International Civil Aviation Organization

Communication Navigation and Surveillance Sub-Group (CNS SG)

Sixth Meeting
(Tehran, Iran, 09 - 11September 2014)

Agenda Item 5: Performance Framework for CNS Implementation in the MID Region

GNSS IMPLEMENTATIONS IN THE MID REGION AND RELATED ISSUES

(Presented by Secretariat)

SUMMARY

This paper presents the development/implementation in the GNSS field, the radio frequency interference on the GNSS signal and proposes mitigation measures.

Action by the meeting is at paragraph 3.

REFERENCE

- AN Conf/12 Report
- MIDANPIRG/14 Report
- PBN SG/1 meeting Report
- Studies in EUR Region

1. INTRODUCTION

1.1 The Aviation Industry now relies on GNSS that are satellite signals to find a location or to keep time. The Global Positioning System (GPS) set up by the USA Government and GLONASS a similar Russian system were both built for military purposes but are now available to anyone with device to receive a signal.

1.2 Module B0-APTA: *Optimization of Approach Procedures including vertical guidance,* clearly indicates that the use of Performance-Based Navigation (PBN) and Ground-Based Augmentation System (GBAS) Landing System (GLS) procedures will enhance the reliability and predictability of approaches to runways, thus increasing safety, accessibility and efficiency. This is possible through the application of Basic Global Navigation Satellite System (GNSS); many other ASBU modules rely on the GNSS.

1.3 The First meeting of the Performance Based Navigation Sub-Group (PBN SG/1) was held at the ICAO MID Regional Office in Cairo, Egypt, 1 – 3 April 2014. The meeting was attended by a total of thirty three (33) participants from ten (10) States (Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Qatar, Saudi Arabia, Sudan, and United Arab Emirates) and one (1) International Organization (IATA).

2. DISCUSSION

2.1 PBN SG/1 meeting discussed the use of NDBs and noted that the following States (Egypt, Iran, Jordan, and Syria) did not complete the decommissioning of NDBs. Accordingly, the meeting urged the concerned States to submit their plans for the decommissioning of NDBs to the ICAO MID Regional Office by December 2014. It was further highlighted that the NDBs could be used for trainings and other domestic purposes.

2.2 The meeting recalled that the PBN/GNSSTF/5 addressed the recommendations concerning GNSS adopted by the AN-Conf/12, and integrated them in the Strategy for GNSS implementation in the MID Region, which was endorsed by MIDANPIRG/14.

2.3 Since GNSS is mainly used to support PBN implementation the meeting agreed that the Strategy for the GNSS implementation in MID Region be integrated within the new MID Region PBN implementation plan, as at **Appendix A** to this working paper.

2.4 In order to foster PBN and GNSS implementation the PBN SG/1 meeting reemphasized on the importance of thorough follow-up on GNSS developments and encouraged States to conduct Workshop/Seminars to share experiences related to PBN and GNSS including GBAS implementation.

2.5 The PBN SG/1 meeting urged States to provide the ICAO MID Regional Office with their GNSS implementation plans as part of their PBN implementation plan also to provide their observations of the effects of ionosphere on GNSS signal in their States, in order that mitigation measures could be proposed and actions taken accordingly.

2.6 The PBN SG/1 meeting received presentation from Jordan on the GNSS Strategy. The objective of the presentation is to formulate a future GNSS roadmap that fosters the implementation of advanced navigation systems in Jordan in order to improve flight efficiency and airports accessibility. It was highlighted that Jordan should consider the multiple GNSS constellations, associated augmentation system and assess the likelihood and effects of GNSS vulnerabilities.

2.7 The meeting recognized that the introduction of multi-constellation, multi-frequency GNSS that will entail number of new technical and regulatory challenges beyond those already associated with current GNSS implementation.

2.8 Based on the above, the PBN SG/1 meeting agreed that the ICAO MID Regional Office organize Seminar on GNSS covering the Augmentation Systems (ABAS, GBAS and SBAS) and Multi-constellations during 2015. Accordingly, the PBN SG/1 meeting agreed to the following Draft Conclusion:

DRAFT CONCLUSION 1/5: GNSS SEMINAR

That, the ICAO MID Regional Office organize, Seminar on GNSS covering the augmentation systems (ABAS, GBAS and SBAS), and Multi-constellations during 2015.

2.9 The meeting may wish to recall that AN-Conf/12 noted the information on the implementation status of GNSS constellations and augmentations systems, and considered a number of related implementation issues and developed recommendations as detailed in **Appendix B** to this working paper. The meeting may wish to note that **Appendix B** is also updated with the Status of the GNSS constellations and the Augmentation Systems; the information provided may support to develop the Provisional Agenda for the proposed GNSS Seminar, which should also cover what augmentation could be implemented for the benefit of the MID Region.

2.10 The meeting may wish to recognize that frequency interference-free operation of GNSS is essential, and that the frequency band 1 559 - 1 610 MHz, is used for elements of GNSS.

2.11 The meeting recalled that the International Telecommunication Union (ITU) process, allows under footnotes No. 5.362B and 5.362C the operation of fixed service in some States on a secondary basis until 1 January 2015. The continued use by the fixed service constitutes a severe constraint on the safe and effective use of GNSS in some areas of the world, as distances of up to 400 km between the stations of the fixed service and the aircraft is required to ensure safe operation of GNSS. Ten States (none of them from the MID Region) have removed their names from footnotes 5.362B and 5.362C during WRC-12. This was a significant step forward towards achieving better worldwide protection of GNSS.

2.12 The PBN SG meeting also noted that based on MIDANPIRG/13 recommendation, the subject related to deleting the footnotes and support of ICAO position to WRC was presented to the DGCA-MID/2 meeting in order to gain support at the highest possible level in the MID States. Accordingly, the DGCA-MID/2 meeting urged States to ensure continuous coordination with their Radio Frequency Spectrum Regulatory Authorities and the Arab Spectrum Management Group (ASMG) for the support of the ICAO position at WRC and its preparatory meetings.

2.13 The meeting may wish to note that the following States (Iraq, Jordan, Qatar, Saudi Arabia, Sudan, Syria and Yemen) still have their names in the footnotes 5.362B and/or 5.362C. In this regard, the meeting recalled MIDANPIRG/13 Conclusion 13/44: Protection of GNSS Signal, urging the concerned Sates to delete their name from these footnotes.

2.14 Based on the above, the PBN SG meeting reiterated the importance of protection of the GNSS Signal. Accordingly, the meeting again urged the concerned States to coordinate and take necessary actions with their National Radio Frequency Spectrum Regulatory Authorities (in some States it is called Telecom Regulatory Authority “TRA”) in order to delete their names from the footnotes 5.362B and/or 5.362C at WRC-15.

2.15 The meeting may wish to note that the ICAO MID Regional Office is planning to organize a WRC-15 Workshop during the First Quarter of 2015, for preparing the MID States on the frequency spectrum issues of concern to Civil Aviation and explore ways and means on the support of ICAO Position at WRC-15. It is to be highlighted that the Workshop will cover the full aviation spectrum and the invitation should be extended to the TRAs and encouraged them to attend the Workshop. An outline of the Agenda of the Workshop is at **Appendix C** to this working paper. Furthermore the Workshop will be follow-up by the ACP panel Working Group F meeting to which the States are invited and would be an opportunity to understand the panel work programme.

2.16 The PBN SG/1 meeting received an update on GNSS NOTAM and noted that the traditional methods for providing navigation aid status information and NOTAMs cannot be directly applied to satellite navigation services. Furthermore, and in accordance with GNSS Manual (Doc 9849) it was highlighted that the issuance of GNSS NOTAM has not been mandated by ICAO. Accordingly, the meeting agreed that necessary follow-up on the developments of the GNSS NOTAM be carried out by the AIM SG, as deemed necessary.

2.17 The meeting noted that one of the ACAC Priorities/Projects is the GNSS implementation in the Region in collaboration with the European Commission based on the SBAS Implementation in the Regions of ACAC and ASECNA (SIRAJ) Project (EGNOS extension). Accordingly, the GNSS Seminar mention 2.8 will be held jointly with ACAC during April 2015.

2.18 The meeting may wish to recall that Egypt has adopted an initiative to establish a Regional Aeronautical Mobile Satellite (Route) System to provide Aeronautical Safety Communication, Navigation and Surveillance/Air Traffic Management Services over Africa and Middle East Regions; the initiative is called “NAVISAT”. It was noted with concern that Egypt was to organize a NAVISAT Seminar, as agreed in MIDANPIRG/14 meeting, and presents its recommendations to the PBN Sub Group. However, since no Seminar was organized, the meeting did not receive any update on the NAVISAT initiative.

