



International Civil Aviation Organization
South American Regional Office - Project RLA/03/902
Transition to GNSS/SBAS in the CAR/SAM Regions –SACCSA – Phase III
Ninth Meeting of the Coordination Committee (RCC/9)
Lima, Peru, 1-4 July 2013

Agenda Item 6: Other business

**PLAN FOR THE IMPLEMENTATION OF AN SBAS/SACCSA TEST BED
IN THE CAR/SAM REGIONS**

(Presented by the Secretariat)

SUMMARY

This working paper presents the Plan for the implementation of an SBAS/SACCSA test bed in the CAR/SAM Regions, expanding on the scope approved in GREPECAS Conclusion 16/4. It is an update to the working paper presented at RCC/8, based on the current situation and aimed at maximising its cost-benefit ratio.

**ICAO Strategic
Objectives**

This working paper is related to Strategic Objectives:

A. Safety

C. Environmental protection and sustainable development of air transport

1. Introduction

1.1 At the seventh meeting of the Coordination Committee (RCC/7) of Project RLA/03/902 – SACCSA, held in San Carlos de Bariloche, Argentina, on 11-15 October 2010, a real-time demonstration was made of the broadcast of an SBAS / SACCSA signal through GEO INMARSAT 3F4 PRN 122 and using the GMV SBAS processing centre magicSBAS, with GPS observation data from IGS GPS receiver networks, SIRGAS (IGS, IBGE, UNESP, RAMSAC, PRSN, etc). The result was highly satisfactory and has permitted the proposal of steps for developing an SBAS/SACCSA test bed in these regions, as discussed and agreed upon by the meeting through the following conclusion:

CONCLUSION

RCC/7/SACCSA/10 –

IMPLEMENTATION OF AN SBAS-SACCSA TEST BED

That, recognising the convenience and the benefits of implementing an SBAS-SACCSA test bed in the CAR/SAM Regions to meet the objectives listed in paragraph II.9 of this report:

- a) *Project RLA/03/902 draft a plan for the implementation of an SBAS – SACCSA test bed, defining the required infrastructure, costs, and other related aspects; and*

- b) *Accordingly, ICAO invite the States and International organisations of these Regions to participate in the aforementioned test bed.*

1.2 Accordingly, ICAO requested the project technical coordinator to study the possibility of implementing a test bed in the CAR/SAM Regions.

1.3 Likewise, the GREPECAS/16 meeting agreed on the following conclusion and paragraphs concerning SACCSA:

**GREPECAS:
CONCLUSION 16/4**

**SUPPORT FOR THE COMPLETION OF PROJECT
RLA/03/902 SACCSA STUDIES AND PARTICIPATION IN
THE TEST-BED IMPLEMENTATION**

In view of the first results obtained by the SACCSA Project – Phase III-A and its contribution to the implementation of PBN, and in order to support the completion of this Project, CAR/SAM States/Territories/International Organizations are urged to:

- a) *facilitate/coordinate with their corresponding national authorities access and provision of data to the SACCSA Project from networks with 1-second GPS receiving stations with FTP or NTRIP access and RINEX files; and*
- b) *taking into consideration the objectives indicated in Appendix B to Agenda Item 2 of the report of the CNS/ATM/SG/2 meeting, consider participation in the SACCSA-SBAS test-bed implementation by notifying ICAO Regional Offices by **30 June 2011.***

2. SBAS/SACCSA test bed proposal

2.1 In order to develop an SBAS system, a test bed is required to test and analyse the solutions to be applied, and the necessary improvements must be introduced in order to achieve a proper operation of the system. Furthermore, this test bed would allow for SBAS benefits to be derived in the short term.

2.2 In the case of the CAR/SAM Regions, this is even more important, taking into account the peculiarities of the region with respect to other regions in medium latitudes that have SBAS, like, for instance, the behaviour of the ionosphere and the impact of maximum solar activity on the SBAS, including GEO satellites, and the corresponding reception of the L1 signal from such satellites. Consequently, this is a pioneering test bed with respect to what has been done to date with the existing SBAS systems.

