**International Civil Aviation Organization**
**Western and Central African Office**

**Fourth Meeting of the APIRG Performance Based Navigation/Global Navigation Satellite System Task Force (PBN/GNSS TF/4)**
**(Dakar, Senegal, 3-6 December 2013)**

**Agenda Item 5: AFI GNSS Implementation Strategy**

# Review of AFI GNSS Strategy

*(Presented by the Secretariat)*

**Summary**

This paper discusses the strategy for the introduction of GNSS in the AFI Region as adopted by the APIRG, in view of recent developments at global and regional level.

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

**References**
- Doc 9750 (Global Air Navigation Plan)
- APIRG/16 -19 Reports

This Working Paper is related to Strategic Objectives: **A**

## 1. Introduction

1.1 The Seventeenth Meeting of APIRG (APIRG/17) held in Ouagadougou, Burkina Faso from 2 to 6 August 2010 discussed under its Agenda Item 3.3draft 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 the 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).

1.2 APIRG/17 considered on issues related to the AFI GNSS Strategy and implementation Plan in the Region and formulated two conclusions and one decision.

1.3 The Eighteenth and Nineteenth APIRG Meetings followed up on the status of implementation of the conclusions/decisions of APIRG/17.

## 2. Discussion

*Background on the AFI GNSS Strategy*

2.1 The APIRG/16 meeting *(*Rubavu, Rwanda, 19-23 November 2007) had noted the lack of consensus between stakeholders on available AFI SBAS cost-benefit analyses, and accordingly decided to delay consideration of an Inter-Regional SBAS for Africa (**ISA**) until further cost-benefit analysis in coordination with users demonstrates a conclusive need.

2.2 Subsequently, APIRG/17 (Ouagadougou, Burkina Faso, 3-6 August 2010) requested a cost-benefit analysis to

be conducted by independent experts (Conclusion 17/29 refers), in order to assist States in making an informed implementation decision with respect to SBAS.

2.3 When discussing GNSS issues APIRG/18 (Kampala, Uganda, 27-30 March 2012) meeting noted the follow-up action taken by the Secretariat, in coordination with AFCAC and the ICAO Technical Cooperation Bureau (TCB), including development of the terms of reference and selection of consultants for the study. However, a source of funding for the study was yet to be identified.

2.4 The meeting discussed and endorsed the Draft Updated AFI GNSS Strategy developed by the Second Meeting of the AFI PBN/GNSS Implementation Task Force. The updated strategy combines the use of all available GNSS technologies standardized by ICAO, including basic GNSS, aircraft-based augmentation system (ABAS), satellite-based augmentation system (SBAS), and ground-based augmentation system (GBAS).

2.5 Based on this situation and before the result of the Cost Analysis study is made the revised GNSS implementation strategy addressing SBAS operation was developed on the basis of a balanced compromise by taking into consideration the following:

a) ***Subjected to APIRG Conclusion 17/29: Need of an independent Cost Benefit Analysis***
***b) Full compliance with ICAO technical requirements;***
***c) Case to case Cost Benefit agreement before implementation;***
***d) The Civil Aviation stakeholders in particular governments should guarantee that there will be no cross-subsidization of non-civil aviation users of SBAS. The users pays principle is to be applied across all sectors;***

*Recent developments on GNSS in the AFI Region*

2.6 The 19th APIRG meeting (Dakar, Senegal, 28-31 October 2013) recognized that GNSS services were being introduced throughout the AFI Region to support the implementation of Performance-Based Navigation (PBN) in accordance with the regional strategy adopted by APIRG. APIRG/19 meeting adopted an AFI Air Navigation System Implementation Action Plan aligned with the ICAO Aviation System Block Upgrades (ASBU) Methodology. The implementation of GNSS elements is addressed under ASBU Module **B0-APTA** on Optimization of Approach Procedures including Vertical Guidance, with emphasis on the impact on key performance areas, implementation targets, implementation challenges, performance measurement and monitoring[1].

