STAR is being worked on. The database shows that there is a healthy growth of published PBN (public) approach procedures (comparison Jan 2008 to Jan 2011) to international runways, see diagram below. The NAM is not included in the figure (to avoid distortion of the graph) but shows a surge of 2070 to 3060 approach procedures.



2.1.3 ATM Operational improvement tool

2.1.3.1 ICAO is finalizing an ATM operational improvement tool. One of the main applications will be for PBN to measure track miles saved/fuel saved compared to the pre-PBN implementation. The tool will be finished June/July this year.

2.2 Assembly resolution 37-11

2.2.1 The 37th Assembly adopted a new Assembly resolution on PBN (A37-11) that replaces Assembly resolution A36-23. The main difference between the old and new Resolution is that Aerodromes that have no APV equipped aircraft operating on their runways are exempted from establishing APV procedures however need to have at least LNAV procedures. The new Resolution is attached to this paper.

2.3 Implementation/education activities

2.3.1 **Go-Team.** The GO Team is undertaking activities to assist States in PBN implementation. The target is to address 1 to 2 States per ICAO Region. States that are selected need to have a political will for implementation and are relatively advanced in PBN implementation. Such States could then serve as regional pockets of knowledge and expertise in their region. So far, the Go-Team carried out three visits to Thailand, UAE and Mexico. After a pre-assessment of the PBN implementation gaps, a team formed by ICAO, IATA and industry partners carried out an on-site visit. It is envisaged that the recommendations will result into an enhanced implementation plan and a detailed project plan in 6 months which will cover a three-year implementation path. The next Go Team visits for 2011 are tentatively planned for Germany and Kenya in the fall and Winter. Another 4 visits are planned for 2012. When resources available, in addition, a complete, CDO and approach design will be accomplished to jump-start the process.

2.3.2 **PBN Airspace design.** Four workshops were performed in 2010, Bangkok, Thailand and Santiago, Chile, South Africa, and Damascus, Syria. These workshops were all supported by EUROCONTROL and FAA. Plans are for four more in 2011. The objective of these workshops is to familiarize participants with airspace design as it relates to implementation of Performance Based navigation. The workshops have proven to be very successful and provide States a hands-on exercise in developing the airspace. Four more are planned in New Delhi, Mexico City, Paris and Kiev.

2.3.3 To ensure availability in the future, ICAO is developing an airspace design workshop, based on the EUROCONTROL/FAA workshop. A train-the-trainer course was performed in February 2011 in coordination with the APAC FPP. A new resource has arrived in ICAO HQ and an airspace design manual is to be expected by the fall of this year with more courses to follow.

2.3.4 **Operational Approval.** In a cooperative effort with ICAO COSCAP-SEA and the Australian CASA, a PBN OPS approval handbook has been developed. Based on this document, ICAO is developing guidance for global application. The way forward is to expand the PBN manual with high level guidance on PBN ops approval and to develop detail guidance material that can also be used as technical reference material for course. A consultant has been hired by ICAO and material is expected to be finalized by the end of the year. The following deliverables are expected:

- a) Update the PBN Manual (Doc 9613) to include additional text addressing Operations Approval Guidance. All changes should be kept at a high level consistent with the rest of the Manual.
- b) Additional guidance material to the PBN Manual for consideration by the PBNSG. The guidance material may take multiple and different forms e.g., web-based, list of FAQs, Handbooks.
- c) Training Courses for PBN ops approval:
 - 1) Background to PBN as a foundation course covering aircraft, ops, airspace, ATS – as common across the various disciplines (e.g., see web based training packages);
 - 2) Detailed courses for individuals and organizations with general qualifications in the associated discipline, plus prerequisite knowledge of PBN having completed a foundation level course.

2.4 PANELS AND STUDY GROUPS

2.4.1 Instrument Flight Procedures Panel (IFPP).

2.4.1.1 **New amendments.** New amendments to PANS OPS are approved by the ICAO Council became applicable as of 18 November 2010. A summary of these amendments follows:

- a) Definition of GBAS Landing System (GLS)
- b) General cautions in conventional procedure design to facilitate database coding
- c) **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.