2.3 The basic objectives are to:

- Start deriving benefits from SBAS in the short term (aviation and multimodal), before the implementation of the operational system.
- Demonstrate the technical feasibility of the SACCSA solution.
- Analyse the operation of SACCSA algorithms and solutions, conducting the relevant tests, corrections and/or modifications that will show the technical feasibility of system implementation.
- Have a test bed for analysing the impact of the ionosphere on the set of elements of the SBAS system (reference stations, GPS, GEO, communications) in complex situations, like those that will emerge during the period of greater solar activity of the current solar cycle, between 2012 and 2013, and showing the level of operation of the SACCSA ionosphere algorithm.
- Have a pre-system that, based on the tests and performance analysis, may give way to the definitive operational system.
- Give States and International Organizations the opportunity to become acquainted with the system, developing open multimodal (non-SoL) applications in order to start obtaining benefits from SBAS, based on an open non-SoL service for multimodal, single-frequency and dual-frequency users.
- Develop LPV aeronautical procedures that can be flown with duly equipped aeroplanes (red label receivers).
- Minimise the implementation risks of the final system.
- Help identify the best system management model.
- Promote the use of SBAS technologies in the CAR/SAM Regions both at the aeronautical and multimodal levels.
- Have a multi-frequency and multi-constellation test bed to analyse the advantages and compare the various future technologies, such as multi-frequency (L1/L5) and multi-constellation.
- Take advantage of the existing infrastructure of the CAR/SAM Regions in order to provide added value based on the application of SBAS technology.
- Develop and provide a precision improvement service based on SBAS.

2.4 Through this test bed, it would be possible to integrate some of the most innovative solutions proposed by SACCSA, such as the use of multi-constellations in the earth segment (use of GPS and GLONASS receivers), which represents a big leap with respect to SBAS systems currently in operation or under development.

Test bed description

2.5 In order to achieve these objectives, Project RLA/03/902 has proposed the implementation of an SBAS/SACCSA test bed that is representative of the final system and ensures the development and proper operation of the definitive system. This test bed must combine an operation and service similar to a real system under a least-cost approach, taking into account both equipment and operating costs.

2.6 The test bed will consist of:

- A navigation load in a GEO.
- A GEO satellite access station.
- A central processing unit (CPU).
- A communication network.
- At least 24 reference stations located at sites defined for SACCSA, as shown in the figure below, or as close as possible to such sites.
- Data collection and recording centre for analytical and statistical studies.
- Support centre.
- Operation for a period of two years.

2.7 Several solutions (basic, intermediate and advanced) were presented at the SACCSA RCC/8 meeting. This working paper proposes a solution equivalent to the intermediate level, with a different operational concept.

2.8 The proposed solution is based on the use of elements that already exist that meet the minimum test bed requirements at the level of both the receiver networks and the GEO access stations. The starting point would be the use of the MagicSBAS and an INMARSAT access station (availability to be confirmed) or one already in existence within the satellite visibility footprint, using the receiver networks available in the CAR/SAM Regions. The proposal includes the deployment of new reference stations to improve service availability and assurance in countries interested in the test bed. This alternative would assure a minimum level of service. It is important to note that monitoring stations can be used beyond the testing period as performance monitoring stations for both GPS/GLONASS and SACCSA (if implemented). These stations will be vital for the implementation of PBN based on GNSS (SBAS) navigation, since it will allow the States to know what services are provided by GPS at all times. Therefore, a possible solution would be for each State to purchase its own stations following a general process. Of course, there would be only one station model that could be purchased through the TCB, based on the results of the bidding process, since all stations could be bought for subsequent distribution, at a lower cost than supplying one or two stations to each contracting State.

