

**INTERNATIONAL CIVIL AVIATION ORGANIZATION  
EASTERN AND SOUTHERN AFRICAN OFFICE**



**SUMMARY OF THE DISCUSSIONS AND CONCLUSIONS  
OF THE TWELFTH MEETING OF THE AFI GNSS STUDY GROUP**

**(NAIROBI, 28 FEBRUARY - 1 MARCH 2001)**

*March 2001*

## **SUMMARY REPORT OF THE TWELFTH MEETING OF THE AFI GNSS STUDY GROUP**

**(Nairobi, 28 February - 1 March 2001)**

### **1. Objective**

1.1 The twelfth meeting of the AFI GNSS Study Group was held in Nairobi from 28 February to 1 March 2001. The purpose of the meeting was to review action taken on the work programme items adopted at the eleventh meeting, to review progress on the implementation of an AFI GNSS test bed, the AFI GNSS strategy and proposals for the inclusion of GNSS planning into the AFI FASID and ANP.

### **2. Participants**

2.1 The meeting was attended by all of its members. The list of participants is at **Appendix A** to this report. The Group expressed its satisfaction with the attendance of ASECNA

2.2 The meeting was chaired by the Chairman of the Study Group, Mr. Charles Ashford of South Africa. The secretary of the meeting was Mr. A. Sene, RO/CNS. He was assisted by Mrs. Mary A. Obeng, RO/CNS Dakar Office and Mr. T. Masabarakiza, RO/CNS Nairobi.

### **3. Working language**

3.1 The meeting held its deliberations in English and the documentation was provided in that language.

### **4. Agenda**

4.1 The meeting adopted the following agenda:

1. Report on contacts with EOIG service providers
2. EGNOS test bed activities
3. Report on Eurocontrol cost/benefit analysis for AFI
4. Update of the AFI GNSS Strategy
5. Compilation of documentation on criteria for State approval of aircraft operations using GNSS
6. Inclusion of GNSS planning into the AFI Air Navigation Plan (Basic ANP and FASID)
7. Report on SADC WAAS/EGNOS Study
8. Review of Report on Phase II to the European union
9. Status Information on GNSS SARPs, GPS, Galileo, EGNOS and WAAS

10. Report to the CNS/ATM/IC Sub-group
11. Future work programme
12. Any other business

## 5. Summary of the discussions and conclusions

### 5.1 Agenda Item 1: Report on contacts with EOIG service providers

- 5.1.1 In this agenda item, the Meeting was briefed on the results of contacts by ASECNA and ATNS with the EGNOS Operators and Implementation Group (EOIG) as recommended by the previous meeting.
- 5.1.2 ASECNA had contacted the EOIG with the following objectives:
- a) to define the modes and financial means of implementing first an EGNOS test bed in the AFI Region;
  - b) to implement an EGNOS operational service.
- 5.1.3 ASECNA was informed that:
- a) it is one of the major interests of the EOIG to extend the operational area of EGNOS outside Europe and specially, to contribute to the achievement of gains in safety and regulation of flights in the AFI Region. EOIG is already carrying out some activities to extend the EGNOS Test Bed in Africa and other regions outside Europe.
  - b) EOIG was in the process of finalising the creation of an European Economic Interest Grouping (EEIG) with the purpose to own, manage, operate the EGNOS system and provide services after ORR (Operational Readiness Review), currently foreseen by the end of 2003. It was planned that this legal entity, that will be called "European Satellite Service Provider" (ESSP) was to be established before the end of 2000. One of the task of this entity will be to investigate the opportunities for extension outside ECAC.
  - c) Pending the finalisation of the legal establishment of ESSP, it has been agreed, at the last EOIG Steering Committee Meeting, on the 19<sup>th</sup> and 20<sup>th</sup> September 2000, that DNA<sup>1</sup> would contact ASECNA to initiate preliminary contacts. ASECNA was told that the DNA should be the EOIG interface for the AFI region, but it has to be confirmed These contacts would be pursued by ESSP once formalised.
- 5.1.4 ASECNA informed the Study Group that a meeting with DNA was planned in Dakar at a date to be confirmed (expected in April 2001).
- 5.1.5 ATNS advised the Meeting that the EOIG was approached on 15 January 2001. On 30 January 2001, Mr Hufenbach from the EOIG acknowledged receipt of the Email from ATNS and indicated that the matter will be discussed at the next EOIG meeting, which is scheduled to take place on the 27<sup>th</sup> February 2001.
- 5.1.6 The reply was received during the course of the meeting. It advised that "as the extension of EGNOS outside Europe is a question concerning all parties we decided to contact ESA and the European commission before we give you a definite answer".
- 5.1.7 The Meeting expressed its satisfaction with the contacts already established. It also recalled that only one satellite-based augmentation system was being considered for the benefit of all the AFI Region. The Study Group recommended that the members

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<sup>1</sup> Direction of Air Navigation, a branch of the French Direction Generale de l'Aviation Civile (DGAC)

be represented at the meeting planned in Dakar with the EOIG representative. The following conclusion was adopted:

### **Conclusion 12/1 - Meeting with the EOIG**

That Members of the AFI GNSS Study Group meet with the EOIG Representative for AFI in Dakar at a date to be co-ordinated.