2.19 The meeting noted that EUROMED GNSS II/MEDUSA project (Global Navigation by Satellite Systems EGNOS/GALILEO) held Egypt National Workshop, in Cairo, Egypt 12 March 2014. Egypt informed the meeting on the outcome of the Workshop which was mainly about the EGNOS augmentation system (services, coverage, RIMs).

2.20 The meeting may wish to note that EUR FMG carried out a review of potential sources of non-intentional *GNSS Radio Frequency Interference (*RFI) that may affect GNSS frequencies. It was noted that future GNSS multi-constellation/dual-frequency receivers are expected to provide significant mitigation against GNSS vulnerability. However, it will not provide a full mitigation and it is important to assess and address all vulnerabilities to threats that may impact safety of GNSS-based operations.

2.21 In view of the above, the FMG conducted a review of existing and new material on GNSS vulnerabilities. As a result, some guidance material was collated at **Appendix D** to this working paper that would provide guidance to States when establishing and enforcing their regulatory provisions on the use of GNSS, in particular regulating the use of pseudolites and GNSS repeaters that may have potential safety impact on GNSS. In addition, GNSS jammers and spoofers are seen as significant threats to GNSS.

2.22 Based on the above the meeting may wish to utilize the guidance material in **Appendix D** to this working paper to mitigate potential GNSS radio frequency interference through appropriate legislation/regulation, and agree to the following Draft Conclusion:

DRAFT CONCLUSION 6/XX: GNSS RADIO FREQUENCY INTERFERENCE ISSUES

That, States be urged to use information as detailed in ***Appendix D*** *in establishing their regulatory provisions related to the use of GNSS devices that may affect the safety of Civil Aviation.*

3. ACTION BY THE MEETING

3.1 The meeting is invited to urge States to:

a) take necessary measure to ensure that States delete their names from the foot notes affecting the aviation spectrum and support ICAO position to WRC-15;

b) support the PBN SG Draft Conclusion 1/5 and agree on the Draft Conclusion in para 2.22;

c) support ICAO and ACAC for the organisation of the GNSS Seminar;

d) develop Provisional Agenda for the Seminar ;

e) participate actively in the Seminar; and

f) discuss and share **Appendix D** with their TRAs and report to ICAO the results.

APPENDIX A

INTERNATIONAL CIVIL AVIATION ORGANIZATION

MIDDLE EAST AIR NAVIGATION PLANNING AND IMPLEMENTATION REGIONAL GROUP (MIDANPIRG)

MID REGION PERFORMANCE BASED NAVIGATION IMPLEMENTATION PLAN

Draft version 1.0
June, 2014

AMENDMENTS

The MID Region PBN Implementation Plan should be reviewed and updated by the PBN and/or the ATM Sub-Groups and presented to MIDANPIRG for endorsement.
Stakeholders shall submit their proposal for amendment to the Plan to the ICAO MID Regional Office at least three months prior the PBN or the ATM Sub-Groups meetings in order to ensure adequate time for appropriate coordination. The table below provides a means to record all amendments.
An up to date electronic version of the Plan will be available on the ICAO MID Regional Office website.

Amendment Number	Effective Date	Initiated by	Impacted pages	Remarks

EXECUTIVE SUMMARY

The MID Region Performance Based Navigation (PBN) Implementation Plan has been developed to harmonize PBN implementation in the MID Region and to addresses the strategic objectives of PBN based on clearly established operational requirements, avoiding equipage of multiple on-board or ground based equipment, avoidance of multiple airworthiness and operational approvals and explains in detail contents relating to potential navigation applications.

The Plan was prepared in accordance with ICAO provisions related to PBN, the Global Air Navigation Plan, Aviation System Block Upgrades (ASBU) methodology, MID Region Air Navigation Plan and the MID Region Air Navigation Strategy. In addition to the Assembly Resolutions and the twelfth Air Navigation Conference (AN-Conf/12) Recommendations related to PBN.

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 (2013 – 2017) and for the medium term (2018 – 2022) have been projected in tabular forms to facilitate easy reference. For the long term (2023 and beyond) it has been envisaged that GNSS and its augmentation system would become the primary navigation infrastructure

This Document consolidates, updates and supersedes all previous MID Region PBN and GNSS Strategies/Plans.

The parts related to PBN implementation for En-route will be reviewed and updated by the ATM Sub-Group and those related to terminal and approach will be reviewed and updated by the PBN Sub-Group.

Explanation of Terms

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

MID Region 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.

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.

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.

REFERENCE DOCUMENTS

The below ICAO Documents provide Guidance related to the PBN implementation:

- PANS-ATM (Doc 4444)
- PANS-Ops (Doc 8168)
- PBN Manual (Doc 9613)
- GNSS Manual (Doc 9849)
- RNP AR Procedure Design Manual (Doc 9905)
- CDO Manual (Doc 9931)
- Manual on Use of PBN in Airspace Design (Doc 9992)
- CCO Manual (Doc 9993)
- Procedure QA Manual (Doc 9906)
- PBN Ops Approval Manual (Doc 9997)

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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
ACAC	Arab Civil Aviation Commission
AIS	Aeronautical Information System
APAC	Asia and Pacific Regions
APCH	Approach
APV	Approach Procedures with Vertical Guidance
AOC	Air operator certificate
ATC	Air Traffic Control
ASBU	Aviation System Block Upgrades
Baro VNAV	Barometric Vertical Navigation
CCO	Continuous Climb Operations
CDO	Continuous Decent Operations
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
GLS	GBAS Landing System
IATA	International Air Transport Association
IFALPA	International Federation of Air Line Pilots' Associations
IFATCA	International Federation of Air Traffic Controllers' Associations
IFF	Identification Friend or Foe
INS	Inertial Navigation System
IRU	Inertial Reference Unit
MEL	Minimum equipment list
MIDANPIRG	Middle East Air Navigation Planning and Implementation Regional Group
MID RMA	Middle East Regional Monitoring Agency
MLAT	Multilateration
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
SOP	Standard operating procedure
STAR	Standard Instrument Arrival
TAWS	Terrain awareness warning system
TMA	Terminal Control Area
VOR	VHF Omni-directional Radio-range
WGS	World Geodetic System

CHAPTER 1

PERFORMANCE BASED NAVIGATION

1. INTRODUCTION

1.1 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.

1.2 The main tool for optimizing the airspace structure is the implementation of 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.

1.3 The MID Regional PBN Implementation Plan will serve as guidance for regional projects for the implementation of air navigation infrastructure, such as SBAS, GBAS, GLS etc., as well as for the development of national implementation plans.

1.4 The PBN Manual (Doc 9613) provides guidance on PBN 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. PBN approval will be granted to operators that comply with these two types of approval.

1.5 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.

2. BENEFITS OF PERFORMANCE BASED NAVIGATION

a) *Access and Equity*: Increased aerodrome accessibility.

b) *Capacity*: In contrast with ILS, the GNSS based approaches do not require the definition and management of sensitive and critical areas resulting in potentially increased runway capacity.

c) *Efficiency*: Cost savings related to the benefits of lower approach minima: fewer diversions, overflights, cancellations and delays. Cost savings related to higher airport capacity in certain circumstances (e.g. closely spaced parallels) by taking advantage of the flexibility to offset approaches and define displaced thresholds.

d) *Environment*: Environmental benefits through reduced fuel burn.

e) *Safety*: Stabilized approach paths.

f) *Cost Benefit Analysis*: Aircraft operators and air navigation service providers (ANSPs) can quantify the benefits of lower minima by using historical aerodrome weather observations and modeling airport accessibility with existing and new minima. Each aircraft operator can then assess benefits against the cost of any required avionics upgrade. Until there are GBAS (CAT II/III) Standards, GLS cannot be considered as a candidate to globally replace ILS. The GLS business case needs to consider the cost of retaining ILS or MLS to allow continued operations during an interference event

3. GOALS AND OBJECTIVES OF PBN IMPLEMENTATION

3.1. The MID Region PBN Implementation Plan has the following strategic objectives:

a) ensure that implementation of the navigation element of the MID CNS/ATM system is based on clearly established operational requirements;

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

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

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

3.2. Furthermore, the Plan will provide a high-level strategy for the evolution of the navigation applications to be implemented in the MID Region in the short term (2013-2017), medium term (2018-2022).

3.3. The plan is intended to assist the main stakeholders of the aviation community to plan the future transition and their investment strategies. For example, 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.