*GNSS vulnerabilities*

2.7 Considering that GNSS has the potential to meet performance requirements for all phases of flight and improve safety and efficiency of air navigation, it is essential that the air navigation service providers using GNSS identify the vulnerabilities of this system; and develop the necessary mitigations.

2.8 Accordingly, APIRG/19 meeting discussed the GNSS vulnerabilities (WP12 refers), including interference due to low power signals received from core satellite constellations or satellite-based augmentation systems, intentional corruption of the navigation signals to cause aircraft to deviate and follow a false flight path (spoofing), ionospheric and other atmospheric effects, system failure or human factors as addressed by the ICAO 12th Air Navigation Conference (*WP13Refers*).

*Impact analysis of the implementation of GNSS/SBAS in the AFI Region*

2.9 The meeting noted that Conclusion 18/33 of APIRG/18 on the funding of an AFI GNSS/SBAS cost benefit analysis had not been implemented and agreed that this Conclusion needed to be reformulated for more clarity and to reflect the need for an impact analysis covering operational, technical, environmental and economic aspects of the introduction of SBAS in the AFI Region. AFCAC indicated that some States in the AFI Region are in the process of implementing SBAS within the framework of cooperation between the European Union (EU) and Africa, Caribbean and Pacific (ACP). However, this information had not been formally shared with the Secretariat.

[1] See **Appendix D** to this working paper.

2.10 The summary of APIRG Conclusions/Decisions since APIRG/16 is attached at **Appendix A.**

*Ground-Based Augmentation System (GBAS)*

2.11 The meeting was apprised by ASECNA on feasibility study on the implementation of Ground Based Augmentation System (GBAS) Category I operations at Dakar Leopold Sedar Senghor (L**SS**) International Airport, in Senegal. The study showed that GBAS CAT-I performance was achievable. The next step of the study will include the implementation of an automatic monitoring system for GNSS performance at LSS Airport.

*AFI GNSS Strategy Update*

2.12 The 2012 Global Survey conducted by IATA on aircraft equipage with GNSS – among other Navigation capabilities - is attached as **Appendix B** to this working paper while the AFI GNSS Strategy is attached as **Appendix C.** The meeting may wish to note that the implementation phases are currently aligned with the AFI PBN Roadmap which is governed by ICAO Assembly Resolution A37-11, and agree to align the timelines of the AFI GNSS Strategy with the Regional Air Navigation System Implementation Action Plan adopted by APIRG/19 Meeting, taking due account of the Global Air Navigation Plan Technology Roadmap for navigation systems. **Appendix D** provides a description of the ASBU Block 0 Module on GNSS as per the Regional Action Plan.

## 3 Actions by the meeting

3.1 The meeting is invited to:

a) Take note of the Information given above;
b) Asses the status of implementation of the current GNSS implementation Strategy and;
c) Review the AFI GNSS Strategy as adopted by the APIRG and agree to align the timelines therein with those related to the implementation of GNSS elements under ASBU Block 0 Module B0-APTA as contained in the Regional Air Navigation System Implementation Action Plan, and taking into consideration the Global Air Navigation Plan Technology Roadmap for navigation systems.

## APPENDIX A

## CONCLUSIONS AND DECISIONS OF APIRG MEETINGS PERTAINING TO AFI GNSSS STRATEGY

**CONCLUSION 16/21: IMPLEMENTATION OF GNSS EN-ROUTE AND NON-PRECISION APPROACH OPERATIONS**

**That AFI States continue their efforts to implement GNSS applications for en-route and non-precision approach operations as part of Phase 1 of AFI GNSS Strategy. In so doing, particular attention should be accorded to meeting all GNSS implementation requirements, including establishment of GNSS legislation, regulatory framework, and approval and monitoring procedures.**

**CONCLUSION 16/22: RECORDING OF GNSS PARAMETERS**

**That AFI States that approve GNSS-based operations ensure that GNSS data relevant to those operations are recorded as recommended in ICAO Annex 10, Volume I, Chapter 2, para. 2.4.3. Particularly, for GNSS core systems, the following monitored items should be recorded for all satellites in view:**

