



**INTERNATIONAL CIVIL AVIATION ORGANIZATION
WESTERN AND CENTRAL AFRICA OFFICE**

**Second Meeting of the AFI Performance Based Navigation/Global Navigation Satellite
System AFI Task Force (PBN/GNSS TF/2)
(Dakar, Senegal, 13 - 15 June 2011)**

Agenda Item 5: Review of GNSS implementation strategy

LATEST DEVELOPMENTS RELATING TO GNSS AUGMENTATION

(Presented by the Secretariat)

SUMMARY

This paper provides the meeting with latest developments concerning GNSS augmentation for consideration by the PBN/GNSS Task Force, and accordingly invites the PBN/GNSS Task Force to review, identify areas that may be improved, and propose changes (as required) to the AFI GNSS Strategy developed by CNS/SG/4 Meeting.

Action by the meeting is at **paragraph 3**.

REFERENCES

- Doc. 9613: Performance based Navigation (PBN) Manual
- Doc. 9849 Global Navigation Satellite System (GNSS) Manual
- Doc.8071 Vol II :Manual of Testing Navigation Aids
- APIRG/17 Report
- SL AN 7/1.3.94-09/46 18 June 2009
- SL AN 7/1.3.97-10/43 22 June 2010

This Working Paper is related to Strategic Objectives: **A & C** and is linked to **GPI-1; GPI-2; GPI-5; GPI-6; GPI-1 ;GPI-7 ;GPI-11; GPI-21**

1. INTRODUCTION

1.1 The strategy for the introduction of GNSS for aviation use includes augmented GNSS to support specific air navigation operations. This working paper provides the meeting with latest developments related to GNSS augmentation at global and regional levels. The PBN/GNSS Task Force is invited to review the draft amendments to AFI GNSS Strategy in light of these developments, and propose changes as required in the frame of the implementation of PBN operations within AFI region..

2. DISCUSSION

Proposals for the amendment of Annex 10, Volume I, concerning instrument landing system (ILS) coverage requirements, global navigation satellite system (GNSS) signal-in-space performance requirements and GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS) system requirements
(Ref.: AN 7/1.3.94-09/46 of 18 June 2009)

2.1 The Air Navigation Commission, at the fourth and fifth meetings of its 181st Session held on 21 May and 9 June 2009, considered proposals developed by the Navigation Systems Panel (NSP) Working Group of the Whole to amend the Standards and Recommended Practices (SARPs) in Annex 10 — Aeronautical Telecommunications, Volume I — Radio Navigation Aids concerning instrument landing system (ILS) coverage requirements, global navigation satellite system (GNSS) signal-in-space performance requirements and Global Navigation Satellite System (GLONASS) system requirements, as shown in Attachment A to *State Letter Ref.: AN 7/1.3.94-09/46 of 18 June 2009*, and authorized their transmission to Contracting States and appropriate international organizations for comments.

2.2 The purpose of the proposed amendment is to:

- a) improve the ILS signal quality at aerodromes where building or terrain reflections cause interference of the reflected signal with the desired signal;
- b) enable Category I approach operations supported by satellite-based augmentation system (SBAS); and
- c) reflect the evolution of the GLONASS system.

2.3 The proposed amendment to Annex 10, Volume I, was envisaged for applicability on 18 November 2010.

Proposals for the amendment of Annex 10, Volume I, concerning the global navigation satellite system (GNSS) ground-based augmentation system (GBAS)

(State Letter Ref.: AN 7/1.3.97-10/43 of 22 June 2010)

2.4 The Air Navigation Commission, at the eighth meeting of its 183rd Session held on 9 March 2010, considered proposals developed by the Navigation Systems Panel (NSP) Working Group of the Whole to amend the Standards and Recommended Practices (SARPs) in Annex 10 — Aeronautical Telecommunications, Volume I — Radio Navigation Aids concerning the global navigation satellite system (GNSS) ground-based augmentation system (GBAS), as shown in Attachment A to *State Letter Ref.: AN 7/1.3.97-10/43 22 of June 2010*, and authorized their transmission to Contracting States and appropriate international organizations for comments.

2.5 The purpose of the proposed amendment is to reflect the initial experience gained with the ongoing technical implementations of GBAS for Category I operations. A number of changes to the GBAS SARPs are proposed, including the following:

- a) removal of material on ground-based ranging functions;
- b) clarification of the definition of the GBAS digital modulation method;
- c) introduction of an optional authentication protocol;
- d) clarification of the B-values coding requirements;
- e) introduction of forward compatibility requirements;
- f) modification of carrier smoothing requirements for airborne equipment;
- g) modifications to the guidance material on frequency coordination requirements, link budget, vertical deviations, Type 2 message, and signal quality monitoring; and
- h) several minor editorial changes.