4. PLANNING PRINCIPLES

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

a) implementation of PBN specification and granting PBN operational approvals should be in compliance with ICAO provisions;

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

c) continued application of conventional air navigation procedures during the transition period, to guarantee the operation by users that are not PBN capable;

d) Users/operational requirements should be taken into consideration while planning for PBN implementation;

e) States should provide the ICAO MID Regional Office with their updated PBN implementation Plan on annual basis (before December);

f) the implementation of Advanced-RNP should start by January 2015;

g) implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV only minima, for all runway ends at international Aerodromes, either as the primary approach or as a back-up for precision approaches by 2017 with intermediate milestones as follows: 50 percent by 2015 and 70 per cent by 2016;

h) implementation of straight-in LNAV only procedures, as an exception to g) 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.

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.

5.2. Continuous Climb and Descent Operations (CCO and CDO) are two of several tools available to aircraft operators and ANSPs that, through collaboration between stakeholders, will make it possible to increase efficiency, flight predictability and airspace capacity, while reducing fuel burn, emissions and controller-pilot communications, thereby enhancing safety.

En-route

5.3. Considering the traffic characteristic and CNS/ATM capability of the Region, the En-route operations 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 PBN navigation specification. This implementation strategy will be applied by the States and international organizations themselves, as coordinated at regional level to ensure harmonization.

5.4. 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 more accurate navigation specification on the basis of coordination with stakeholders and affected neighbouring States.

Terminal

5.5. 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.

5.6. In this context, the States should develop their own national plans for the implementation of PBN in Terminal Control Areas (TMAs), based on the MID Region PBN Implementation 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.

Approach

5.7. ATC workload should be taken into account while developing PBN Approach Procedures. One possible way to accomplish this would be by co-locating the Initial Approach Waypoint (IAW) for PBN with the Initial Approach Fix (IAF) of the conventional approaches. States should phase-out conventional non-precision approach procedures at a certain point when deemed operationally suitable and taking in consideration GNSS integrity requirements.

5.8. Therefore, MID States are encouraged to include implementation of CCO and CDO, where appropriate, as part of their PBN implementation plans, in compliance with the provisions of ICAO Documents 9931 and 9993, and in accordance with the MID Region Air Navigation Strategy.

5.9. Sates are encouraged to plan for the implementation of RNP AR procedures, which can provide significant operational and safety advantages over other area navigation (RNAV) procedures by incorporating additional navigational accuracy, integrity and functional capabilities to permit operations using reduced obstacle clearance tolerances that enable approach and departure procedures to be implemented in circumstances where other types of approach and departure procedures are not operationally possible or satisfactory. Procedures implemented in accordance with RNP AR Procedure Design Manual (Doc 9905) allow the exploitation of high-quality, managed lateral and vertical navigation (VNAV) capabilities that provide improvements in operational safety and reduced Controlled Flight Into Terrain (CFIT) risks.

CHAPTER 2

CNS INFRASTRUCTURE

1. NAVIGATION INFRASTRUCTURE

Global Navigation Satellite System (GNSS)

1.1. Global Navigation Satellite System (GNSS) is a satellite-based navigation system utilizing satellite signals, such as Global Positioning System (GPS), and GLONASS 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.

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.

1.3. GNSS augmentations include Aircraft-Based Augmentation System (ABAS), Satellite-Based Augmentation System (SBAS) and Ground-Based Augmentation System (GBAS).

1.4. For GNSS implementation States need to provide effective spectrum management and protection of GNSS frequencies by enforcing strong regulatory framework governing the use of GNSS repeaters, and jammers. States need to assess the likelihood and effects of GNSS vulnerabilities in their airspace and apply, as necessary, recognized and available mitigation methods.

1.5. 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 consulted and given reasonable transition time to allow them to equip accordingly.

1.6. GNSS implementation should take advantage of the improved robustness and availability made possible by the existence of multiple global navigation satellite system constellations and associated augmentation systems.

1.7. Operators consider equipage with GNSS receivers able to process more than one constellation in order to gain the benefits associated with the support of more demanding operations. States allow for realization of the full advantages of on-board mitigation techniques.

2. OTHER NAVIGATION INFRASTRUCTURE SUPPORTING PBN

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

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

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

2.4. 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 2017.

3. SURVEILLANCE INFRASTRUCTURE

3.1. 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 (Doc 9613) and ICAO PANS-ATM (Doc 4444), and information on the current surveillance infrastructure in the MID can be found in ICAO FASID table.

3.2. Multilateration (MLAT) employs a number of ground stations, which are placed in strategic locations around an airport, its local terminal area or a wider area that covers the larger surrounding airspace. Multilateration requires no additional avionics equipment, as it uses replies from Mode A, C and S transponders, as well as military IFF and ADS-B transponders. MLAT is under consideration by several MID States (Bahrain, Egypt, Oman and UAE).

4. COMMUNICATION INFRASTRUCTURE

4.1. 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 MID FASID tables.

CHAPTER 3

IMPLEMENTATION OF PBN

1. ATM OPERATIONAL REQUIREMENTS

1.1. 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.

1.2. During the planning phase of any implementation of PBN, 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

1.3. In this regard, the following should be taken into consideration:

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
m) Establish PBN approval database

1.4. Table 2-1 shows the navigation specifications published in Parts B and C of PBN Manual (Doc 9613), Volume II. It demonstrates, for example, that navigation specifications extend over various phases of flight. It also contains the Navaids/Sensor associated with each PBN specification.

1.5. The implementation of PBN additional functionalities/path terminator should be considered while planning/designing new procedures such as:

- the Radius to Fix (RF) for approach;
- Fixed Radius Transition (FRT) for En-route; and
- Time of Arrival Control (TOAC).

Table 3-1. Application of navigation specification by flight phase

Navigation Specification	***FLIGHT PHASE***								**NAVAIDS/SENSORS**				
	En-route oceanic/ remote	***En-route continental***	***Arrival***	***Approach***				***DEP***	**GNSS**	**IRU**	**DME/ DME**	**DME/ DME/ IRU**	**VOR/ DME**
				Initial	***Intermediate***	***Final***	***Missed***[1]						
RNAV 10	10	N/A		N/A				N/A	O	O	N/A		
RNAV 5[2]	N/A	5	5						O	O	O	N/A	O
RNAV 2		2	2					2	O	N/A	O	O	N/A
RNAV 1		1	1	1	1	N/A	1	1	O		O	O	
RNP 4	4	N/A		N/A				N/A	M				
RNP 2	2	2	N/A						M		SR	SR	
RNP 1[3]	N/A		1	1	1	N/A	1	1	M		SR	SR	
Advanced RNP (A-RNP)[4]	2	2 or 1	1	1	1	0.3	1	1	M		SR	SR	
RNP APCH[6]	N/A			1	1	0.3[7]	1	N/A	M		N/A		
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1		M				
RNP APCH APV				1	1	0.3	1		M				
RNP 0.3[8]	N/A		0.3	0.3	0.3	0.3	0.3	0.3	M				

O: Optional; M: Mandatory; SR: Subject ANSP Requirements

1. *Only applies once 50 m (40 m, Cat H) obstacle clearance has been achieved after the start of climb.*
2. *RNAV 5 is an en-route navigation specification which may be used for the initial part of a STAR outside 30 NM and above MSA.*
3. *The RNP 1 specification is limited to use on STARs, SIDs, the initial and intermediate segments of IAPs and the missed approach after the initial climb phase. Beyond 30 NM from the ARP, the accuracy value for alerting becomes 2 NM.*
4. *A-RNP also permits a range of scalable RNP lateral navigation accuracies*
5. *PBN manual contains two sections related to the RNP APCH specification: Section A is enabled by GNSS and Baro-VNAV, Section B is enabled by SBAS.*
6. *RNP 0.3 is applicable to RNP APCH Section A. Different angular performance requirements are applicable to RNP APCH Section B only.*
7. *The RNP 0.3 specification is primarily intended for helicopter operations*.

2. IMPLEMENTATION PHASES:

En-route

Short Term:

2.1. The current application of RNAV 10 will continue for Oceanic and Remote continental routes.

2.2. For Continental RNAV 5 specifications should be completed by December 2017. Before the PBN concept, the MID Region adopted the Regional implementation of RNP 5.Furtehr to application of the PBN concept it is now required that RNP 5 be changed 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).

Medium Term:

2.3. RNP 4 and/or RNP 2 routes would be considered for implementation for the En-route oceanic/remote operations.

2.4. RNP 2 or 1 would be considered for implementation for En-route continental/local domestic operations.

Terminal

Short Term:

2.5. 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.

2.6. CCO and CDO should be implemented at the defined TMAs, in accordance with the State PBN implementation Plans, the MID Region Air navigation Strategy and the MID ANP.