- d) **Alignment of RNAV holding criteria with PBN.** The proposed amendment to PANS-OPS, Volume I pertains to RNAV holding requirements and is consequential to existing PANS-OPS, Volume II design criteria, and seeks alignment with the PBN concept. It furthermore removes some impracticable requirements, incorporated before the PBN concept materialized, that cannot be coded into the navigation database.
- e) **Use of SBAS equipment for 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.
- f) **Continuous Descent Operations (CDO).** The CDO manual (doc 9931) has been completed and is available on the ICAONET as well as a hard copy. One CDO workshop was held in coordination with the APAC FPP. Further workshops are suspended depending on resources.

2.4.1.2 **Amendments in progress.** Currently new amendments to PANS-OPS, Volume II and Annex 15 are under review by the ANC, State consultation has just been finalized and will be submitted to the ANC for final review. These amendments are envisaged to be applicable in 2012 and include:

2.4.1.2.1 **RF legs charting**

2.4.1.2.1.1 A key component of RNP departure, arrival and approach procedures is the curved flight track. Constant radius turns around a fix are referred to as radius-to-fix (RF) legs. These turns, encoded into the navigation database, allow the aircraft to avoid critical areas of terrain, airspace and noise sensitive areas while maintaining positional accuracy by maintaining precise and positive course guidance along the curved track. The introduction of RF legs into the design of terminal and approach RNP procedures will result in improved use of airspace and allow procedures to be developed to/from runways that are otherwise limited to traditional linear flight paths – or in some cases – not served by an instrument flight rules (IFR) procedure at all. Navigation systems with RF capability are a prerequisite to flying a procedure which includes an RF leg.

2.4.1.2.1.2 The proposed amendment to PANS-OPS, Volume II and consequential amendment to Annex 15 are required to achieve an unambiguous description both for the pilot and for the navigation database coder. For the pilot, this is achieved by a curved nominal (required) ground track, starting and ending at fly-by waypoint and an along track distance with speed and altitude restrictions published as required. As far as the database provider is concerned, the arc centre coordinates, the coordinates of the waypoints at each end of the turn, and the path descriptor need to be provided to clearly define the RF leg.

2.4.1.2.2 **Identification of SBAS service provider**

2.4.1.2.2.1 With the commissioning of multiple SBAS providers, it is becoming increasingly important to address the responsibility of the entity that will identify which provider needs to be used in a procedure in order to prevent the wrong SBAS service provider being coded in the navigation database. An amendment is proposed to PANS-OPS, Volume II to address this issue.

2.4.1.2.3 **Defining the term “course”**

2.4.1.2.3.1 In RNAV and RNP procedures, the correct execution of an RNAV instrument flight procedure is highly dependent on correct implementation of the intended procedure in a navigation database. The coding of the procedure in these navigation databases is based on path terminators. Different path terminators are used to differentiate between an aircraft on a heading, on a track that is anchored to a waypoint and on a course that has no anchoring waypoint. In some States, the term “course” has taken on different meanings and is often confused with the term “track”. In order to avoid misunderstanding of the term “course” between the procedure designer and the navigation database coder and consequential path definition errors, it is important that the term be defined. An amendment is proposed for PANS-OPS, Volume II. Furthermore, in reviewing this issue, it became evident that from the current procedure design descriptions (tabular and formal textual descriptions), the tabular description is less prone to misinterpretation. An amendment to PANS-OPS is proposed to indicate the preference for tabular.

2.4.1.2.4 **Clarification on vertically guided approaches**

2.4.1.2.4.1 There are two main elements concerning this issue. The first one deals with a clarification that when using SBAS vertical guidance on procedures designed for barometric vertical navigation (baro-VNAV), the prerequisite is that the procedure is located within a designated SBAS service area with vertical guidance. The second one is related to vertically guided procedures down to localizer performance with vertical guidance (LPV) minima. As the complexity is relatively high for these types of procedures, it is proposed to provide some background information on these criteria as was done with the instrument landing system (ILS) procedures which are equivalent in complexity.