## **5.2 Agenda item 2: EGNOS test bed activities**

- 5.2.1 Under this agenda item, the Study Group was briefed on the results of meetings held by ASECNA with the European Space Agency (ESA) and the European Commission (EC), regarding AFI test bed activities.
- 5.2.2 ASECNA held a meeting with ESA in Paris at the ESA premises on 22 February 2001. The objective of the meeting was to review with ESA the assistance required in the definition of an EGNOS test bed for the AFI Region. The meeting emphasised the need for detailed objectives of the test bed, the identification of additional resources.
- 5.2.3 A second meeting was held in Brussels on 23 February 2001 between ASECNA, ESA and the EC. The objectives of the meeting were:
- a) presentation of the AFI GNSS strategy; and
  - b) definition of actions for effective implementation of the strategy.
- 5.2.4 The ASECNA/ESA/EC meeting agreed on the need to establish an AFI-EUR SBAS Working Group for the preparation of the test bed activities. It also developed a preliminary work plan for the implementation of Phase I of the AFI GNSS strategy, which encompassed the deployment of an EGNOS test bed, the conduct of the trials and preparatory work for the definition of activities leading to the implementation of Phase II of the AFI GNSS strategy. Among the urgent tasks is the preparation of a project document to be submitted in June 2001 to the EC for the funding of the test bed. The work plan and the related action plan are shown in **Appendix B** to this report.
- 5.2.5 The Study Group took note of the information provided. It tasked ASECNA and South Africa to draft the project document to be submitted to the EC. In the discussions, it was suggested that GNSS test bed activities should be extended to other modes of transport in the AFI region in order to enhance its usefulness and impact. Furthermore, with regard to trials in the AFI Region, the Study Group identified the need to seek the participation of States and navigation services providers for the provision of test-bed resources (on-site facilities and services, flight calibration, design of GNSS-based approach procedures at locations where tests would be conducted, communications services, etc...).
- 5.2.6 In view of the above discussions, the Study Group adopted the following conclusions.

### **Conclusion 12/2 - AFI/EUR GNSS Test bed Working Group**

That:

- a) South Africa and ASECNA be the representatives of the AFI GNSS Study Group in the AFI/EUR GNSS test bed Working Group; and
- c) States or navigation services providers, which want to support GNSS test bed activities, be invited to join the AFI/EUR GNSS test bed Working Group.

**Conclusion 12/3: AFI Test bed project document**

That South Africa and ASECNA prepare a draft AFI test bed project document to be submitted in June 2001 to the European Commission for funding.

**Conclusion 12/4: Involvement of multimodal transport organizations in the AFI GNSS test bed trials**

That contact be established with multimodal transport organizations in the AFI Region for their participation in the AFI GNSS test bed trials, as follows:

- a) ICAO for IMO, ECA, OAU
- b) ATNS for SASAR (South African SAR Organization)

**Conclusion 12/5: Contact with flight calibration organizations**

That ICAO contact the operators of flight calibration aircraft in the AFI Region for their participation in the AFI GNSS test bed trials.

**Conclusion 12/6: Assistance for GNSS procedures design**

That ICAO contact the following organizations to assist in designing GNSS-based approach procedures (NPA, APV-1, APV-2) at locations where trials will be conducted: Eurocontrol, FAA, French DGCA, ASECNA, ATNS, Dutch RLD.

**5.3 Agenda Item 3: Report on Eurocontrol cost/benefit analysis for AFI**

- 5.3.1 The Study Group reviewed the preliminary report on a cost/benefit analysis being done by Eurocontrol regarding the implementation of an AFI SBAS.
- 5.3.2 The Meeting noted the comments formulated in the report regarding the AFI GNSS strategy on the need to shift the target years to take into account the actual year of operation of EGNOS. The Group was informed that the numbers of Nav aids in the AFI region needed to be precisely identified as they influenced significantly the outcome of the cost benefit analysis. ICAO would reconfirm the figures on Nav aids requirements.
- 5.3.3 IATA presented its comments on the report. They laid emphasis on the need to stick to the present AFI GNSS strategy and the consideration of the removal of terminal area VOR/DMEs. The comments requested also to clearly identify operational benefits as they were not taken into account in the draft report.
- 5.3.4 Following the discussions on the report, the Meeting requested members to forward any additional comments to IATA. The following conclusion was adopted.

**Conclusion 12/7: Comments on the AFI CBA analysis**

That members of the Study Group forward to IATA their final comments on the AFI CBA analysis, as soon as possible.