**a) observed satellite carrier-to-noise density;**

**b) observed satellite raw pseudo-range code and carrier phase measurements;**

**c) broadcast satellite navigation messages, for all satellites in view; and**

**d) relevant recording receiver status information.**

**CONCLUSION 16/23: AERONAUTICAL INFORMATION RELATED TO GNSS**

**That when implementing GNSS-based operations, AFI States ensure that the relevant aeronautical information is provided to the users as appropriate.**

**DECISION 16/24: AFI GNSS IMPLEMENTATION STRATEGY**

**That the action taken by the Commission on APIRG/15, Conclusions 15/18, 15/19 and 15/20 be referred to the AFI GNSS Implementation Task Force for updating the AFI GNSS Strategy and progressing its work accordingly.**

**……..**

**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.**

**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).**

**…….**

**CONCLUSION 18/31: UPDATED AFI GNSS STRATEGY**

**That, AFI States adopt and implement the GNSS Strategy contained at Appendix 3.4K to this report.**

**DECISION 18/32: MONITORING OF SBAS DEVELOPMENT IN ICAO REGIONS IN THE EQUATORIAL AREA**

**That, APIRG CNS and ATM/AIM/SAR Sub-groups monitor SBAS developments in other ICAO regions in the equatorial area, for consideration as appropriate when developing/updating its strategy for a cost-effective implementation of GNSS in the AFI Region.**

**CONCLUSION 18/33: FUNDING OF AFI SBAS COST-BENEFIT ANALYSIS**

**That, in coordination with AFCAC, ICAO facilitates the search for funding to support the conduct of an independent cost-benefit analysis on an AFI satellite-based augmentation system (SBAS).**

**……**

**CONCLUSION 19/28: ASSESSMENT AND MITIGATION OF GNSS VULNERABILITIES**

**That States providing GNSS services should:**

**a) Assess and report GNSS vulnerabilities in their airspace, including:**
- **i). unintentional and intentional interference;**
- **ii). ionospheric scintillation in equatorial regions;**
- **iii). other vulnerabilities as may be identified; and**

**b) Implement appropriate mitigation measures depending on**
- **i). the airspace in question; and**
- **ii). the operations that must be supported.**