2.4.1.3 **Work in progress.** Most of the new work in IFPP is in support of PBN in one way or another. It varies from new flight procedure design criteria, ATM issues, Charting and database requirements as well as quality assurance matters. Below is an overview provided of the work currently undertaken by the various IFP working groups:

- a) ATM WG
 - 1) CCO Manual, Planning, Initial draft Q3, 2011, Final draft Q3, 2012
 - 2) RNAV Transitions into terminal area
- b) PBN WG
 - 1) Guidance to the pilots regarding PBN flight procedures, involving Amdt to PANS-OPS Vol I. (Fall 2012)
 - 2) Guidance material on the implementation of RNP AR procedures, emphasis on FOSA activities (work completed)
 - 3) Identification of NavSpecs (ongoing)
 - 4) Design criteria for NavSpecs (Fall 2011 – Fall 2012)
 - 5) Data Collection (ongoing)
 - 6) Alignment of vertical guided approach criteria (Fall 2012)
 - 7) Maintenance of RNP AR design manual (ongoing)
- c) Helicopters WG
 - 1) Finalise Manoeuvre Visual segment package (Spring 2011)
 - 2) Finalise Helicopter LPV criteria (Spring 2011)
 - 3) Initialise development of Helicopter PBN Departure & En-route Criteria (Spring 2012)
- d) Integration WG
 - 1) Development of SARPs for PBN Procedures charting (Spring 2011)

- 2) Development of Helicopter PinS Departure procedures charting (Spring 2011)
 - 3) Development of new Charting criteria & SARPs to harmonise with Industry development
- e) Quality Assurance WG
- 1) Finalisation of Doc 9906 Vol 5 and Vol 6, Minor adjustment to 8168 for references (Spring 2011)
 - 2) Preparation of Regulatory oversight material, possibly on Annex level
 - 3) Implementation of a stable reporting form
- f) CRM WG
- 1) Maintain & Update to the CRM to improve the user interface
 - 2) CRM Software and related documentation on hold
 - 3) Update of the CRM for new ACFT
 - 4) Completion of Height Loss model study (Fall 2011)
 - 5) Completion and Validation of the pilot models (Spring 2012)
 - 6) Identifying design requirements for modern ACFT (Spring 2013)
 - 7) Advanced Risk Assessment Methodology (ARAM)(tbd)
 - 8) Application beyond Final approach segment for the entire operation, allowing an objective measurement of safety levels
 - 9) PBN applications
- g) Maintenance WG
- 1) Continuation LPV200' activities
 - 2) Naming convention to be accepted and confirmed
 - 3) Interaction with NSP, AC-TF and AP needed
 - 4) Deliverable planned for Spring 2011
 - 5) SBAS LP (Spring 2011)
 - 6) LP/Baro VNAV (Spring 2012)

2.4.2 Separation and Airspace Safety Panel (SASP).

2.4.2.1 **New amendments.** The Separation and Airspace Safety Panel Working Group of the Whole finalized work on changes to the PANS ATM that will address existing shortcomings related to current variations allowed in true airspeed before they have to be reported. The proposed amendment is out for State comments. A second amendment finalized by SASP and also out for State comments is an amendment to the PANS ATM that will allow the use of ADS-B and MLAT to separate aircraft by 3 NM. According to plans, these amendments will become effective in November 2012 if no problems arise.

2.4.2.2 **Work in progress.** Currently the Panel is working on several issues as listed below:

- a) Math sub-group (MSG) was formally tasked to look at the risk associated with extending the applicability of the 2.5nm radar separation in the approach environment from 10 NM out to 20 NM
- b) Reviewed the Enroute Monitoring Agency handbook used in Asia/Pac and endorsed by APANPIRG to assess whether it had global applicability in similar cast as the RMA Manual. This work is on-going.
- c) Finalised a new version of the RVSM Manual (Doc 9574)

- d) MSG tasked to review the quantitative aspect of the risk model used in the Rlong separation minima developed for the NAT. This work will be essential before these minima can be published in the Doc 4444
- e) Finalised an amendment of the Five Minute Arrival/Departure Procedure (Doc 4444 5.7) to address safety concerns
- f) Further work progressed on an amendment to Independent and Dependent Parallel Approach procedures (Doc 4444 6.7) to include availability of GLS approaches and the use of a STAR to position aircraft on centerline
- g) Developed a revised concept of the Advanced Strategic Offset Concept (ASOC) that incorporates ASOC within the current SLOP procedure and expands applicability to Continental airspace using micro-offsets
- h) MSG tasked to undertake detailed modelling of the ASOC/SLOP operational requirement
- i) Drafted revised performance requirements for ADSB for 5nm and 3nm separation minima that results in States being able to select lower values of NUC and aligns to RTCA/Eurocae criteria
- j) **Finalised amendment proposals for a 5nm minima for terminal operations between B-RNP1 aircraft on published instrument flight procedures**
- k) **Met with some members of the PBNSG and agreed to draft a new nav spec fto accommodate low end GNSS equipped aircraft.**
- l) **Further developed new PBN based minima for crossing track scenarios**