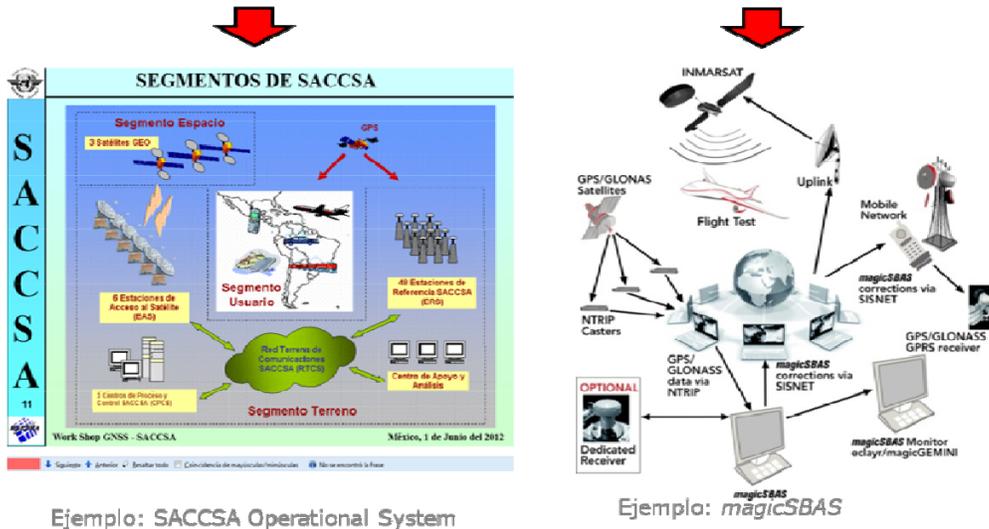
2.9 Likewise, a flexible operations concept is proposed to reduce costs while continuing obtaining benefits. Consequently, mixed operations are proposed: through the Internet, followed by a period of GEO broadcasts.

2.10 A high-level description of each of the elements proposed for the system and the assumptions under consideration follows:

- A **navigation load** in a geostationary satellite (GEO), which in this case, is the INMARSAT 4F4 satellite (at 54W).
- A **GEO satellite access station** (*uplink* station): The proposal is to use an INMARSAT station already in existence within the satellite visibility footprint.
- **Reference stations:** The proposal is to re-use the existing public reference stations as much as possible in those places where they exist and meet test bed requirements. If a country wishes to ensure its services, it shall reach an agreement with the provider regarding station availability, or install its own additional reference stations. Taking into account the behaviour of the existing magicSBAS test bed and based on GMV experience, the installation of 8 to 10 reference stations throughout the CAR/SAM Regions is recommended.
- **Communication network:** It is assumed that communications will be established through the Internet. This assumption entails the existence of an appropriate communication line that permits the transmission of at least the basic 250 bits/second for the operation of the test bed and the whole SBAS system. In case such line is not available, it could be provided as part of the test bed through local providers.
- **Central processing unit** (*magicSBAS*). The central processing unit is responsible for calculating SBAS messages (GPS corrections and their corresponding integrity), including satellite and ionosphere model corrections. It is really the core of an SBAS system. This central processing unit includes the SACCSA algorithms that have been adapted to the ionosphere conditions of the CAR/SAM Regions. The central processing unit consists of HW and SW. The proposal is to install this processing unit (magicSBAS) in one of the SACCSA participating States.
- **Performance analysis centre** (*magicgemini*). This element makes up the support centre, which is responsible for analysing system performance. It is based on the magicGEMINI product. The proposal is to install it with magicSBAS at AEROCIVIL facilities. magicGEMINI can operate in post-processing and real-time mode, allowing for optimum GNSS control.

2.11 The following figure shows the main elements of an operational SBAS system and of the test bed (prototype in the figure) proposed herein:

SISTEMA OPERACIONAL VS. TEST-BED/PROTOTIPO



Ejemplo: SACCSA Operational System

Ejemplo: magicSBAS



2.12 Since the test bed may involve a broad range of prices, and taking into account that the main operating costs are those derived from the rental of the GEO navigation load, the proposal is to apply a flexible operations concepts so as to derive maximum benefits while minimising costs. To that end, the proposal is to operate the test bed for a period of **two years**, as follows:

- **6 months** with GEO broadcast
- **18 months** without GEO broadcast.