Medium Term:

2.7. RNAV 1, A-RNP 1 will be implemented in all TMAs, expected target will be 70 % by the end of this term.

Approach

Short Term:

2.8. Implementation of PBN approaches with vertical guidance (APV) for runway ends at the international aerodromes listed in the MID ANP should be completed by December 2017, including LNAV only minima.

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

Medium Term:

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

2.11. To progress further with the universal implementation of PBN approaches. GLS procedures should be implemented for the defined runway ends to enhance the reliability and predictability of approaches to runways increasing safety, accessibility, and efficiency.

2.12. Table 3-2 summarizes the implementation targets of each PBN navigation specification in the MID Region:

Table 3-2. SUMMARY TABLE AND IMPLEMENTATION TARGETS

Airspace	Short term 2014-2017		Medium term 2018-2022	
	Navigation Specification Preferred	**Targets**	**Navigation Specification Acceptable**	**Targets**
En-route – Oceanic	RNAV 10	100 % by 2016	RNP 4* RNP 2* Defined airspace (A-RNP)	TBD
En-route - Remote continental	RNAV 5 RNAV 10	W/A 100% by 2016	RNP 4* RNP 2* Defined airspace (A-RNP)	TBD
En-route – Continental	RNAV 5 RNAV 1	100 % by 2017 W/A[1]	RNP 2* or 1* Defined airspace (A-RNP)	TBD
En-route - Local / Domestic	RNAV 5 RNAV 1	100 % by 2017 W/A	RNP 2 or 1 Defined airspace (A-RNP)	TBD
TMA – Arrival	RNAV 1 in surveillance environment and with adequate navigation infrastructure. Basic RNP 1 in non-surveillance environment	50% by December 2015 100% by 2017	RNP 1 and RNP 2 beyond 30 NM from ARP (A-RNP)	TBD
TMA – Departure	RNAV 1 in surveillance environment and with adequate navigation infrastructure. Basic RNP 1 in non- surveillance environment	50% by 2015 100% by 2017	RNP 1 and RNP 2 beyond 30 NM from ARP (A-RNP)	TBD
Approach	LNAV: for all RWY Ends at International Aerodromes LNAV/VNAV: for all RWY Ends at International Aerodromes	80 % by 2014. 100% by 2015 70% by 2015 100% by 2017	GLS (GBAS) For the defined RWY Ends	TBD
CCO and CDO	W/A	100% by 2017	W/A	TBD

- *W/A: where applicable/defined Airspace, in accordance with State PBN implementation Plans, the MID Region Air navigation Strategy and the MID ANP.*
- ** would be considered for implementation at the identified Airspace/TMAs*
- *When no month is specified (e.g. by 2017) means by the end of the year (December 2017).*

Long Term (2023 and Beyond)

2.13. In this phase, GNSS augmentation 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.

2.14. 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.

2.15. The required PBN navigation specifications and their associated targets to be implemented for the Long term will be defined in due course.

CHAPTER 4

SAFETY ASSESSMENT AND MONITORING

1. NEED FOR SAFETY ASSESSMENT

1.1. 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

2. ROLES AND RESPONSIBILITIES

2.1. 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.

2.2. In undertaking a safety assessment to enable en-route implementation of PBN, a State or the implementing agency 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;

c) conduct safety and readiness assessments;

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

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

CHAPTER 5
OPERATIONAL APPROVAL

1. OPERATIONAL APPROVAL REQUIREMENTS

1.2. Operational approval is usually the responsibility of the regulatory authority of the State of the Operator for commercial air transport operations and the State of Registry for general Aviation (GA) operations. For certain operations, GA operators may not be required to follow the same authorization model as commercial operators.

1.3. The operational approval assessment must take account of the following:

a) Aircraft eligibility and airworthiness compliance;

b) Operating procedures for the navigation systems used;

c) Control of operating procedures (documented in the OM);

d) Flight crew initial training and competency requirements and continuing competency requirements;

e) Dispatch training requirements;

f) control of navigation database procedures. Where a navigation database is required, operators need to have documented procedures for the management of such databases. These procedures will define the sourcing of navigation data from approved suppliers, data validation procedures for navigation databases and the installation of updates to databases into aircraft so that the databases remain current with the AIRAC cycle. (For RNP AR applications, the control of the terrain database used by TAWS must also be addressed.)

Aircraft eligibility

1.4. An aircraft is eligible for a particular PBN application provided there is clear statement in:

a) the Type Certificate (TC); or
b) the Supplement Type Certificate (STC); or
c) the associated documentation — Aircraft Flight manual (AFM) or equivalent document; or
d) a compliance statement from the manufacturer that has been approved by the State of Design and accepted by the State of Registry or the State of the Operator, if different.

1.5. The operator must have a configuration list detailing the pertinent hardware and software components and equipment used for the PBN operation.

1.6. The TC is the approved standard for the production of a specified type/series of aircraft. The aircraft specification for that type/series, as part of the TC, will generally include a navigation standard. The aircraft documentation for that type/series will define the system use, operational limitations, equipment fitted and the maintenance practices and procedures. No changes (modifications) are permitted to an aircraft unless the CAA of the State of Registry either approves such changes through a modification approval process, STC or accepts technical data defining a design change that has been approved by another State.

1.7. For recently manufactured aircraft, where the PBN capability is approved under the TC, there may be a statement in the AFM limitations section identifying the operations for which the aircraft is approved. There is also usually a statement that the stated approval does not itself constitute an approval for an operator to conduct those operations. Alternate methods of achieving the airworthiness approval of the aircraft for PBN operations is for the aircraft to be modified in accordance with approved data. (e.g. STC, minor modification, etc.)

1.8. One means of modifying an aircraft is the approved Service Bulletin (SB) issued by the aircraft manufacturer. The SB is a document approved by the State of Design to enable changes to the specified aircraft type and the modification then becomes part of the type design of the aircraft. Its applicability will normally be restricted by the airframe serial number. The SB describes the intention of the change and the work to be done to the aircraft. Any deviations from the SB require a design change approval; any deviations not approved will invalidate the SB approval. The State of Registry accepts the application of an SB and changes to the maintenance programme, while the State of the Operator accepts changes to the maintenance programme and approves changes to the MEL, training programmes and Operations specifications. An Original Equipment Manufacturer (OEM) SB may be obtained for current production or out of production aircraft.

1.9. In respect of PBN, in many cases for legacy aircraft, while the aircraft is capable of meeting all the airworthiness requirements, there may be no clear statement in the applicable TC or STC or associated documents (AFM or equivalent document). In such cases, the aircraft manufacturer may elect to issue an SB with appropriate AFM update or instead may publish a compliance statement in the form of a letter, for simple changes, or a detailed aircraft type specific document for more complex changes. The State of Registry may determine that an AFM change is not required if it accepts the OEM documentation. **Table 5-1** lists the possible scenarios facing an operator who wishes to obtain approval for a PBN application, together with the appropriate courses of action.

Table 5-1

Scenario	Aircraft certification status	Actions by operator/owner
1	Aircraft designed and type certificated for PBN application. Documented in AFM, TC or the STC	No action required, aircraft eligible for PBN application
2	Aircraft equipped for PBN application but not certified. No statement in AFM. SB available from the aircraft manufacturer	Obtain SB (and associated amendment pages to the AFM) from the aircraft manufacturer
3	Aircraft equipped for PBN application. No statement in AFM. SB not available. Statement of compliance available from the aircraft manufacturer	Establish whether the statement of compliance is acceptable to the regulatory authority of the State of Registry of the aircraft
4	Aircraft equipped for PBN application. No statement in AFM. SB not available. Statement of compliance from the aircraft manufacturer not available	Develop detailed submission to State of Registry showing how the existing aircraft equipment meets the PBN application requirements
5	Aircraft not equipped for PBN application	Modify aircraft in accordance with the aircraft manufacturer’s SB or develop a major modification in conjunction with an approved design organization in order to obtain an approval from the State of Registry (STC).

Operating procedures

1.10. The Standard operating procedure (SOP) must be developed to cover both normal and non-normal (contingency) procedures for the systems used in the PBN operation. The SOP must address:

a) preflight planning requirements including the MEL and, where appropriate, RNP/RAIM prediction;
b) actions to be taken prior to commencing the PBN operation;
c) actions to be taken during the PBN operation; and
d) actions to be taken in the event of a contingency, including the reporting of significant incidents

GA pilots must ensure that they have suitable procedures/checklists covering all these areas

Control of operating procedures

1.11. The SOP must be adequately documented in the OM and checklists

Flight crew and dispatch training

1.12. A flight crew and dispatch training programme for the PBN operation must cover all the tasks associated with the operation and provide sufficient background to ensure a comprehensive understanding of all aspects of the operation. The operator must have adequate records of course completion for flight crew, flight dispatchers and maintenance personnel.