2.4.3 **Navigation Systems Panel (NSP).** The main focus of PBN-related work in the Navigation Systems Panel (NSP) is currently on the development of an updated version of the GNSS Manual (ICAO Doc 9849). The original version of the Manual was published before the PBN concept was introduced in ICAO, and therefore does not explicitly provide guidance on PBN-related issues. The updated version is intended to incorporate PBN terminology and in general address the main developments in the GNSS field since publication of the original version. A consultant has been hired by ICAO to prepare a draft updated version for consideration by NSP. The 9 – 18 November 2010 meeting of NSP reviewed the initial draft and provided comments and suggestions for further work. The next meeting of NSP (9-20 May 2011) will review and finalize the draft as updated on the basis of the inputs at the previous meeting. It is expected that an English-only version of the material will be available on the ICAO website before the end of 2011.

2.4.4 **Performance Based Navigation Study Group (PBN SG).** The PBN SG met March 2011 and worked on the next phase of PBN. Decisions were made on the direction to take with respect to new navigation specifications. These additions will be included in the new edition of the PBN Manual which is expected to be available as by October 2011, **subject to review of operational justification and positive business case.** Included in the revised manual are:

- a) Development of a navigation specification for SBAS and its inclusion in RNP APCH. These amendments were finalized in the last meeting and were made available by means of a State Letter prior to publication of the new addition of the manual;

- b) Development of an RNP 2 nav spec for enroute continental application, including remote continental;
- c) Application of RF turns outside final approach for all RNP applications. RF requirements will be made available by means of a State letter in the beginning of 2011 prior to publication of the revised PBN manual. Early review by the IFPP has shown that the RF leg should end 1 x ATT from the FAP. This means for an RNP 1 arrival, 1NM before the FAP
- d) Advanced RNP nav spec applicable for enroute, arrival, departure and approach. It is envisaged that this will be a “super navspec” and avoid the need for separate approvals for enroute, terminal and approach; and
- e) Development of an RNP 0.3 navigation specification. This navspec is specifically designed for helicopter operations but can also be applied by fixed wing ops.
- f) RNP AR APCH navspec will be extended by RNP AR departures. Also the SG is looking into AR operations with one engine inoperative.
- g) Any editorial and technical issues that were found in the past 3 years.
- h) Ops approval high level guidance

2.4.5 **Approach Classification Task Force.** The ACTF convened in March this year to sort the issue of approach classification. The current Annex 6 classification is not intuitive for the pilot, furthermore the classification as it is today is not fully integrated in ICAO documentation (e.g. no mention of APV in Annex 14). The ACTF has now agreed on a concept which will be brought forward to the AN/12 conf. one of the main issues associated with this is the procedure naming (Charts/navigation databases/phraseology). This will be addressed in the IFPP and reviewed by the ACTF. Any amendment to the procedure naming should not be expected applicable before 2014.

2.5 FLIGHT PROCEDURE PROGRAMME (FPP)

2.5.1 In the first year, the FPP focused on training programs. Since starting operations the FPP has trained 133 people from 22 States and Administrations in Initial and PBN Procedure Design Courses, RNP AR Procedure Design and other advanced courses. Additionally, the FPP has started to provide On-the-Job Training (OJT).

2.5.2 In addition to the training activities, the FPP is presently working on a PBN implementation project for Timor-Leste and is preparing for a possibly another. Since February the FPP, in cooperation with the Asia COSCAPs, has conducted PBN Implementation Workshops in five States and has nine more scheduled in the next six months. These workshops focus on identifying the impediments to PBN implementation in the State and developing a short term (less than 2 years) action plan for the State that will result into real implementation. The FPP is tracking these actions.

2.5.3 FPP Phase 2. The FPP Steering Committee, agreed at its December 2010 meeting, on the necessity to continue the FPP past the initial three years for which it was established. It was agreed that Phase 2 for the FPP will start January 1, 2013 and run until December 31, 2017. A Phase 2 Planning Meeting will be held at the end of May to decide on criteria for selection of the host State in Phase 2. The decision on the host State for Phase 2 will be made in December by the Steering Committee.