#### **5.4 Agenda Item 4: Update of the AFI GNSS Strategy**

5.4.1 The Study Group was aware that the augmentation systems being developed (EGNOS and WAAS) will not achieve the requirements for sole-means navigation. Furthermore, both systems are experiencing delays in their implementation schedules. WAAS is expected to be operational in 2002 over the continental USA and EGNOS will be available in late 2003 over the ECAC area. In addition, Europe is developing a civil navigation constellation, Galileo, which will be available in the ECAC, at the earliest, around 2008, and about 2010 in the AFI Region.

5.4.2 In view of the above developments, the Study Group undertook a review and update of the AFI GNSS strategy. A three-phase approach was agreed:

- Phase I (up to 2004)
  - GNSS as a primary-means of navigation for en route
  - GNSS as a supplemental-means for TMA and NPA
  - Implementation of a test bed (up to 2003)
  - Implementation and validation of SBAS to be operational at the end of Phase I (2004). This will allow APV-I to be available at the beginning of Phase II.
- Phase II (from 2004 to 2009)
  - APV-I, 20 m vertical accuracy available over the AFI Region
  - GNSS sole-means for en route
  - Decommissioning of en route Nav aids
  - GNSS sole-means for terminal areas
  - Decommissioning of terminal Nav aids (VOR/DME and NDB)
  - ILS maintained at airports
  - Development of GNSS-2
- Phase III (2010 onwards)
  - Two GNSS constellations are available
  - GNSS sole-means from en route to CAT-I landing
  - Decommissioning of ILS Cat I
  - CAT II/III requirements implemented by GBAS or SBAS.

5.4.3 The Meeting formulated amendments to the AFI GNSS strategy as shown in **Appendix C** to this report. It was agreed that the issue of the residual network of ground Nav aids would be re-discussed at the next meeting. The following conclusion was adopted.

#### **Conclusion 12/8: Updated AFI GNSS strategy**

That the updated AFI GNSS strategy shown at Appendix C to the report be presented to the CNS/ATM/IC/SG for adoption.

## 5.5 Agenda Item 5: **Compilation of documentation on criteria for State approval of aircraft operations using GNSS**

- 5.5.1 The Study Group recalled that the AFI/7 RAN Meeting adopted Conclusion 13/5, which, inter alia, requested that APIRG “*develop criteria for the approval of aircraft operations using GNSS, giving consideration to the needs of all phases of flight, for en route navigation in oceanic areas and continental areas and for terminal area navigation*”. This task has been assigned to the GNSS Study Group for follow up.
- 5.5.2 The Meeting recognized that in order to implement GNSS, it will be necessary for all States to introduce any legislative and/or regulatory changes which may be needed in order to authorize the use of GNSS as a means of navigation within their airspace. There could be considerable variation in the nature of the amendments required, depending on the structure of the legislation and regulations in each State. For example, amendments could potentially be required to legislation or regulations relating to:
- a) navigation of aircraft;
  - b) requirements for flight under IFR;
  - c) conditions applying to descent by IFR aircraft below LSALT;
  - d) operations at night by VFR aircraft;
  - e) operations by VFR aircraft on top of cloud.
- 5.5.3 This list is presented only as an example. Each State will have to make its own assessment of the areas where changes are needed.
- 5.5.4 *Airworthiness and operational approval*
- 5.5.5 The Group was aware that development and implementation of procedures for airworthiness and operational approval of GNSS is a State responsibility. It is noted that there is no ICAO guidance material available for these approval procedures.
- 5.5.6 There are a number of airworthiness and operational approval examples available from States which have already implemented GNSS procedures. The Group compiled the following documents.
- 5.5.7 The FAA has published Advisory Circular AC 20-130 *Airworthiness Approval of GPS Navigation Equipment for use as VFR and IFR Supplemental Navigation System*. This document is attached at **Appendix D** to this report. All GPS receivers used for IFR operations must be certified to FAA TSO C129a, which is attached at **Appendix E**.
- 5.5.8 The FAA has published a very useful manual as a *Guide for the Approval of GPS receiver Installation and Operation*”. This document contains instructions for airworthiness and operations approval of GPS installations onboard aircraft. This document has been at several times distributed to participants at ICAO GNSS seminars.
- 5.5.9 In approving the use of GPS as a primary means long range navigation system (LRNS) in the NAT, the North Atlantic Systems Planning Group (NATSPG)



recommended that States use FAA Notice 8110.60, *GPS as a primary means of navigation for oceanic/remote operations*, and the FAA Air Transportation Handbook Bulletin HBAT 95-09, *Guidelines for Operational Approval of Global Positioning System (GPS) to Provide the Primary Means of Class II Navigation in Oceanic and Remote Areas of Operation*, as reference material for developing their approval procedures. FAA Notice 8110.60 is attached as **Appendix F** to this report.

5.5.10 The European Commission has published a *Manual for the Validation of GNSS in Civil Aviation* (MUSST). The document describes a methodology for a formal validation procedure for the entire GNSS from signal generation to signal processing including the use of the resulting information for navigation purposes.