Control of navigation database procedures

1.13. If a navigation database is required, the procedures for maintaining currency, checking for errors and reporting errors to the navigation database supplier must be documented in the maintenance manual by commercial operators

2. DOCUMENTATION OF OPERATIONAL APPROVAL

2.1. Operational approval may be documented as an endorsement of the Air operator certificate (AOC) through:

a) an Operations specification, associated with the AOC; or
b) an amendment to the OM; or
c) an LOA.

2.2. During the validity of the operational approval, the CAA should consider any anomaly reports received from the operator or other interested party. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in restrictions on use or cancelation of the approval for use of that equipment. Information that indicates the potential for repeated errors may require modification of an operator's training programme. Information that attributes multiple errors to a particular pilot or crew may necessitate remedial training and checking or a review of the operational approval.

2.3. The State may determine that a GA aircraft may operate on a PBN route/procedure provided that the operator has ensured that the aircraft has suitably approved equipment (is eligible), the navigation database is valid, the pilot is suitably qualified and current with respect to the equipment, and adequate procedures (checklists) are in place.

3. STATE REGULATORY MATERIAL

3.1. Individual States must develop national regulatory material which addresses the PBN applications relevant to their airspace or relevant to operations conducted in another State by the State's operators or by aircraft registered in that State. The regulations may be categorized by operation, flight phase, area of operation and/or navigation specification. Approvals for commercial operations should require specific authorization.

4. APPROVAL PROCESS

General

4.2. Since each operation may differ significantly in complexity and scope, the project manager and the operational approval team need considerable latitude in taking decisions and making recommendations during the approval process. The ultimate recommendation by the project manager and decision by the DGCA regarding operational approval should be based on the determination of whether or not the applicant:

a) meets the requirements established by the State in its air navigation regulations;
b) is adequately equipped; and
c) is capable of conducting the proposed operation in a safe and efficient manner.

4.3. The complexity of the approval process is based on the inspector's assessment of the applicant's proposed operation. For simple approvals, some steps can be condensed or eliminated. Some applicants may lack a basic understanding of what is required for approval. Other applicants may propose a complex operation, but may be well prepared and knowledgeable. Because of the variety in proposed operations and differences in an applicant's knowledge, the process must be thorough enough and flexible enough to apply to all possibilities.

Phases of the approval process

Step 1 — Pre-application phase

4.4. The operator initiates the approval process by reviewing the requirements; establishing that the aircraft, the operating procedures, the maintenance procedures and the training meet the requirements; and developing a written proposal to the regulator. A number of regulators have published "job aids" to assist the operator in gathering the necessary evidence to support the approval application. At this stage a pre-application meeting with the regulator can also be very beneficial. If the proposed application is complex, the operator may need to obtain advice and assistance from OEMs or other design organizations, training establishments, data providers, etc.

Step 2 — Formal application phase

4.5. The operator submits a formal, written application for approval to the CAA, which appoints a project manager either for the specific approval or generally for PBN approvals.

Step 3 — Document evaluation phase

4.6. The CAA project manager evaluates the formal, written application for approval to determine whether all the requirements are being met. If the proposed application is complex, the project manager may need to obtain advice and assistance from other organizations such as regional agencies or experts in other States.

Step 4 — Demonstration and inspection phase

4.7. During a formal inspection by the project manager (assisted as necessary by a CAA team), the operator demonstrates how the requirements are being met.

Step 5 — Approval phase

4.8. Following a successful formal inspection by the CAA, approval is given via:

a) an Operations specification, associated with the AOC; or
b) an amendment to the OM; or
c) an LOA.

Some PBN applications may not require formal approval for GA operations — this will be determined by the State of Registry.

Note.— The approval procedure described above consists of a simplified process of the certification guidance contained in Part III of the Manual of Procedures for Operations Inspection, Certification and Continued Surveillance *(Doc 8335).*

5. FOREIGN OPERATIONS

5.1. A State undertakes, in accordance with Article 12 to the Convention, to ensure that every aircraft flying over or manoeuvring within its territory shall comply with the rules and regulations relating to the flight and manoeuvre of aircraft there in force. Article 33 to the Convention provides that certificates of airworthiness and certificates of competency and licences issued, or rendered valid, by the State in which an aircraft is registered, shall be recognized by other States, provided that the requirements under which such certificates or licences were issued or rendered valid are equal to or above the minimum standards which may be established by ICAO. This requirement for recognition is now extended by Annex 6, Part I and Part III, Section II, such that Contracting States shall recognize as valid an AOC issued by another Contracting State, provided that the requirements under which the certificate was issued are at least equal to the applicable Standards specified in Annex 6, Part I and Part III.

5.2. States should establish procedures to facilitate the application by foreign operators for approval to operate into their territory. States should be careful in their requirements for applications, to request only details relevant to the evaluation of the safety of the operations under consideration and their future surveillance. When evaluating an application by an operator from another State to operate within its territory a State will examine both the safety oversight capabilities and record of the State of the Operator and, if different, the State of Registry, as well as the operational procedures and practices of the operator. This is necessary in order for the State, in the terms of Article 33 to the Convention, to have confidence in the validity of the certificates and licences associated with the operator, its personnel and aircraft, in the operational capabilities of the operator and in the level of certification and oversight applied to the activities of the operator by the State of the Operator.

5.3. The operator will need to make applications to each State into or over which it is intended to operate. The operator will also need to keep its own CAA, as the authority of the State of the Operator, informed of all applications to operate in other States. Applications should be made direct to the CAAs of the States into which it is intended to operate. In some cases it will be possible to download information and instructions for making an application and the necessary forms from a website maintained by the CAA in question.

5.4. States should promote the implementation and operational approval of Advanced RNP (A-RNP) navigation specifications, which serves all the flight phases as follows:

- En-Route Oceanic, Remote: RNP 2;
- En-Route Continental: RNP 2 or RNP 1;
- Arrival and Departures: RNP 1;
- Initial, intermediate and missed approach phases: RNP 1; and
- Final Approach Phase: RNP 0.3.

5.5. Because functional and performance requirements are defined for each navigation specification, an aircraft approved for an RNP specification is not automatically approved for all RNAV specifications. Similarly, an aircraft approved for an RNP or RNAV specification having a stringent accuracy requirement (e.g. RNP 0.3 specification) is not automatically approved for a navigation specification having a less stringent accuracy requirement (e.g. RNP 4).

APPENDIX B

Status of core GNSS constellations

The United States is currently deploying modernized global positioning system (GPS) satellites with L1C/A and L5 signals and improved military encrypted signals that will enable civil and authorized State aircraft with modernized equipment to remove ionosphere induced errors and take advantage of increased performance and robustness.

The Russian GLObal navigation Satellite System (GLONASS) was operating with a stable constellation of twenty-four GLONASS-M satellites, with additional back-up satellites. In addition, the Russian Federation is continuing its work to develop a new generation of GLONASS-K satellites. In-orbit tests are currently being conducted on an experimental GLONASS-K satellite. The ground control system is also being improved.

The Galileo is a GNSS constellation that is being developed by the European Union in cooperation with the European Space Agency. The first four satellites have already been successfully launched, and it is expected that 18 satellites will be operational by 2015, enabling the provision of initial services in combination with GPS and other constellations. It is planned that the Galileo constellation will be fully deployed by 2020.

The BeiDou system, a GNSS constellation developed and operated by China. The deployment of the system is progressing as scheduled. The second phase of development has just been completed, supporting a position, navigation and timing (PNT) service for China and the surrounding areas. According to the schedule, full global deployment of the constellation will be completed by 2020.

Satellite-Based Augmentation System (SBAS)

SBAS Interoperability Working Group (IWG) is the forum for SBAS service providers to assure common understanding and implementation of the SARPs. The implementation status of several SBAS is as follows:

The critical (Safety-of-Life) service of the European Geostationary Navigation Overlay Service (EGNOS) system was declared operational for aviation in 2011, and offered to ICAO for use by the civil aviation community.

The progress made in the deployment of the GPS Aided Geo Augmented navigation (GAGAN) system developed by India, with the completion of the final system acceptance test and the inception of the certification process.

The Wide Area Augmentation System (WAAS) – (United States) Operational since 2003 Supports en route, terminal and approach operations and CAT I-like approach capability.

The Multi-function Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS) – (Japan) is Operational since 2007 Supports en route, terminal and non-precision approach operations.

The System of Differential Correction and Monitoring (SDCM) – (Russia), in development with plans for providing horizontal and vertical guidance.