2.6 The proposed amendment to Annex 10, Volume I, is envisaged for applicability on 17 November 2011.

Status of the implementation of the satellite-based Augmentation system (SBAS)

2.7 ICAO noted the commencement of the operational phase of European Geostationary Navigation Overlay Service (EGNOS) on 2nd August 2010, and congratulated the European Commission (EC) for implementing the satellite-based augmentation system (SBAS) for augmenting the global positioning system (GPS) service in accordance with Standards contained in Annex 10 — Aeronautical

Telecommunications, Volume I — Radio Navigation Aids. Copies of the documents providing further information on the subject are attached.

2.8 EGNOS is the latest addition to a set of regional SBAS projects that have been successfully implemented, namely the wide area augmentation system (WAAS) and the multifunctional transport satellite (MTSAT) satellite-based augmentation system (MSAS). Some other systems such as GPS and geostationary orbit augmented navigation (GAGAN) and system for differential correction and monitoring (SDCM) are currently under development.

2.9 The procedure to transition towards the EGNOS Safety-of-Life (SoL) service started on 2 August 2010, was expected to trigger the broadcast of the first EGNOS SoL signal, by removing from the EGNOS Signal-in-Space the specific message (called Message Type 0) which limits EGNOS utilization to Open Service (OS) users. However, a few minutes after the first step of this procedure, the EGNOS Signal-In-Space broadcasted "NOT MONITORED" messages for all GPS satellites and for the ionosphere correction data, therefore causing the service to be unusable. On 6 August 2010, ESSP reverted to the OS signal, i.e. broadcasting the EGNOS signal with Message Type 0.

2.10 A consolidated safety analysis was presented to the civil aviation authorities for review. On this basis, and subject to due coordination of the deployment of the change with the civil aviation authorities, EC and ESSP expect the SoL transition procedure to be initiated again in early November 2010. The completion of the SoL transition was planned for the end of 2010. First EGNOS APV approaches should then be possible from January 2011 once the SoL service has been declared available.

2.11 EGNOS, the European Satellite Based Augmentation System Safety-of-Life Service was made available, **on 2nd March 2011** after having been certified by French National Supervisory Authority (NSA) on 12 July 2010.

Air Navigation Service Providers in the EGNOS service area may now proceed with the publication of SBAS precision approach procedures (LPV) based on EGNOS, once they have established working agreements with ESSP as required by the Single European Sky (SES) regulation.

AFI GNSS Strategy – Outcome of APIRG/17 Meeting

2.12 The Seventeenth Meeting of APIRG (APIRG/17) was held in Ouagadougou, Burkina Faso from 2 to 6 August 2010. Under its Agenda Item 3.3, APIRG/17 discussed draft amendments to AFI GNSS Strategy as developed by CNS/SG/3 Meeting (Nairobi, Kenya, 26-30 April 2010) as a follow-up to APIRG Decision 16/24, based on the work accomplished the 4th Meeting of AFI GNSS Implementation Task Force (GNSS/I/TF/4) (Nairobi, Kenya, 8-9 December 2008) and the Joint Meeting of APIRG PBN and GNSS Implementation Task Forces (Nairobi, Kenya, 8-10 September 2009).

2.13 The updated AFI Strategy drafted by the CNS Sub-group is shown in **Appendix A** to this working paper, together with the GNSS infrastructure in support of PBN requirements shown in **Appendix B**.

2.14 AFCAC informed APIRG meeting that the provision of SBAS over AFI was being considered in the frame work of Africa-European Union strategic partnership. The plan for the implementation will be discussed at a planned Africa – European Union Summit in November 2010.

2.15 The meeting discussed at length a number of issues related to the extension of EGNOS to the AFI Region, such as system certification, lack of consensus with users (IATA, AFRAA) on the cost-benefit analysis, cost-recovery, safety assurance, impact of Galileo on EGNOS development, Aircraft – Based Augmentation System (ABAS) performance, and transition timelines.

2.16 APIRG/17 agreed to the need for the transition plan to consider aspects related to human resources, and to be based on the principle of non-renewal of conventional navigation aids as opposed to their withdrawal from operation during the transition period until satellite-based navigation systems become

sufficiently mature.

2.17 In view of the above, the meeting agreed on the need to organize a high-level meeting on AFI GNSS Strategy under the aegis of AFCAC, in close coordination with ICAO, ASECNA, IATA, AFRAA, and other relevant stakeholders. The following conclusion was formulated:

CONCLUSION 17/28: NEED FOR A HIGH LEVEL MEETING ON AFI GNSS STRATEGY

That, in order to assist AFI States in making an informed decision on the regional strategy for the introduction of GNSS applications, AFCAC organize as a matter of urgency a high level meeting in coordination with ICAO, ASECNA, IATA, AFRAA and other relevant stakeholders.