5.5.11 The Meeting agreed that some of these documents could be made available to States. It was agreed that States would be provided with the Internet address of the bulky documents and be invited to request from the originators those available in hard copy form. In discussing the main impediments to AFI States in authorizing use of GNSS, the Group identified the lack of expertise in GNSS airworthiness and operational approval. The Meeting adopted the following conclusion.

**Conclusion 12/9: Documentation for States**

That:

a) the following documentation be sent to States for their studies and use as appropriate for criteria on approving aircraft operations using GNSS:

FAA	N8110.60
FAA	Advisory Circular (AC No.20-130)
FAA	TSO-C129a

b) ICAO be invited to conduct workshops in AFI Region to sensitize States on the need and importance of airworthiness and operational certifications of on board equipment for GNSS operations.

**5.6 Agenda Item 6: Inclusion of GNSS planning into the AFI Air Navigation Plan (Basic ANP and FASID)**

5.6.1 The Meeting reviewed a proposal for the inclusion of GNSS planning into the radionavigation Plan, as an input to the AFI FASID. The proposed table would identify locations where the navigation function (en route, approach and landing) could be satisfied by SBAS or GBAS or conventional nav aids.

5.6.2 Taking into account of the AFI GNSS strategy, the Study Group agreed on the following criteria:

a) SBAS to provide the service for:

- i) NPA or NINST approach and landing
  - ii) where APV-I can meet the requirements for landing. Reference would be made to the results of Phase II of the GNSS Study.
  - iii) CAT-I, if feasible, in selected areas identified in the GNSS Study.
- c) GBAS/CAT-I for areas where CAT-I is required and cannot be covered by SBAS.
  - d) CAT II/III ILS to remain, unless the capability can be provided by GBAS or SBAS.
- 5.6.3 It was agreed that the Secretariat would prepare a draft proposal and circulate it to other members of the Study group. The following conclusion was adopted.

**Conclusion 12/10: Inclusion of GNSS planning into the AFI ANP**

That:

- a) the Secretariat complete the inclusion of GNSS planning in the draft FASID Radionavigation Table, using the results of Phase II of the GNSS Study;
- b) circulate the results of a) above to the members of the Study Group for comment.

**Agenda Item 7: Report on SADC WAAS/EGNOS Study**

- 5.7.1 At its eleventh meeting, the Study Group requested South Africa to prepare a report on the SADC WAAS/EGNOS Study for review at its twelfth meeting. The report is shown at **Appendix G** to the report.
- 5.7.2 The Group noted that the SADC study proposed a phased introduction of GNSS which is similar to that of the AFI GNSS Strategy.
- Phase I: 2000 - 2004
  - Phase II: 2005 - 2009
  - Phase III: 2010 - 2017.
- 5.7.3 It was noted that the SADC study proposes the introduction of RNP 2 for en route navigation during Phase III. At present, the AFI region has not identified the need for en route RNP 2.
- 5.7.4 The Study Group was of the view that the cost comparison between WAAS and EGNOS had a major omission. To be inclusive, there is need to take into consideration the cost of providing geostationary augmentation signals (GEO) over the AFI Region. For WAAS there is the need to provide the satellites, while for EGNOS, the AFI Region could take advantage of the European satellites (3 GEOs).
- 5.7.5 The Meeting noted the respective recommendations of the SADC Committee of Ministers and of the Civil Aviation Committee (CAC). It was agreed that the SADC Study was an important contribution to the future implementation of GNSS in the AFI Region, since it has marshalled the support of the highest authorities in the SADC area. However, the Group felt that comments should be formulated and appropriately

transmitted to the CAC in order to harmonize the SADC States approach with that of APIRG. The following conclusion was adopted.

**Conclusion 12/11: Comments on the SADC WAAS/EGNOS Study**

That comments on the SADC WAAS/EGNOS study be drafted by the Secretariat and circulated to members of the Study Group, prior to final transmission to SADC.

- 5.7.6 The Meeting was informed that IATA was conducting in the SADC States a project aimed at implementation of GNS (WGS-84, NPA procedures, legislation).

**5.8 Agenda Item 8: Review of the report on Phase II to the European Commission**

- 5.8.1 Under this agenda item, it was planned to review the administrative and financial report made by ASECNA to the European Commission on the conduct of Phase II of the GNSS Study. The Group was advised that a report had been made and would be forwarded to members after the meeting.

- 5.8.2 IATA reported that its consultant who made the traffic forecast study had not yet been paid and that the work corresponding to the aggregation of the traffic data according to the routing areas of the CNS/ATM Plan had not been taken into consideration. ASECNA clarified that the contract needs to be amended in order to correct the situation. It was agreed that ASECNA would draft an addendum to the contract. The following conclusions were adopted.

**Conclusion 12/12: Addendum to the IATA consultancy contract**

That ASECNA prepare an Addendum to the IATA consultancy contract to take into account the update of the air traffic forecast.