RECOMMENDATIONS ADOPTED BY AN-CONF/12	Remark
Recommendation 6/5 – ICAO work programme to support global navigation satellite system evolution That ICAO undertake a work programme to address: a) interoperability of existing and future global navigation satellite system constellations and augmentation systems, with particular regard to the technical and operational issues associated with the use of multiple constellations; b) identification of operational benefits to enable air navigation service providers and aircraft operators to quantify these benefits for their specific operational environment; and c) continued development of Standards and Recommended Practices and guidance material for existing and future global navigation satellite system elements and encouraging the development of industry standards for avionics.	Progressing in ICAO Panels
Recommendation 6/6 – Use of multiple constellations That States, when defining their air navigation strategic plans and introducing new operations: a) take advantage of the improved robustness and availability made possible by the existence of multiple global navigation satellite system constellations and associated augmentation systems; b) publish information specifying the global navigation satellite system elements that are approved for use in their airspace; c) adopt a performance-based approach with regard to the use of global navigation satellite system (GNSS), and avoid prohibiting the use of GNSS elements that are compliant with applicable ICAO Standards and Recommended Practices; d) carefully consider and assess if mandates for equipage or use of any particular global navigation satellite system core constellation or augmentation system are necessary or appropriate;	<u>On regional Level this was included in the MID Regional GNSS Implementation Strategy</u> a) States take advantage of the improved robustness and availability made possible by the existence of multiple GNSS constellations and associated augmentation systems; b) States publish information specifying the GNSS elements that are approved for use in their airspace; c) States adopt a performance-based approach with regard to the use of GNSS, and avoid prohibiting the use of GNSS elements that are compliant with applicable ICAO SARPs d) States carefully consider and assess if mandates for equipage or use of any particular global navigation satellite system

RECOMMENDATIONS ADOPTED BY AN-CONF/12	Remark
That aircraft operators: e) consider equipage with GNSS receivers able to process more than one constellation in order to gain the benefits associated with the support of more demanding operations.	core constellation or augmentation system are necessary or appropriate; e) IOs consider equipage with GNSS receivers able to process more than one constellation in order to gain the benefits associated with the support of more demanding operations
Recommendation 6/7 – Assistance to States in mitigating global navigation satellite system vulnerabilities That ICAO: a) continue technical evaluation of known threats to the global navigation satellite system, including space weather issues, and make the information available to States; b) compile and publish more detailed guidance for States to use in the assessment of global navigation satellite system vulnerabilities; c) develop a formal mechanism with the International Telecommunication Union and other appropriate UN bodies to address specific cases of harmful interference to the global navigation satellite system reported by States to ICAO; and d) assess the need for, and feasibility of, an alternative position, navigation and timing system.	Progressing well at the ICAO Panels.

RECOMMENDATIONS ADOPTED BY AN-CONF/12	Remark
Recommendation 6/8 – Planning for mitigation of global navigation satellite system vulnerabilities That States:	On regional Level this was included in the MID Regional GNSS Implementation Strategy
a) assess the likelihood and effects of global navigation satellite system vulnerabilities in their airspace and apply, as necessary, recognized and available mitigation methods;	a) States assess the likelihood and effects of GNSS vulnerabilities in their airspace and apply, as necessary, recognized and available mitigation methods.
b) provide effective spectrum management and protection of global navigation satellite system (GNSS) frequencies to reduce the likelihood of unintentional interference or degradation of GNSS performance;	b) States provide effective spectrum management and protection of GNSS frequencies to reduce the likelihood of unintentional interference or degradation of GNSS performance.
c) report to ICAO cases of harmful interference to global navigation satellite system that may have an impact on international civil aviation operations;	c) States report to ICAO cases of harmful interference to global navigation satellite system that may have an impact on international civil aviation operations.
d) develop and enforce a strong regulatory framework governing the use of global navigation satellite system repeaters, pseudolites, spoofers and jammers;	d) States develop and enforce a strong regulatory framework governing the use of global navigation satellite system repeaters, pseudolites, spoofers and jammers.
e) allow for realization of the full advantages of on-board mitigation techniques, particularly inertial navigation systems; and	e) States allow for realization of the full advantages of on-board mitigation techniques, particularly inertial navigation systems.
f) where it is determined that terrestrial aids are needed as part of a mitigation strategy, give priority to retention of distance measuring equipment (DME) in support of inertial navigation system (INS)/DME or DME/DME area navigation, and of instrument landing system at selected runways.	f) States where it is determined that terrestrial aids are needed as part of a mitigation strategy, give priority to retention of DME in support of inertial navigation system (INS)/DME or DME/DME area navigation, and of instrument landing system at selected runways.

RECOMMENDATIONS ADOPTED BY AN-CONF/12	Remark
Recommendation 6/9 – Ionosphere and space weather information for future global navigation satellite system implementation That ICAO: a) coordinate regional and global activities on ionosphere characterization for global navigation satellite system implementation; b) continue its effort to address the global navigation satellite system (GNSS) vulnerability to space weather to assist States in GNSS implementation taking into account of long-term GNSS evolution as well as projected space weather phenomena; c) study the optimum use of space weather information that is globally applicable from low to high magnetic latitude regions for enhanced global navigation satellite system performance at a global context; That States: d) consider a collaborative approach to resolve ionospheric issues including ionospheric characterization for cost-effective, harmonized and regionally suitable global navigation satellite system implementation.	Progressing in ICAO Panels also Manual on Ionosphere On regional Level this was included in the MID Regional GNSS Implementation Strategy d) States consider a collaborative approach to resolve ionospheric issues including ionospheric characterization for cost-effective, harmonized and regionally suitable global navigation satellite system implementation
Recommendation 6/10 – Rationalization of terrestrial navigation aids That, in planning for the implementation of performance-based navigation, States should: a) assess the opportunity for realizing economic benefits by reducing the number of navigation aids through the implementation of performance-based navigation; b) ensure that an adequate terrestrial navigation and air traffic management infrastructure remains available to mitigate the potential loss of global navigation satellite system service in their airspace; and	a) States assess the opportunity for realizing economic benefits by reducing the number of navigation aids through the implementation of PBN; b) States ensure that an adequate terrestrial navigation and air traffic management infrastructure remains available to mitigate the potential loss of global navigation satellite system service in their airspace; and

RECOMMENDATIONS ADOPTED BY AN-CONF/12	Remark
c) align performance-based navigation implementation plans with navigation aid replacement cycles, where feasible, to maximize cost savings by avoiding unnecessary infrastructure investment.	c) States align performance-based navigation implementation plans with navigation aid replacement cycles, where feasible, to maximize cost savings by avoiding unnecessary infrastructure investment.

APPENDIX C

AERONAUTICAL FREQUENCY SPECTRUM WORKSHOP, WRC-15 PREPARATIONS

AGENDA

1. INTRODUCTION

- ITU/WRC process, results of WRC-12
- Preparation for future WRCs, outcome of ANConf/12.

2. PREPARATION OF THE WRC/15: ACTION PLAN TO BE IMPLEMENTED AT THE NATIONAL AND REGIONAL LEVELS

- An overview of all aviation relevant agenda items to be addressed by the next WRC (WRC-15)
- WRC-15 Agenda Item 1.1 - Spectrum for mobile and broadband
- WRC- 15 Agenda Item 1.5 - FSS allocations for Unmanned Aircraft Systems (UAS)
- WRC-15 Agenda Item 1.7 - Review the use of the band 5091 – 5150 MHz by the FSS
- WRC- 15 Agenda Item 1.17 - Wireless Avionics Intra- communications WAIC
- WRC-15 Agenda Item 9.1.5 - VSAT
- Satellite reception of ADS-B
- ASMG preliminary views on the various WRC-15 agenda items.

3. THE REALITY OF FREQUENCY MANAGEMENT IN APAC: CURRENT PRACTICES AND NEW CHALLENGES

- Radio Frequency Management and Interference Mitigation
- Aeronautical frequency management in the MID Region
- ICAO provisions: Handbook on Radio Frequency Spectrum Requirements for Civil Aviation (Doc 9718), Volume I, and the new Volume II
- New ICAO frequency manager - tool and exercises.

4. ANY OTHER BUSINESS

Use of GNSS pseudolites and repeaters

1. Introduction

1.1 As for all systems using the radio frequency spectrum, GNSS is vulnerable to interference and measures (radio regulatory) are in place through the provisions of the ITU Radio Regulations to protect GNSS systems from harmful interference. Technical measures such as the specification of the GNSS receiver interference mask are in Annex 10.

1.2 Despite various regulatory mechanisms being in place, including those agreed at European (CEPT) level. In the recent years harmful interference that was either caused intentionally or unintentionally has been experienced to GNSS systems.