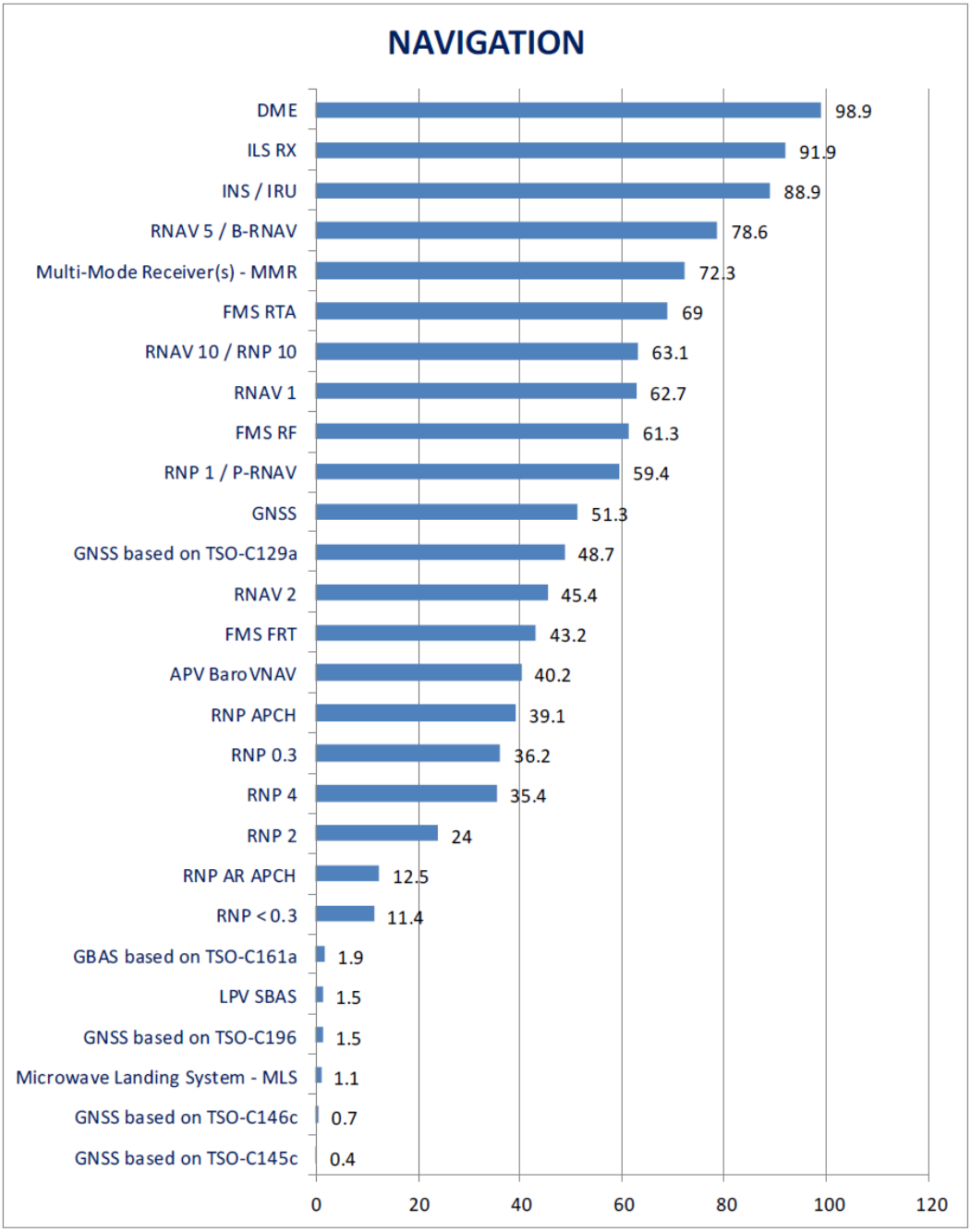
**CONCLUSION 19/29: IMPACT ANALYSIS OF THE IMPLEMENTATION OF GNSS/SBAS IN THE AFI REGION**

**That, In order to enable States to make informed decision and to facilitate dialogue among stakeholders, concerning the implementation of GNSS satellite-based augmentation system (SBAS) in the AFI Region, the ICAO Regional Offices should facilitate the search for the funding of an impact analysis related to SBAS, that covers operational, technical, environmental and economic aspects of this GNSS augmentation system.**

## APPENDIX B

## IATA 2012 Global Survey on Aircraft Equipage with GNSS Capabilities

**Survey Sample Size:**
**4874 aircraft**
**286 fleets**
**86 airspace users**



**APPENDIX C**

# GNSS IMPLEMENTATION STRATEGY FOR THE AFI REGION

**(As adopted by APIRG/17)**

## 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 aerodromes[1].

*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.

### 3.3. 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<br>Supplemental for TMA<br>Non-precision approach (NPA) | Primary means from en route to APV | Primary means from en route to CAT-I |
| Oceanic and Remote Continental<br>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)<br>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.*

**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<br>Supplemental for TMA<br>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 environnent<br>Basic RNP-1 in non-surveillance environment | Expand RNAV-1, or RNP-1 application<br>Mandate RNAV-1, or RNP-1 in high density TMAs | RNAV-1 in a surveillance environment<br>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<br>RNP APCH: APV with Baro-VNAV<br>or<br>RNP AR APCH: APV with Baro-VNAV | RNP APCH: NPA<br>RNP APCH: Expand APV (with Baro-VNAV and/or augmented GNSS)<br>Expand RNP AR APCH: APV with Baro-VNAV | RNP APCH: NPA<br>RNP APCH: APV (with Baro-VNAV and/or augmented GNSS)<br>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.***