**Conclusion 12/13: Circulation of the administrative and financial Report on Phase II of the GNSS Study**

That ASECNA circulate to members of the Study Group the administrative and financial report addressed to the European Commission on Phase II of the GNSS Study.

**5.9 Agenda Item 9: Status information on GNSS SARPs, GPS, Galileo, EGNOS and WAAS**

- 5.9.1 The Meeting was advised that the Air Navigation Commission and ICAO Council were reviewing the GNSS SARPs for adoption and inclusion into Annex 10. It is planned that they become applicable on 1 November 2001.

- 5.9.2 The Group was provided with documentation on the status of EGNOS and Galileo.

**5.10 Agenda Item 10: Report to the CNS/ATM/IC Sub-group**

- 5.10.1 The Group agreed that the report of the twelfth meeting would constitute its report to the CNS/ATM/IC Sub-group.

**5.11 Agenda Item 11: Future work programme**

5.11.1 The Meeting, based on its discussions, developed and adopted its future work programme as shown at **Appendix H** to the report.

**5.12 Agenda Item 12: Any other business**

5.12.1 The Meeting agreed to hold its next meeting in Johannesburg. The date of the meeting, to be held in the last quarter of 2001, will be co-ordinated between the Secretariat and South Africa.

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## APPENDIX A / APPENDICE A

## List of participants / Liste des participants

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**APPENDIX B / APPENDICE B**

**PRELIMINARY WORKPLAN**

**GNSS PROGRAMME IMPLEMENTATION  
IN AFI STATES**

- PHASE 1: AFI TEST BED (Duration 1 year) - Before 2003
  - Test bed deployment and trials
  - Consolidation of Phase 2 user/mission requirements for the region
  - System engineering activities (specific analysis, architecture studies, I/F with EGNOS, Draft SRD)
  - Identification of programmatic/institutional issues in view of Phase 2
  - Identification of source of financing/required budget for Phase 2
  - Definition of operational validation plan
  - Definition of training requirements

## PROPOSED ACTION PLAN

Kick off all necessary actions/prerequisites to prepare start of Phase 1 (1/03/2001)

Set up and mandate a working group ESA/EC/AFI to work on the preparation of Phase 1 (1/03/2001)

Develop actions/prerequisites for the preparation of Phase 1 launch (1/03/2001-May 2001)

- Development of Phase 1 scope
- Draft RFQ for Phase 1
- Define and implement necessary steps to raise funds from EC/ESA/AFI (paperwork)

Decide to launch Phase 1 (June 2001)

- Launch RFQ/ get and evaluate proposals

Kick off Phase 1 industrial contract (January 2002)



**INITIAL CONCEPT OF THE GNSS STRATEGY FOR THE AFI REGION (Rev. 1)****Introduction**

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

**General Considerations**

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 of the available capabilities at every step of deployment.
- Methods of application will take into full consideration safety considerations of any functional limitations;
- Users must be given sufficient advance notice to re-equip before ground-based systems are decommissioned.

**Evolving functionality\***

**Phase I (Short term), up to ~~2004~~ 2003:** *Additional ranging and health information on GPS constellation provided via GEO satellites*

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

**Phase I-A (up to 2003)**

- An AFI GNSS test bed will be implemented to validate the objectives and differential correction algorithms ~~of Phase II and Phase III~~ of the operational EGNOS system to be implemented during Phase I.

**Phase I-B (up to 2004):** This phase will be achieved by the deployment of a network of RIM stations through the AFI Region.

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\*Dates are indicative

- To prepare EGNOS implementation, numerous activities must be carried out: final system definition, specifications development, cost/benefit analysis (CBA) and funding, preparation of the institutional and operational framework and programmatic issues will be carried out.
- This phase will end with EGNOS validation in the AFI Region.

**Phase II (Medium term) ~~2005-2009~~ 2003-2008:** APV-I NPV-I, 20m vertical accuracy, will be available everywhere in the AFI Region

1. This phase will allow for:
  - En-route phase: sufficient capability to meet en-route navigation requirements everywhere in the AFI Region; GNSS is approved as a sole-means system for en-route navigation. En-route navigation aids will be progressively withdrawn accordingly in consultation with users.
  - Terminal areas: sufficient capability to meet TMA navigation requirements everywhere in the AFI Region; GNSS is approved as sole-means system for TMAs.
  - ILS will continue to be provided at aerodromes.
  - Approach and landing phase: sufficient capability for APV-1 non-precision approach and landing in the whole AFI Region.
  - Terminal area VOR/DME/NDB, and Locators not associated with ILS, will be progressively withdrawn in consultation with users during Phase II.
2. During Phase II, the implementation of GNSS-2 will be developed. ~~a satellite-based augmentation system (SBAS) ground infrastructure will be put in place in the AFI Region; en-route navigation aids will be progressively withdrawn. VOR/DME and ILS will continue to be provided in terminal areas and at aerodromes.~~

**Phase III (Long term) 2008 2010 onwards:** sole-means navigation services from en-route to CAT I operations. *SBAS CAT I 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). This will require the deployment of additional RIMS in the AFI. It is also assumed that at least two constellations of navigation satellites will be available.*