1.3 In addition to interference caused by RF emissions, GNSS signals are also vulnerable to ionospheric scintillation which may cause loss of GNSS signals in particular in equatorial and auroral regions.

1.4 Detailed material on GNSS vulnerability and GNSS interference is in the ICAO GNSS Manual (Doc. 9849) which is currently being revised by the Navigation Systems Panel. Relevant (draft) material on interference from this Manual is reproduced in **Appendix A**

1.5 Of concern to aviation is the protection of the frequency bands 1559 – 1610 MHz, used by GLONASS and GPS and the band 1164 – 1215 MHz which is foreseen to be used by GLONASS and GPS. Also the European Galileo system and the Chinese BEIDOU system are planning to use these bands to provide GNSS signals for use by aviation. Various satellite based augmentation systems are operating in the frequency band 1559 – 1610 MHz.

2. Interference

2.1 Unintentional interference.

2.1.1 Unintentional interference is normally caused by equipment authorized to operate on GNSS frequencies under strict conditions that are aimed at not causing harmful interference to the reception of GNSS signals. Problematic is that not in all cases such equipment is being used in accordance with these conditions, thus resulting in causing harmful interference.
Equipment that can cause such interference include GNSS repeaters and GNSS Pseudolites

2.1.2 In Europe provisions were developed by the ECC/CEPT to avoid harmful interference by inappropriate use of GNSS pseudolites and GNSS repeaters. These provisions and other relevant material is available from the website of the European Communications Office (ECO) in the following Reports and Recommendation:

ECC Report 129: Technical and operational provisions required for the use of GNSS repeaters
ECC Report 145: Regulatory framework for Global Navigation Satellite System (GNSS) repeaters
ECC Recommendation (10)02, A framework for authorization regime of Global Navigation Satellite System
ECC Report 128: Compatibility Studies between Pseudolites and Services in the frequency bands 1164-1215 MHz, 1215-1300 MHz and 1559-1610 MHz
ECC REC (04)01, which declares jammers as illegal.
ECC Report 183, Regulatory Framework for Outdoor Pseudolites

2.1.3 In addition various ITU-R Recommendations provide relevant information on the compatibility and use of RNSS networks, including:

Recommendation ITU-R M.1904: Characteristics, performance requirements and protection criteria for receiving stations of the radionavigation-satellite service (space-to-space) operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz

Recommendation ITU-R M.1901: Guidance on ITU-R Recommendations related to systems and networks in the radionavigation-satellite service operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz

Recommendation ITU-R M.1787: Description of systems and networks in the radionavigation-satellite service (space-to-Earth and space-to-space) and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz,1 215-1 300 MHz and 1 559-1 610 MHz

Recommendation ITU-R M.1903: Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) and receivers in the aeronautical radionavigation service operating in the band 1 559-1 610 MHz

Recommendation ITU-R M.1318: Evaluation model for continuous interference from radio sources other than in the radionavigation-satellite service to the radionavigation-satellite service systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz bands

Recommendation ITU-R M.2030: Evaluation method for pulsed interference from relevant radio sources other than in the radionavigation-satellite service to the radionavigation-satellite service systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz frequency bands

ITU R M.2220 which provides criteria to determine compatibility between DME and GNSS L5.

2.1.4 States are invited to consult this material with the view to develop national regulations that will enforce the operation of GNSS Pseudolites and Repeater in a manner that harmful; interference to the reception of GNSS signals by aviation is prevented. Particular attention should be given to the practicality to enforce these provisions.

2.2 Intentional interference

Intentional interference is caused by equipment of which the user has the intention to cause harmful interference to the reception of GNSS signals, either on a local (e.g. less than 100 m) scale or a large scale (e.g. in the order of 100 – 200 NM).

Equipment used to cause intentional interference includes jammers and spoofers (intentional interference that may result in an aircraft to follow a false flight path).

The sale and use for jammers developed to cause Intentional interference, (e.g. to avoid tracking of vehicles) and spoofers should be forbidden. Although difficult, these systems should not be allowed on any market (national or international).

2.3 ICAO Electronic Bulletin on Interference to GNSS Signals.

ICAO has drawn the attention of States to the need to ensure protection of GNSS signals from interference and point to the need of cooperation between national aeronautical and telecommunication authorities in the introduction and enforcement of appropriate regulations (Electronic Bulletin EB 2011/56 from 21 November refers). This Electronic Bulletin is, for the ease of reference, reproduced in **Appendix B**

3. Cooperation with ITU

3.1 Interference to GNSS systems can affect international civil aviation and [in some cases] international coordination may be required to solve such interference. A framework for cooperation in the format of a Memorandum of Understanding between the ITU and ICAO has been established with the prime view to maximize the joint efforts of the ITU and ICAO to eliminate cases of harmful interference. This Memorandum is reproduced in Appendix C

4. Fixed Service

4.1 The frequency band 1559 – 1610 MHz is shared with the (terrestrial) Fixed Service. Use of this band by both the Radionavigation Satellite Service and the Fixed service in a compatible manner is not feasible. Although the allocation to the Fixed Service is on a secondary basis, attention is drawn to the fact that the Fixed Service may cause harmful interference to the reception of GNSS signals. In 2015 the allocation to the Fixed Service is expected to be withdrawn from the Radio Regulations and attention should be given to the need to secure that any operation of the Fixed Service in this band will cease by that time.

5. Summary

5.1 This information material highlights a number of cases where harmful interference can be caused to the reception of GNSS signals by aviation. Measures to prevent such interference are recommended together with an operational evaluation of the interference risks.
Work on the assessment of RF interference (intentional and unintentional) is ongoing in the Navigation Systems Panel.

APPENDIX A of the ICAO GNSS Manual (Doc. 9849)

Source: GNSS Manual – Chapter 5

5.8 GNSS VULNERABILITY

5.8.1 General

5.8.1.1. The most notable GNSS vulnerability lies in the potential for interference, which exists in all radionavigation bands. As with any navigation system, the users of GNSS navigation signals should be protected from harmful interference resulting in the degradation of navigation performance.

5.8.1.2 The GNSS SARPs require a specified level of performance in the presence of levels of interference as defined by the receiver interference mask. These interference levels are generally consistent with the International Telecommunication Union (ITU) regulations. Interference at levels above the mask may cause degradation or even loss of service, but such interference is not allowed to result in hazardously misleading information (HMI).

5.8.1.3 GPS and Global Navigation Satellite System (GLONASS) have filings with the ITU to operate, using spectrum allocated to the Radionavigation Satellite Service (RNSS) in the 1 559 – 1 610 MHz and 1 164 – 1 215 MHz bands. The RNSS allocation in these bands is shared with the Aeronautical Radionavigation Service (ARNS). SBAS also has a filing under the RNSS allocation in the former band. GBAS is operated in the 108 – 117.975 MHz band, shared with ILS and VOR (ARNS).

5.8.2 Sources of Vulnerability

5.8.2.1 There are a number of sources of potential interference to GNSS from both in-band and out-of-band sources. Of particular concern is the use of the 1 559 – 1 610 MHz band by point-to-point microwave links that are allowed by a number of States. The use of these links, as stated in footnotes 5.362B and 5.362C in the Radio Regulations of the ITU, is due to be phased out starting in 2005 and completed by no later than 2015. In addition, no new links should be permitted.

5.8.2.2 *Unintentional interference*. The likelihood and operational effect of interference vary with the environment. Unintentional interference is not considered a significant threat provided that States exercise proper control and protection over the electromagnetic spectrum for both existing and new frequency allocations. Furthermore, the introduction of GNSS signals on new frequencies will ensure that unintentional interference does not cause the complete loss of GNSS service (outage) although enhanced services depending upon the availability of both frequencies might be degraded by such interference.

5.8.2.3 *Intentional interference*. The risk of intentional interference depends upon specific issues that must be addressed by States. For States that determine that the risk is unacceptable in specific areas, operational safety and efficiency can be maintained by adopting an effective mitigation strategy through a combination of on-board mitigation techniques (e.g. use of inertial navigation system (INS)), procedural methods and terrestrial navigation aids.

5.8.2.4 *Ionosphere*. Scintillation can cause loss of GNSS satellite signals in the equatorial and auroral regions, but is unlikely to cause complete loss of GNSS service and will be mitigated with the addition of new GNSS signals and satellites. Ionospheric changes may limit the SBAS and GBAS services that can be provided in the equatorial region using a single GNSS frequency. These changes must be considered when designing operations based on the augmentation systems.