2.18 The meeting was presented with an updated Cost-Benefit Analysis (CBA) prepared by the European Commission on the extension of EGNOS in the AFI Region. After noting the lack of consensus between stakeholders on available cost-benefit analysis, the meeting also identified the need for a cost-benefit analysis to be conducted by independent experts, based on objective assumptions. The outcome of the study will be reviewed by the high-level meeting on AFI GNSS Strategy. Such a study should be based on credible and consistent traffic data. The following conclusion and decision were formulated:

CONCLUSION 17/29: NEED FOR AN INDEPENDENT COST-BENEFIT ANALYSIS

That, considering the lack of consensus between stakeholders on available cost-benefit analyses related to SBAS implementation in the AFI Region, a cost benefit analysis based on objective assumptions should be performed by independent experts, and submitted to the high level meeting to be organized by AFCAC on AFI GNSS strategy, for consideration.

DECISION 17/30: COORDINATION OF TRAFFIC DATA FOR AERONAUTICAL STUDIES

That, APIRG bodies should closely coordinate their work with the AFI Traffic Forecasting group (TFG) to ensure that accurate and reliable traffic data are made available for aeronautical studies conducted in the AFI Region, including CNS/ATM related Cost Benefit Analysis (CBA).

2.19 The High Level meeting was held on November 2010 at the AFCAC Office in Dakar. ICAO developed Terms of Reference to facilitate the study to be conducted with AFCAC. The independent Cost Benefits analysis needs an independent consultant with the relevant capability to conduct the study. ICAO is requested by AFCAC to identify available structure that can provide such consultant.

2.20 Based on this current situation and before the result of the Cost Analysis study is made available it should be advisable for the Task Force to seek for the best arrangement in the GNSS implementation strategy in order to propose a balanced compromise aiming to take into consideration the following:

- a) Implementation of SBAS (EGNOS) under the condition of full compliance with ICAO technical guidance and requirement in particular those related to the mitigation ionosphere effects in tropical area;
- b) Case by case Cost Benefit agreement between Air Navigation Providers and Airlines
- c) Civil aviation does not support the cost of augmentation service provided to sectors out of Civil aviation activities

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information provided in this working paper, concerning:

- 1) the development of SARPs for SBAS and GBAS;
- 2) the status of implementation of SBAS; the proposed draft amendments to AFI GNSS Strategy; and
- 3) Accordingly review, identify areas that may be improved, and propose changes (as required) to the updated AFI GNSS Strategy at Appendices A and B to this working paper.

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APPENDIX A

Concept of the GNSS Strategy for the AFI Region Amendment proposals to AFI CNS/ATM Implementation Plan (Doc 003)

1. INTRODUCTION

1.1 The purpose of the AFI GNSS strategy is to define an evolution path for replacement of ground-based navigation aids, i.e. VOR/DME/ILS/NDB, ensuring that operational and other concerns such as positive cost-benefit are fully taken into account.

1.2 The AFI GNSS strategy assumes availability of a GNSS meeting of the specified parameters at every phase of deployment. It does not analyze GNSS systems configuration per se nor the advantages and disadvantages of various deployment strategies.

2. GENERAL CONSIDERATIONS

2.1 By necessity, satellite-based and ground-based navigation systems will co-exist for a period of time. Considering that the operation of a dual system is detrimental to a positive cost-benefit, users and providers will co-operate with the view of reducing the duration of the transition period as much as possible, having due regard for the following principles:

- The level of safety will not be downgraded during the transition;
- GNSS-based service must, before the end of the transition period, fully meet the required parameters of accuracy, availability, integrity and continuity for all phases of flight;
- During the transition, gradually evolving levels of functionality will be available;
- Operational advantage shall be taken in to consideration the available and capabilities at every step of deployment;
- Methods of application will take into account full consideration of safety considerations of any functional limitations;
- Users must be given sufficient advance notice to re-equip before ground-based systems are decommissioned.

3. EVOLVING FUNCTIONALITY

3.1 Phase I (Short term), up to 2012:

- This phase will allow the use of GNSS as a primary-means of navigation for en-route, and for NPA; and as a supplemental-means navigation system for TMA. Existing ground infrastructure remains intact.

3.2 Phase II (Medium term) -2013 - 2016:

- **This phase will allow for:**

- a) En-route phase: sufficient capability to meet en-route navigation requirements everywhere in the AFI Region. GNSS will continue to be used as principal en-route navigation. The same principle will be characterized by a clearly planned transition for the use of GNSS as the sole means for en-route navigation. Navigational aids will accordingly not be replaced, subject to consultation with the Users.
- b) Terminal areas: sufficient capability to meet TMA navigation requirements everywhere in the AFI region. GNSS is approved as sole-means for TMAs, taking into account technical and legal developments, and institutional aspects.
- c) Terminal area VOR/DME/NDB, and Locators not associated with ILS, will not be replaced during Phase II.