- a) During Phase III, ILS CAT I will be withdrawn in consultation with users.
- b) 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 GNSS.
- ~~c) The plan of withdrawal of ILS should ensure availability of an ILS at least within 500 NM. This reduced back-up network of ILS will remain in place as long as necessary and until sufficient level of confidence has been built on GNSS as sole means navigation system for CAT I approach and landing operations.~~

3. ~~Terminal area VOR/DME will also be progressively withdrawn during Phase III in a coordinated ILS/VOR/DME withdrawal plan, catering for the alternate availability of the two sets of facilities at different locations.~~

***Institutional issues***

- d) Phases II and III of the AFI GNSS strategy will require the deployment of AFI specific GNSS components. In order to minimize costs associated with the deployment and operation of these components, AFI should seek cooperation agreements with systems providers in adjacent regions with a view to the joint use of GNSS components where feasible and cost-effective.
- e) Meanwhile the modalities of installation and cost-recovery of multinational facilities, essentially RIMS, in some AFI States, must be addressed without delay so that deployment can be initiated as soon as technically possible.

<b>AFI GNSS Strategy: SBAS APV-1</b>				
	<b>Phase I</b>		<b>Phase II</b>	<b>Phase III</b>
Time scale	2000 - 2004		2005 - 2009	2010 - 2017
Certification	Supplemental	Primary	Sole-means from en-route to APV1	Sole means from en route to CAT I
Oceanic/En route		GPS	GNSS-1 (GPS with EGNOS)	GNSS-2
Continental/En route		GPS	GNSS-1 (GPS with EGNOS)	GNSS-2
Terminal	GPS		GNSS-1 (GPS with EGNOS)	GNSS-2
Approach and landing	(GPS/Baro) NPA		APV-1 SBAS CAT I GBAS	CAT II/III GBAS

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## SADC WAAS/EGNOS STUDY SUMMARY REPORT

## Background

The Southern African Transport and Communications Commission (SATCC) initiated a project to identify the Southern African Development Community's (SADC's) satellite based air traffic control requirements. The goal of this project was to provide managerial guidelines and a technical roadmap for a regional implementation of satellite navigation.

This study was aimed at addressing the following project objectives:

- **Recommend architecture to support future CNS/ATM services for both aviation and non-aviation users.**
- Develop program plan to satisfy current and future operational demands of all potential local, regional and international users.
- Minimize schedule risk and impact to guarantee an accurate, safe, and reliable system.
- Chart a path to compatibility and inter-operability with other satellite based augmentation systems.
- Develop an evolutionary implementation plan to satisfy operational benefits at lowest cost.
- Develop documentation for decision-makers in SATCC nations and potential investors/financiers.
- Assist SATCC to inform members of program plan and to gain regional support for that plan.
- Design an implementation plan for the SATCC region that can be expanded to all of Africa.

## Introduction to Study

The study commenced with an assessment of the current SATCC regional infrastructure to form a baseline from which the need for progression to a CNS/ATM system could be established.

To ensure that implementation is attained in the most effective manner, satellite navigation has been targeted to be implemented in three phases:

- **Phase I 2000-2004** - transition from ground-based to space-based navigation
- **Phase II 2005-2009** - improvements in the en-route and approach phases of flight
- **Phase III 2010-2017** - precision services to all airports

These phases have been developed according to the schedules for implementation indicated by system developers. This roughly follows the AFI CNS/ATM Implementation Plan's three phases of Evolving functionality.

The matrix below indicates the current capabilities in the SADC Region and the study's recommendations for the region's future minimum navigation requirements.

As indicated in the matrix, the study advised SATCC to adopt the goal of Category I precision approaches in Phases II for all international airports and in Phase III for all domestic airports. This recommendation is based on safety and traffic flow objectives.

The study also recommended RNP-2 for en-route navigation. This was extrapolated from current US test programs involved with future separation reduction criteria. At the current time, the AFI region does not have a plan to introduce RNP-2 for en-route navigation as a minimum future requirement.

REGIONAL NAVIGATION REQUIREMENTS*					
	CURRENT CAPABILITIES		MINIMUM FUTURE REQUIREMENTS		
Phases of Flight	Minimum	Maximum	Phase I (2004)	Phase II (2009)	Phase III (2017)