2.13 The duration of the GEO broadcast period depends on the needs of the countries, and may be longer or shorter as deemed appropriate.

Notes:

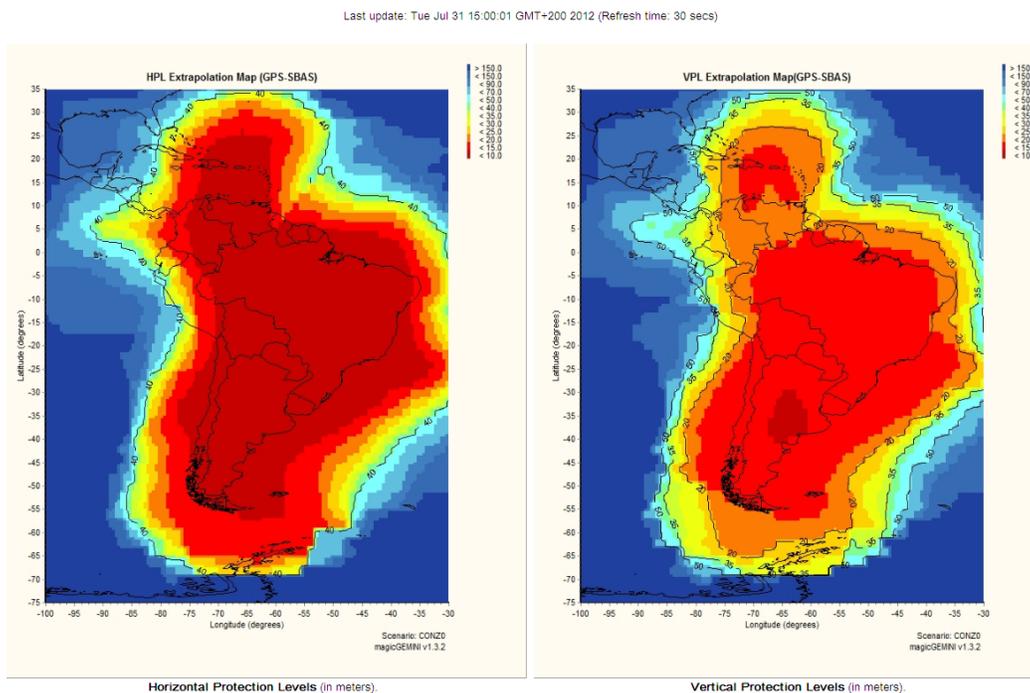
- The PRN code assigned to the 3F4 satellite is no longer valid. Now the procedure is for the service provider (SACCSA-ICAO) and not the satellite operator, to request the PRN. Inmarsat offers assistance in these proceedings. This applies to GEO broadcast.
- MTO: The “do not use” message will be used for the test bed to ensure safety. The GEO broadcast must be coordinated with the FAA (WAAS) and EC (EGNOS), as was done for the demonstration in Argentina. This applies to GEO broadcast.

Expected test bed performance

2.14 This section deals with the expected performance of the SACCSA test bed proposed in this working paper.

2.15 GMV has a magicSBAS + magicGEMINI test bed running in real time in the CAR/SAM Regions with SACCSA algorithms. In turn, this test bed includes a web platform that shows performance results obtained in real time: <http://magicgnss.gmv.com/sam/>.

2.16 By way of example, the performance in terms of availability that would be obtained in the SACCSA region through the implementation of an SBAS system adapted to the region is shown below.



2.17 Horizontal (left) and vertical (right) availability obtained in SACCSA on 31/07/2012, with the network of stations used in SACCSA.