- d) Approach and landing phase: sufficient capability for APV1 in the whole AFI Region. ILS will continue to be provided at aerodromes¹.

Note 1: Where the requirements for approach and landing can be met by APV 1, ILS CAT I should not be replaced.

During Phase II, the implementation of Long- term GNSS will be developed.

Phase III (Long term) 2017 onwards: It is assumed that more constellations of navigation satellites will be available to support GNSS as the sole-means of navigation from en-route to CAT I operations. CAT I by SBAS or GBAS will be available in those locations where analysis of historical MET data or traffic characteristics justifies the requirement. Other requirements will be met by ground-based augmentation system (GBAS). During Phase III, ILS CAT I will not be replaced, subject to consultation with users. Where CAT II/III ILS requirements have been confirmed, these facilities will remain unless technical evolution then demonstrates that the requirement can be supported by GBAS or SBAS.

4. The strategy will be reviewed periodically. In particular, it will be reviewed and updated at the beginning of each planning phase to ensure continuous relevance in support of the global ATM operational concept, taking into account technological evolution and developments in the field of GNSS.

5. Summary of AFI GNSS Strategy

AFI GNSS Strategy – Synopsis

	Short term	Medium term	Long term
Time scale	2008 – 2012	2013 – 2016	2017 and beyond
Certification	Primary for en-route Supplemental for TMA Non-precision approach (NPA)	Primary means from en route to APV	Primary means from en route to CAT-I
Oceanic and Remote Continental En route	Basic GNSS	Basic GNSS	Multi-constellation GNSS
Continental En route	Basic GNSS	Basic GNSS	Multi-constellation GNSS
Terminal	Basic GNSS	Basic GNSS	Multi-constellation GNSS
Approach and Landing	Basic GNSS with Barometric Altimetry	Basic GNSS with ABAS, SBAS*	Multi-constellation GNSS with ABAS, SBAS, GBAS
			CAT I (GLS) CAT II/III/ (GLS) as required

**Note: As from 18 November 2010, it is expected that ICAO Annex 10, Volume I will enable Category I approach operations supported by satellite-based augmentation system (SBAS). The upper vertical alert limit (VAL) for CAT I operations has drastically been increased from 15.0 m to 35.0 m. However, a vertical alert limit greater than 10 m for a specific system design may only be used if a system-specific safety analysis has been completed.*

APPENDIX B

GNSS INFRASTRUCTURE IN SUPPORT OF PBN REQUIREMENTS

Time scale		Short term	Medium term	Long term
		2008 – 2012	2013 – 2016	2017 and beyond
Certification		Primary for en-route Supplemental for TMA Non-precision approach (NPA)	Primary means from en route to APV	Primary means from en route to CAT-I
Oceanic and Remote Continental/ En route	GNSS Configuration	Basic GNSS	Basic GNSS	Multi-constellation GNSS
	PBN Nav Spec	RNAV-10, RNP-4	RNAV-10, RNP-4	RNAV-10, RNP-4
Continental En route	GNSS Configuration	Basic GNSS	Basic GNSS	Multi-constellation GNSS
	PBN Nav Spec	RNAV-5, RNAV-1	RNAV-5, RNAV-2, RNAV-1	RNAV-5, RNAV-2, RNAV-1
Terminal	GNSS Configuration	Basic GNSS	Basic GNSS	Multi-constellation GNSS
	PBN Nav Spec	RNAV-1 in a surveillance environment Basic RNP-1 in non- surveillance environment	Expand RNAV-1, or RNP-1 application Mandate RNAV-1, or RNP-1 in high density TMAs	RNAV-1 in a surveillance environment Basic RNP-1 in non- surveillance environment
Approach	GNSS Configuration	Basic GNSS	Basic GNSS with ABAS, SBAS*	Multi-constellation GNSS with ABAS, SBAS*
	PBN Nav Spec	RNP APCH: NPA RNP APCH: APV with Baro-VNAV or RNP AR APCH: APV with Baro-VNAV	RNP APCH: NPA RNP APCH: Expand APV (with Baro- VNAV and/or augmented GNSS) Expand RNP AR APCH: APV with Baro-VNAV	RNP APCH: NPA RNP APCH: APV (with Baro-VNAV and/or augmented GNSS) RNP AR APCH: APV with Baro-VNAV

**Note: Although SBAS operations not yet included in the PBN concept contained in ICAO Doc 9613, they have been introduced in the spirit of Assembly Resolution A36-23.*