<b>Oceanic Enroute</b>	100nm/20min (RNAV)	100nm/20min (GNSS/Omega/RNAV)	50nm/10min RNP-10	30nm/10min RNP-5	30nm/10min RNP-5
<b>Domestic Enroute</b>	100nm/20min (NDB)	100nm/20min (VOR/DME/RNAV)	50nm/10min RNP-10	30nm/10min RNP-5	15nm/5min RNP-2
<b>Terminal International</b>	RNP-4 (VOR/DME)	RNP-4 (VOR/DME)	RNP-2	RNP-2	RNP-.3
<b>Terminal Domestic</b>	RNP-4 (NDB)	RNP-4 (VOR/DME)	RNP-4	RNP-2	RNP-1
<b>Approach International</b>	RNP-.3 (VOR/DME)	CAT II (ILS)	NPV1** RNP-.3	CAT I PA RNP-.02	CAT II/III PA
<b>Approach Domestic</b>	RNP-.5 (NDB)	CAT I (ILS)	NPA RNP-.3	NPV1** RNP-.3	CAT I PA RNP-.02
<b>Surface</b>	Not Available	Not Available	Not Available	Not Available	RNP-.5
			Supplemental	Primary	Sole Means
<p>* All RNP values are in nautical miles (nm) unless otherwise indicated  ** NPV1-Nonprecision approach with vertical guidance I; landing minimums slightly lower than VOR NPA, decision height 500 feet  SBAS- Space-based Augmentation System, e.g., WAAS, EGNOS  GBAS- Ground-based Augmentation System, e.g., LAAS</p>					

## Discussion

The study divided the technology into the different possible elements of satellite navigation, which includes BASIC GNSS systems, Space Based Augmentation Systems (SBAS) and Ground Based Augmentation Systems (GBAS). The study then expanded on:

- The present three candidate systems for the BASIC GNSS stage of implementation, i.e. the Global Positioning System (GPS), the Global Orbiting Navigational Satellite System (GLONASS) and Galileo.
- The SBAS i.e. WAAS, EGNOS as well as private commercial initiatives from Lockheed Martin and Boeing.
- GBAS systems available or being developed i.e. Special Category I or SCAT I, Local Area Augmentation Systems (LAAS) and Extended LAAS or ELAAS.

Multiple technology options were covered in the study, to serve as an overview of available technology during the recommended phases of implementation. Using defined boundary choices and the requirement that all architecture options and scenarios must satisfy the minimum regional requirements, the alternatives were limited to the following five architecture options for analysis:

**Scenario 1 -** Upgrading the current ground based systems with no SBAS.

- Scenario 2 -** Implement only GBAS when needed at the airports.
- Scenario 3 -** Implement only SBAS to satisfy the minimum regional requirements. The only exception to the requirement for Cat II/III GBAS in Phase III international airports since SBAS cannot meet this requirement.
- Scenario 4 -** Implement both GBAS and SBAS late in order to learn from the mistakes made by the leaders of any technology.
- Scenario 5 -** Implement both GBAS and SBAS early in order to obtain maximum benefit from the new improvements in technology.

The five architecture options all satisfy the minimum regional requirements and therefore, in theory each alternative is as good as the next one with the only differences in the cost benefits.

### Cost Benefit Analysis

The ICAO compliant Cost Benefit Analysis was based on the ICAO established guidance for Cost-Benefit Analysis in Circular No: 257 AT/106, *Economics of Satellite Based Air Navigation Services: Guidelines for Cost/Benefit Analysis of Communications, Navigation and Surveillance / Air Traffic Management (CNS/ATM) Systems*

Each of the five scenarios was analyzed using a comprehensive cost-benefit model for both WAAS and EGNOS configurations. In this analysis, Scenario 3 had the highest cumulative net present value. This scenario also offered the highest value to air traffic control organizations, so it represents the best possibility for future profitability.

The analysis found that there was a marginal benefit associated with using WAAS for this implementation over EGNOS. This was based on current equipment costs and may vary in the future, depending on how vendors actually market their products when SATCC decides to implement a system.

Based on the cost benefits, the recommended architecture is Scenario 3, where only SBAS is implemented until Phase III, when a Cat II/III GBAS has to be implemented to satisfy landing requirements at all international airports. This study only focuses on the minimum regional requirements, so that some States may want and need additional requirements that was not addressed in the study. To satisfy these minimum regional requirements, the following architecture was recommended:

- Phase I - Implement GPS procedures
- Phase II - Implement Cat I/NPV SBAS
- Phase III - Cat II/III GBAS at all international airports

The table below summarises the implementation of Scenario 3:

<b>Scenario 3: SBAS with Cat II/III GBAS</b>			
	<b>Phase I</b>	<b>Phase II</b>	<b>Phase III</b>
<b>Time scale (SADC Study)</b>	2000 - 2004	2005 – 2009	2010 - 2017
<b>Time scale (AFI GNSS Study)</b>	→ 2003	2003 - 2008	2008 →
<b>Certification</b>	Supplemental	Primary means	Sole means

<b>Oceanic/En route</b>		Basic GNSS	Basic GNSS (GPS with limited Galileo)	Basic GNSS (GPS/Galileo)
<b>Domestic/En route</b>		Basic GNSS (GPS)	Basic GNSS (GPS with limited Galileo)	Basic GNSS (GPS/Galileo)
<b>Terminal</b>	<b>International</b>	Basic GNSS (GPS)	Basic GNSS (GPS with limited Galileo)	Basic GNSS (GPS/Galileo)
	<b>Domestic</b>	Basic GNSS (GPS)	Basic GNSS (GPS with limited Galileo)	Basic GNSS (GPS/Galileo)
<b>Approach</b>	<b>International</b>	Basic GNSS (GPS/Baro NPV)	Cat I/NPV SBAS	Cat II/III LAAS
	<b>Domestic</b>	Basic GNSS (GPS)	Cat I/NPV SBAS	Cat I/NPV SBAS