## 6. SBAS implementation criteria

1. *Availability of conclusive cost-benefit analysis (APIRG Conclusion 17/29 refers)*
2. *Full compliance with ICAO technical requirements (Standards and Recommended Practices);*
3. *Agreement between stakeholders on pre-implementation cost benefit analyses on case by case basis;*
4. *Application of the user pays principle across all sectors (SBAS users). National authorities shall prevent cross-subsidization of non-civil aviation users of SBAS.*

-END-

## APPENDIX D

### AFI Regional Planning for ASBU Modules

| 2. REGIONAL PERFORMANCE OBJECTIVE – B0-65/APTA: Optimization of Approach Procedures Including Vertical Guidance<br>Performance Improvement Area 1: Airport Operations | | | | | |
|---|---|---|---|---|---|
| **3. ASBU B0-65/APTA: Impact on Main Key Performance Areas (KPA)** | | | | | |
| | **Access & Equity** | **Capacity** | **Efficiency** | **Environment** | **Safety** |
| **Applicable** | Y | Y | Y | Y | Y |

| 4. ASBU B0-65/APTA: Planning Targets and Implementation Progress | |
|---|---|
| **5. Elements** | **6. Targets and implementation progress (Ground and Air)** |
| 1. APV with Baro VNAV | December 2016 – Service Providers and users |
| 2. APV with SBAS | December 2017 – As per AFI – GNSS Strategy |
| 3. APV with GBAS | December 2018 – Initial implementation at some States (services providers) |

| 7. ASBU B0-65/APTA: Implementation Challenges | | | | |
|---|---|---|---|---|
| **Elements** | **Implementation Area** | | | |
| | **Ground system Implementation** | **Avionics Implementation** | **Procedures Availability** | **Operational Approvals** |
| 1. APV with Baro VNAV | NIL | Insufficient number of equipped aircraft | Insufficient appropriate training | Lack of appropriate training |
| 2. APV with SBAS | Network infrastructure | Cost of Aircraft equipage Insufficient number of equip Lack of cost benefit analysis ped aircraft | Limited to certain states who has implemented | Lack of knowledge and appropriate training |
| 3. APV with GBAS | Lack of cost benefit analysis Adverse ionosphere | Insufficient number of equipped aircraft | Insufficient appropriate training | Lack of appropriate training Evaluation of a real operational requirement |

| 8. ASBU B0-65/APTA: Performance Monitoring and Measurement<br>8A. B0-65/APTA: Implementation Monitoring | |
|---|---|
| **Elements** | **Performance Indicators/Supporting Metrics** |
| 1. APV with Baro VNAV | Indicator: Percentage of international aerodromes having instrument runways provided with APV with Baro VNAV procedure implemented (Where the % is defined)<br>Supporting metric: Number of international airport having approved APV with Baro VNAV procedure implemented |
| 2. APV with SBAS | Indicator: Percentage of international aerodromes having instrument |

| 8. ASBU B0-65/APTA: Performance Monitoring and Measurement<br>8A. B0-65/APTA: Implementation Monitoring | |
|---|---|
| **Elements** | **Performance Indicators/Supporting Metrics** |
| | runways provided with APV SBAS procedure implemented<br>Supporting metric: Number of international airport having APV |
| 3. APV with GBAS | Indicator: Percentage of international aerodromes having instrument runways provided with APV GBAS procedure implemented<br>Supporting metric: Number of international airport having APV GBAS procedure implemented. |

| . ASBU B0-65/APTA: Performance Monitoring and Measurement<br>8 B. ASBU B0-65/APTA: Performance Monitoring | |
|---|---|
| **Key Performance Areas** | **Metrics ( if not indicate qualitative Benefits)** |
| Access & Equity | Increased aerodrome accessibility |
| Capacity | Increased runway capacity |
| Efficiency | Reduced fuel burn due to lower minima, fewer diversions, cancellations, delays |
| Environment | Reduced emissions due to reduced fuel burn |
| Safety | Increased safety through stabilized approach paths. |