5.8.2.5 *Other vulnerabilities*. System failure, operational errors and discontinuation of service could be significantly mitigated by independently managed constellations, funding and robust system design. Spoofing, the intentional corruption of signals to cause an aircraft to deviate and follow a false flight path, is mitigated through normal procedures and independent ground and collision avoidance systems.

5.8.2.6 States should assess the GNSS vulnerability in their airspace and select appropriate mitigations depending on the airspace in question and the operations that must be supported. These mitigations can ensure safe operations and enable States to avoid the provision of new terrestrial navigation aids, reduce existing terrestrial navigation aids, and discontinue them in certain areas. Fault detection features such as RAIM are built into GNSS receivers, which eliminate the risk of position errors posing threat to navigation availability. To date, no vulnerabilities have been identified that compromise the ultimate goal of a transition to GNSS as a global system for all phases of flight. The assessment of GNSS vulnerability aspects and mitigation alternatives should continue.

5.8.3 Evaluating GNSS vulnerabilities

5.8.3.1 There are three principal aspects to be considered in the evaluation of GNSS vulnerabilities.

a) Interference and atmospheric (ionosphere) effects are of primary concern. Operational experience is the best way to assess the likelihood of unintentional interference. Each State must consider the motivation to intentionally interfere with GNSS based on the potential safety and economic impacts on aviation and non-aviation applications. Atmospheric effects are unlikely to cause a total loss (outage) of GNSS but may impact some services (e.g. approaches with vertical guidance in equatorial regions). The likelihood of specific effects can be categorized as negligible, unlikely or probable.

b) All operations and services dependent on GNSS should be identified and considered together, since GNSS interference can potentially disrupt all GNSS receivers at the same time over a certain area. GNSS is used for navigation services as well as other services such as precision timing with communications and radar systems, and may also be used for ADS services. In these cases, GNSS represents a potential common point of failure.

c) The impact of a GNSS outage on an operation or service should be assessed by considering the types of operations, traffic density, availability of independent surveillance and communications and other factors. The impact can be categorized as none, moderate or severe.

5.8.3.2 By considering these aspects as a function of airspace characteristics, air navigation service providers can determine whether mitigation is required and, if so, at what level. Appendix D provides examples of assessments. Mitigation is most likely to be required for vulnerabilities with major impacts that have a moderate to high likelihood of occurrence.

5.8.4 Reducing the Likelihood of Unintentional Interference

5.8.4.1 On-aircraft interference can be prevented by proper installation of GNSS equipment, its integration with other aircraft systems (e.g. shielding, antenna separation and out-of-band filtering) and restrictions on the use of portable electronic devices on board aircraft.

5.8.4.2 *Spectrum management*. Effective spectrum management is the primary means of mitigating unintentional interference from man-made transmitters. Operational experience has indicated that the threat of unintentional interference can be virtually eliminated by applying effective spectrum management. There are three aspects of effective spectrum management, namely:

a) creation of regulations/laws that control the use of spectrum;

b) enforcement of those regulations/laws; and

c) vigilance in evaluating new radio frequency (RF) sources (new systems) to ensure that they do not interfere with GNSS.

APPENDIX B of the ICAO GNSS Manual (Doc. 9849)
ELECTRONIC BULLETIN EB 2011/56 AN 7/5 FROM 21 NOVEMBER 2011

INTERFERENCE TO GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) SIGNALS

1. Aviation operations increasingly rely on the global navigation satellite system (GNSS) to improve navigation performance and to support air traffic control surveillance functions.

2. However, the full benefits of GNSS can only be achieved if GNSS signals are adequately protected from electromagnetic interference which can cause loss or degradation of GNSS services.

3. Potential sources of interference to GNSS include both systems operating within the same frequency bands as GNSS and systems operating outside those bands. Interference can be intentional ("jamming") or unintentional.

4. ICAO Member States have an essential role in ensuring protection of GNSS signals from interference. This can be achieved through cooperation of national aviation and telecommunication authorities in the introduction and enforcement of appropriate regulations controlling the use of the radio spectrum.

5. Attachment A briefly describes some sources of interference to GNSS and discusses regulatory means available to States to deal with them. Attachment B contains a list of documents that can be used as guidance for States in developing a regulatory framework.

Enclosures:
A — Sources of interference to GNSS
B — References

ATTACHMENT A to EB 2011/56

SOURCES OF INTERFERENCE TO THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

1. **INTERFERENCE TO GNSS CAUSED BY SYSTEMS TRANSMITTING IN GNSS FREQUENCY BANDS**

1.1 **GNSS repeaters and pseudolites**

1.1.1 Certain non-aeronautical systems transmit radio signals intended to supplement GNSS coverage in areas where GNSS signals cannot be readily received (e.g. inside buildings). These systems include GNSS repeaters and pseudolites.

1.1.2 GNSS repeaters (also known as “re-radiators”) are systems that amplify existing GNSS signals and re-radiate them in real-time. Pseudolites are ground-based systems that generate ranging signals similar to those transmitted by GNSS satellites.

1.1.3 When these systems do not operate under appropriate conditions, harmful interference may be caused to the reception of the original GNSS signals by aircraft and other aeronautical systems (such as the reference receivers used in augmentation systems). This may disrupt a wide range of GNSS applications.

1.1.4 To prevent this disruption, a State needs to create a regulatory framework for the sale, ownership and operation of these systems. The framework must include regulations to ensure that use of the systems be permitted only where they have a legitimate application and their operation is not harmful to existing primary users of GNSS-based services. Additional measures may be necessary when repeaters and pseudolites are used on or in the vicinity of airports (e.g. in hangars, for testing/maintenance purposes).
1.1.5 Attachment B contains a list of documents that can be used as guidance for States developing a regulatory framework. They include interference analyses and examples of regulations currently in force in Europe and the United States.

1.2 **GNSS jammers**

1.2.1 GNSS jammers are devices which intentionally generate harmful interference to GNSS signals to impair or deny their reception. They may be employed for various reasons, typically with the intent of disabling devices that record and/or relay GNSS position information (e.g. for tracking or fee collection purposes). However, the interference they generate can potentially affect all users of GNSS, not only the intended targets of the jamming. Thus, they may have an impact far greater than intended by their operator.

1.2.2 Usage of GNSS jammers may proliferate further if GNSS-based fee collection or tracking services are not adequately designed, e.g. if the simple use of a jamming device enables the avoidance of the charge or tracking.

1.2.3 To prevent degradation of GNSS services due to GNSS jammers, States should implement and enforce policies and regulations that forbid the sale, export, purchase, ownership and use of GNSS jammers, and they should prohibit all actions that lead to an interruption of GNSS signals[1].
Adequate means of enforcement of such policies and regulations require the availability of GNSS signal monitoring capabilities. Furthermore, GNSS-based services should be designed in such a way that simple jamming does not result in denial of the service.

2. **INTERFERENCE TO GNSS CAUSED BY SYSTEMS TRANSMITTING OUTSIDE THE GNSS FREQUENCY BANDS**

2.1 In addition to the threats described above, systems operating outside the GNSS frequency bands that are not properly designed or are inappropriately regulated and operated may interfere with GNSS.

2.2 GNSS frequencies are protected by international agreements (ICAO *Convention on International Civil Aviation* and ITU Radio Regulations), and enable aviation services that have significant economical and societal benefits. However, there is also significant demand for electromagnetic spectrum for new applications, such as mobile phone and broadband data services, which may compromise spectrum compatibility. States should require that any such application will not interfere with GNSS signals through execution of adequate spectrum management practices.

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[1] In some States, military authorities test their equipment by occasionally transmitting jamming signals that deny service in a specific area. This activity should be coordinated with State spectrum authorities and air navigation service providers to enable them to determine the airspace affected, advise aircraft operators and develop any required contingency procedures.

ATTACHMENT B to EB 2011/56

REFERENCES

ECC Report 129: "Technical and operational provisions required for the use of GNSS repeaters", Dublin, January 2009 (available at: http://www.ecodocdb.dk/, see under "ECC Reports")

ECC Report 145: "Regulatory framework for Global Navigation Satellite System (GNSS) repeaters", St. Petersburg, May 2010 (available at: http://www.ecodocdb.dk/, see under "ECC Reports")

ECC Recommendation (10)02, "A framework for authorization regime of Global Navigation Satellite System (GNSS) repeaters" (available at: http://www.ecodocdb.dk/, see under "ECC Recommendations")

United States National Telecommunications and Information Administration (NTIA) Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook), sections 8.3.28 – 8.3.30 (available at: http://www.ntia.doc.gov/page/2011/manual-regulations-and-procedures-federalradio-frequency-management-redbook)

Note.— The relevant sections of the NTIA Redbook only apply to the United States Federal Government users. Use of repeaters by non-government users is prohibited in the United States.

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