## Transition planning

To realize the benefits of satellite navigation SATCC will need to plan its transition to all stages of system implementation. The proposed transition plan for the SATCC region is divided into three focus areas:

### ◆ Institutional

Institutional activities focus on the **process** supporting the introduction of satellite-based navigation systems. Some of the high level considerations that need to be addressed by SATCC include the following issues:

- Establishment of a Program Development Organization
- Establishment of a legal framework and Government Coordination
- Familiarization of decision-makers with the Technology and related concerns
- Development of an Acquisition Strategy
- Financing of the Project

### ◆ Technical

Key elements that need to be addressed includes the following:

- Identify Add-on Requirements
- Establish a Test Bed
- Refine and Finalize Technical Design for Architecture
- Decommission Traditional Navigation Systems

### ◆ Operational

From an operational point of view transition planning would involve the following key activities:

- Airspace Management
- Procedure Development, including WGS-84 compliant airport surveys
- Train Staff on System Usage and Maintenance
- Full Utilization of Basic GNSS
- Avionics Installation and Certification
- Operations and Maintenance
- Final Systems Evaluation and Commissioning

## Recommendations

After considering the ISI report, the SADC Civil Aviation Committee made the following recommendations to the SADC Committee of Ministers (COMI):

The SADC Committee of Ministers to:

- a) Note that the study by ISI on the SADC Regional Satellite Based Air Traffic Control has been completed and that the Civil Aviation Committee (CAC) accepted ISI's report and its recommendations.
- b) Note that from previous arrangements South Africa would present the report of this study, to the AFI GNSS Study Group when it meets in May (June) 2000.

Furthermore the Civil Aviation Committee recommended to the Committee of Ministers to accept the recommendations of the report as follows:

- a) The SADC region defers the choice of an appropriate satellite based augmentation system between WAAS and EGNOS until such time that the two systems are operational and has proved themselves.
- b) The SADC region implements Scenario 3 that recommends that only SBAS be implemented to satisfy the minimum regional requirements with GBAS at Seychelles and Mauritius. Cat II/III GBAS is also recommended for airports where required.
- c) That SATCC approaches the providers of the two systems to explore the possibility of SADC's participation in test beds if these would be availed free of charge to SADC by the providers.

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## FUTURE WORK PROGRAMME

**Future work programme of the AFI GNSS Study Group**

<b>Item</b>	<b>Description</b>	<b>Target Date</b>	<b>Responsibility</b>
1	Report on contact and liaison with EOIG service providers	Next meeting (GNSS/13)	ASECNA and ATNS
2	EGNOS test bed activities: co-ordination with ESA, definition of test sites	On-going	ASECNA and ATNS (initially)
3	Meeting with EOIG representative in Dakar	to be co-ordinated	All Members
4	Prepare a draft proposal for funding of AFI EGNOS test bed	June 2001	ASECNA, ATNS
5	Contact with flight calibration organizations	Next Meeting	ICAO
6	Contact with procedure designers	Next Meeting	ICAO
7	Reply to SADC Study to be sent to SATCC	15 March 2001	ICAO after co-ordination with all
8	Comments on Eurocontrol CBA to be sent to IATA	15 March 2001	All
9	Inclusion of GNSS in AFI FASID	15 March 2001	ICAO, with comments by members
10	Circulation of the administrative and financial report to EC on Phase II of the GNSS Study	22 March 2001	ASECNA
11	Further development of the AFI GNSS strategy	On-going	All
12	Circulation of documentation to States	after APIRG/13	ICAO
13	Define detailed system architecture to meet APV-I over continental AFI, taking into account, as appropriate, developments in other regions.	2003	Candidate AFI SBAS providers: AFI Working Group

Item	Description	Target Date	Responsibility
14	<ul style="list-style-type: none"> <li>• Perform an AFI SBAS APV-I <b>definition and design</b> phase, including:   Definition of a Programme Organisation   Development and Issue of detailed Mission requirements (Service Levels).   Definition of Service Area   Preliminary System Definition and Design   Issue of System Requirement Document   Preparation of a system development plan   Preparation of an operational validation plan   Carrying out initial trials/systems tests in order to support the design phase.   For this purpose, the candidate AFI SBAS Providers will explore the possibility of cooperation agreements with the EOIG (EGNOS operators and Infrastructure Group).   In this context, an AFI GNSS test bed will be implemented to validate the objectives, design parameters and algorithms for Phase II and III of the AFI GNSS strategy.                         </li> </ul>	2003	candidate AFI SBAS providers (to be defined)

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