Test bed financing

2.18 The SACCSA test bed is a necessary and important step before deciding to implement the definitive system, and is the result of the work done during PHASE II and the work being done in PHASE III. The test bed will demonstrate the operation of the proposed solutions and of the algorithms being developed.

2.19 Accordingly, the test bed is a consequence of the SACCSA project and, as such, is a supplementary activity linked to the work currently being carried out, but with an additional budget that is independent from that for PHASE III.

2.20 When financing the test bed, we must separate the cost of the equipment or capital costs (CAPEX - **capital expenditures**) from operating expenditures (OPEX). Let us analyse both costs:

CAPEX

2.21 These costs refer to the cost of the equipment necessary for the implementation of the test bed, and basically include hardware/software (HW/SW) elements and installation infrastructure, if needed.

2.22 In this regard, the elements to be taken into account are:

- the SACCSA test bed reference stations
- the communication network
- the CPU (central processing unit - magicSBAS) prototype
- the support or performance analysis centre
- satellite access stations and the infrastructure associated to the GEO

2.23 There will be a single reference station model, thus diluting engineering costs and reducing their impact on the final cost. Since these stations would be owned by the States, the proposal is for each State/International Organization to purchase the corresponding stations using their own resources, outside of the project budget. This would also apply to other system elements, such as the CPU prototype or the support centre, in case any State wishes to have one in their territory.

2.24 The other elements are common to the test bed and therefore their costing will be based on the project budget.

OPEX

2.25 This includes the operating costs of the system, applied periodically throughout the life of the system, with the corresponding annual variations established in the corresponding contracts. They would include, *inter alia*:

- rental of the GEO load (6 months)
- operation and rental of the satellite access station (6 months)
- rental of CPU license with GEO broadcast (magicSBAS)
- operation of the CPU prototype: with and without GEO broadcast
- operation of the support centre: with and without GEO broadcast
- communication network
- engineering

- system management

Service assurance and protection

2.26 Participation in Project RLA/03/902 SACCSA and/or the test bed is open to all States and International Organizations willing to participate. For those that are not interested in participating and receiving its signal, the IGPs of non-contracting States may be annulled in the central processing unit (CPU). Thus, they would only see the GEO L1 signal but not the corrections provided by the system, so they would not be able to use it. This is a service assurance and protection element, since it would only be available for the participating States.

Implementation strategy

2.27 Taking into account that one of the main objectives is to maximise the cost-benefit ratio of the test bed, it is recommended that the SACCSA test bed be implemented gradually, thus minimising investment risks.

Roadmap

2.28 The purpose of this section is to provide a long-term vision of the SACCSA implementation and the relationship with the SACCSA test bed. This is essential for the sustainability of the project, not only from the point of view of the test bed concept but also from a broader viewpoint.

2.29 This section includes the recommendations for the development of an SBAS in SACCSA. The roadmap proposed is based on the following aspects:

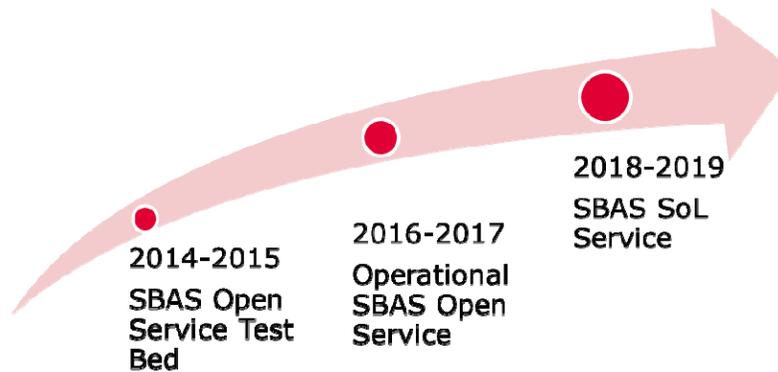
- fast implementation, low cost, and early development of an Open Service to start obtaining benefits in the short term.
- transfer of technology to the customer
- incremental approach applied to different areas:
 - incorporation of local partners
 - incremental re-definition, based on customer needs: possibility of including new services
- multimodal solution, drastically expanding the range of users
- interoperable with other SBAS systems (EGNOS, WAAS) but preserving independence and sovereignty.