2.5.4 FPP plans for the future include continuing the training and implementation efforts already mentioned, while developing additional capabilities and training in validation, quality assurance and safety assessment, based on available resources.

2.5.5 An FPP has now been requested by Africa; however D/ANB will be completing a top to bottom review of the current project before any expansion will be considered. Program Review scheduled for the end of July in Beijing

3. **ACTION BY THE MEETING**

3.1 The meeting is invited to review and consider the information in this WP as they develop plans for implementation of PBN in their State.

APPENDIX A**Resolution A37-11: Performance-based navigation global goals**

Whereas a primary objective of ICAO is that of ensuring the safe and efficient performance of the global Air Navigation System;

Whereas the improvement of the performance of the air navigation system on a harmonized, worldwide basis requires the active collaboration of all stakeholders;

Whereas the 11th Air Navigation Conference recommended that ICAO, as a matter of urgency, address and progress the issues associated with the introduction of area navigation (RNAV) and required navigation performance (RNP);

Whereas the 11th Air Navigation Conference recommended that ICAO develop RNAV procedures supported by global navigation satellite system (GNSS) for fixed wing aircraft, providing high track and velocity-keeping accuracy to maintain separation through curves and enable flexible approach line-ups;

Whereas the 11th Air Navigation Conference recommended that ICAO develop RNAV procedures supported by GNSS for both fixed and rotary wing aircraft, enabling lower operating minima in obstacle rich or otherwise constrained environments;

Whereas Resolution A33-16 requested the Council to develop a programme to encourage States to implement approach procedures with vertical guidance (APV) utilizing such inputs as GNSS or distance measuring equipment (DME)/DME, in accordance with ICAO provisions;

Recognizing that not all airports have the infrastructure to support APV operations and not all aircraft are currently capable of APV;

Recognizing that many States already have the requisite infrastructure and aircraft capable of performing straight-in approaches with lateral guidance (LNAV approaches) based on the RNP specifications and that straight in approaches provide demonstrated and significant safety enhancements over circling approaches;

Recognizing that the Global Aviation Safety Plan has identified Global Safety Initiatives (GSIs) to concentrate on developing a safety strategy for the future that includes the effective use of technology to enhance safety, consistent adoption of industry best practices, alignment of global industry safety strategies and consistent regulatory oversight;

Recognizing that the Global Air Navigation Plan has identified Global Plan Initiatives (GPIs) to concentrate on the incorporation of advanced aircraft navigation capabilities into the air navigation system infrastructure, the optimization of the terminal control area through improved design and management techniques, the optimization of the terminal control area through implementation of RNP and RNAV SIDs and STARs and the optimization of terminal control area to provide for more fuel efficient aircraft operations through FMS-based arrival procedures; and

Recognizing that the continuing development of diverging navigation specifications would result in safety and efficiency impacts and penalties to States and industry;

Noting with satisfaction that planning and implementation regional groups (PIRGs) have completed regional PBN implementation plans;

Recognizing that not all States have developed a PBN implementation plan by the target date of 2009;

The Assembly:

1. *Urges* all States to implement RNAV and RNP air traffic services (ATS) routes and approach procedures in accordance with the ICAO PBN concept laid down in the *Performance-based Navigation (PBN) Manual* (Doc 9613);
2. *Resolves* that:
 - a) States complete a PBN implementation plan as a matter of urgency to achieve:
 - 1) implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones; and
 - 2) implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV only minima 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; and
 - 3) implementation of straight-in LNAV only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting available and where there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5 700 kg or more;
 - b) ICAO develop a coordinated action plan to assist States in the implementation of PBN and to ensure development and/or maintenance of globally harmonized SARPs, Procedures for Air Navigation Services (PANS) and guidance material including a global harmonized safety assessment methodology to keep pace with operational demands;
3. *Urges* that States include in their PBN implementation plan provisions for implementation of approach procedures with vertical guidance (APV) to all runway end serving aircraft with a maximum certificated take-off mass of 5 700 kg or more, according to established timelines and intermediate milestones;
4. *Instructs* the Council to provide a progress report on PBN implementation to the next ordinary session of the Assembly, as necessary;
5. *Requests* the Planning and Implementation Regional Groups (PIRGs) to include in their work programme the review of status of implementation of PBN by States according to the defined implementation plans and report annually to ICAO any deficiencies that may occur; and
6. *Declares* that this resolution supersedes Resolution A36-23.

— END —