2.30 Based on this approach, the following roadmap is proposed:

- Stage #1: SBAS Open Service – SACCSA Test bed. With the following objectives:
 - Consolidation of SBAS mission requirements (Open Service and SoL-Safety of Life)
 - SBAS feasibility assessment
 - Review of the SBAS (SoL) definition proposed in SACCSA, if necessary
 - Detailed definition of an SBAS OS (Open Service)
 - Deployment of an SBAS Open Service Test bed
- Stage #2: SBAS Operational SACCSA Open Service. Based on Stage #1 (Test bed)

- Phase C1: Detailed definition of SBAS Open Service
- Phase D1: Qualification and production of the SBAS Open Service
- Phase E1: Deployment of SBAS OS. Pre-operation to formal acceptance
- Stage #3: SBAS SoL Service. Based on Stage #1 (Test bed) and Stage #2 (SBAS OS operational)
 - Phase C2: Detailed definition of SBAS SoL
 - Phase D1: Qualification and production of SBAS SoL
 - Phase E1: Deployment of SBAS SoL. Pre-operation to formal acceptance

2.31 A schematic view of the proposed roadmap (tentative dates) follows:



2.32 The main advantages of this gradual approach are:

- Stage #1: SBAS Test bed. magicSBAS
 - Provides an engineering design platform. At the aeronautical level, it will enable the development of procedures, training, demonstrations, applications, etc. It will be possible to fly the defined procedures.
 - Definition and development of the safety methodology (CON-OPS, FHA, PSSA) to be applied in the development and implementation of future LPV procedures based in SACCSA.
 - Adaptation of the ionosphere model.
 - Allows for the provision of almost immediate service.
 - Use by multimodal users for the development of their own applications and services.
 - And, above all, permits the early creation of a user community.

- Stage #2: SBAS OS operational.
 - It is the infrastructure essential for SoL service.
 - Safety critical assessment to define SBAS SoL
 - In-flight use of experimental LPV reference procedures
 - Users of multimodal applications
 - Service assurance in the provision of the SBAS OS service
 - Incremental evolution of Stage #1 infrastructure (magicSBAS), focusing on the following elements:
 - Reference stations, communications, evolution of algorithms, and processing centre infrastructure (CPCS)
- Stage #3: SBAS SoL operational
 - Infrastructure redundancy to meet Safety of Life requirements:
 - 48-50 dedicated reference stations
 - 2-3 CPCS
 - 2-3 GEOs
 - Communication network: internal redundancy to meet availability, integrity and continuity requirements
 - 2 support centres
 - 4-6 satellite access stations (2 for each GEO): Uplink stations

3. Conclusion

3.1 The implementation of the SACCSA test bed will allow States and International Organizations to become quickly acquainted with SBAS signals, with the possibility of developing multimodal, non-SoL applications and services based on SACCSA, thus obtaining a return on investment, since services are tradable, just as applications, providing prompt benefits to non-aeronautical users.

3.2 At the aeronautical level, LPV procedures may be designed and flown with “red label” receivers (we must not forget that the MT0 message must be activated), or with the solutions proposed for the operation of the test bed. This will make it possible to gradually design procedures and appreciate the improvements obtained. Thus, it will be possible to develop the methodology for the design and implementation of LPV procedures and have it ready when the SACCSA SoL system becomes operational.

4. Suggested action

4.1 States are invited to:

- a) take note of the information provided in this working paper.
- b) analyse the possibility of implementing the cited test bed and participating in its implementation and development.
- c) promote in their States the aeronautical and multimodal applications based on the test bed, obtaining the benefits derived from said applications.