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New Orleans, United States, 1 - 3 December 2015**

Agenda Item 8: Regional Technical Cooperation

8.2 Project RLA/03/902 "Transition to GNSS in the CAR/SAM Regions – SACCSA" Phase III – Transition to GNSS/SBAS in the CAR/SAM Regions – SACCSA - Project Results

COMPLETION OF THE STUDY OF AN OWN SATELLITE BASED AUGMENTATION SYSTEM (SBAS) FOR THE CAR/SAM REGIONS - PROJECT RLA/03/902– TRANSITION TO GNSS/SBAS IN THE CAR/SAM REGIONS - AUGMENTATION SOLUTION FOR THE CARIBBEAN, CENTRAL AND SOUTH AMERICA - (SACCSA) – PHASE III

(Presented by the Secretariat)

EXECUTIVE SUMMARY

This information paper presents the completion and result of the SACCSA Project with respect to the study of an own SBAS system for the CAR/SAM Regions, detailing activities carried out, the conclusion of the Work Packages and compliance with objectives.

<i>Strategic Objectives:</i>	<ul style="list-style-type: none">• Safety• Air Navigation Capacity and Efficiency• Environmental Protection
<i>References:</i>	<ul style="list-style-type: none">• Report of the Tenth Meeting of the Project RLA/03/902 Coordination Committee/Closing Meeting of Project RLA/02/902 (Bogotá, Colombia, 9 to 13 February 2014)

1. Introduction

1.1 The trials conducted with the Wide Area Augmentation System (WAAS) and European Geostationary Navigation Overlay Service (EGNOS) determined that their extension was not feasible in the CAR/SAM Regions due to the particular ionospheric behavior experienced, which suggests the development of an own Satellite Based Augmentation System (SBAS) with algorithms adapted to the needs of the CAR/SAM Regions, known as the Caribbean, Central America and South America Augmentation Solution (SACCSA) whose main purpose is to develop and plan the technical, financial, operational and institutional aspects of a SBAS system for the CAR/SAM Regions. As shown in Figure 1, the project has had several phases, finalizing at this time the execution of the Project.

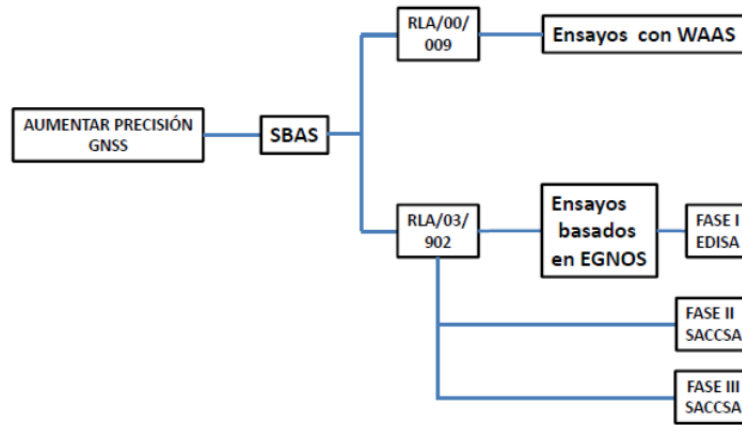


Figure 1
SACCSA Origin and Phases

2. Description of the SACCSA Project – Study delivered

2.1 The SACCSA Project – RLA/03/902 was created as a result of the Regional Planning and Implementation Group (GREPECAS) conclusions on the transition process to the Global Navigation Satellite Systems (GNSS) with SBAS augmentation, for the CAR/SAM Regions, with the purpose of developing a Technical Feasibility, Cost/Benefit and Financial Study of the Augmentation Based on Satellites for the CAR/SAM Regions. The project is coordinated by the ICAO Technical Cooperation Bureau (TCB).

2.2 The States/International Organizations that have participated in SACCSA include (all phases): Argentina, Bolivia, Chile, Colombia, Costa Rica, Guatemala, Panama, Spain, Trinidad and Tobago, Venezuela and COCESNA.

2.3 The SACCSA Project began with previous analysis since 2003 and started since 2005 through RLA/03/902 and RLA/00/009 Conclusions related to the subject that neither EGNOS nor Wide Area Augmentation System (WAAS) may adequately be extended in the CAR/SAM Regions.

2.4 The objective of the Project was to develop and plan technical, financial, operational and institutional aspects of a SBAS system for the CAR/SAM Regions referred as a whole as the Study for an own SBAS in the CAR/SAM Regions [Reference: GREPECAS ATM/CNS/SG/3 Meeting in Rio de Janeiro, Brazil, March 2004].

2.5 Based on the positive results of SACCSA Phase II, it was decided to start a phase III to complete the studies of the phase II. The working packages contemplated in Phase II were:

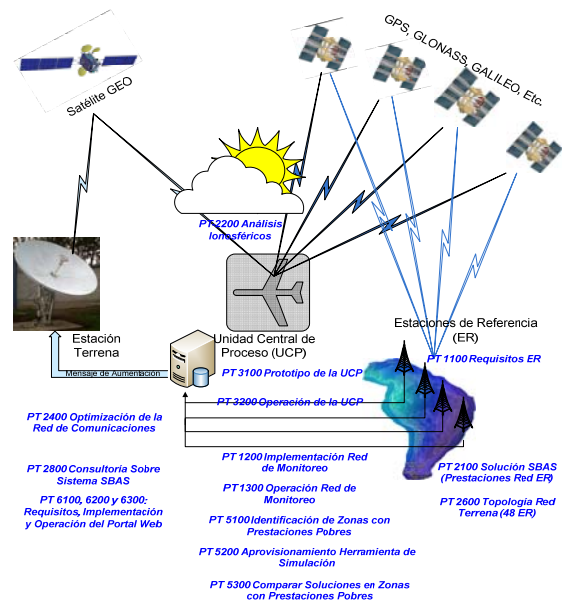
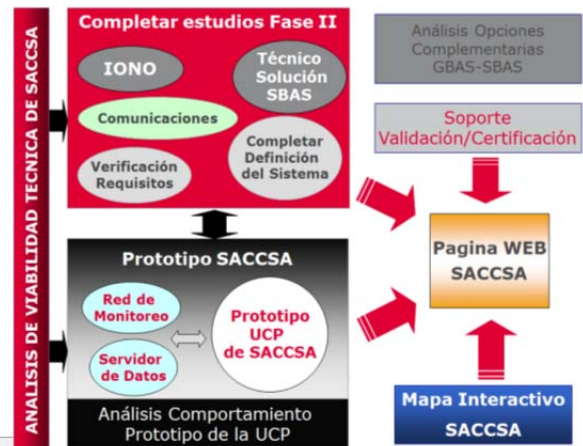
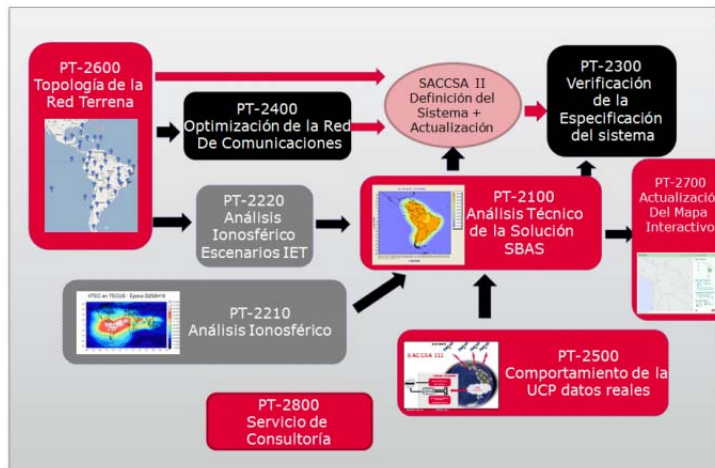


Figure 2
Phase III Scheme

- Interactive database (PT-1000)
- System definition: Spatial, terrain and user segment.
- Requirements/specifications (PT-5000)
- Design (PT-3000)
- Analysis SACCSA terrain topology (PT-2000)
- Ionospheric Study (PT-4000)
- SACCSA Management model, Operation/Exploitation model, Service Provider Model (PT-7000)
- Analysis of the Needs and GNSS Training Levels (PT-8000)
- Cost/Benefit Analysis (PT-9000)
- Financial Aspects

2.6 Due to the complexity of Phase III and cost of the tasks to contract TCB, and in compliance with its procedures, in August 2009, ICAO invited some companies to participate in the Phase III offer process selecting the consortium formed by GMV (principal contractor), plus INDRA, SENASA, Raytheon, GESA-La Plata and CENAT. The following figures show the functional relation of the Project's activities/working packages contained in the study, as well as the numbering for their execution.



2.7 In order to manage the tasks related to this third phase, a working group was created under the ICAO direction and international coordination initially with AENA and later on with the Civil Aviation-Colombia, as technical coordinator for the implementation of the technical activities. The following figure shows the coordination of the Project:

2.8 For phase III, the execution strategy consisted of two main activities plus a series of complementary tasks:



- Study to complete the results obtained in the previous phase, as part of the technical feasibility analysis.
- Complement the technical feasibility analysis by developing an UCP SACCSA prototype, based on the GMV magic SBAS tool and adapted to the CAR/SAM Regions, having special attention to the ionospheric aspects.

2.9 By agreement of the Project for Phase III, only the working packages to complete the study were carried out, not performing the necessary working packages to validate the study nor the part of the cost/benefit detailed study. Therefore the working packages contracted were:

- PT 1300: Monitoring Network Operation – only for the use of the Process Central Unit
- PT 3200: Processing Central Unit Prototype Operation
- PT 5200: Simulation Tool Supply
- PT 5300: Solution comparison in zones of poor output
- PT 6300: Website portal operation and maintenance – 3 months and transition to a new website supported by States Management



2.10 The technical coordination presented the following considerations for the results of the Project:

- The multiconstellation (GPS+GLONASS) and the multifrequency (dual frequency) to minimize the solar activity impacts in the ionosphere and the SBAS signal affectionation.
- Compliance of the SBAS technical feasibility indicated in ICAO Annex 10 – *Aeronautical Telecommunications*, Volume I, which has been demonstrated by GMV, in real time the performance and coverage up to APV-I in the CAR/SAM Regions.
- Satisfactory results of the approach path scenarios analysis for El Dorado, Bogota and San José, Costa Rica airports.
- Results of the coverage limitations (La Patagonia) and poor performance in some regions (part of Brazil) of the CAR/SAM Regions.

2.11 The GMV company (Project contractor), set up a platform that in real time analyzes the SACCSA performance through the GMV magic SBAS and Magic Gemini tools in real time, taking advantage to this effect of the reference stations installed for other purposes by universities, geographic institutes, etc. The results are available in the following link: <http://magicgnss.gmv.com/sam/>. The horizontal and vertical mistakes, as well as the associated protection levels could be observed in real time. The Figure 3 shows the reference stations source of the magic SBAS.

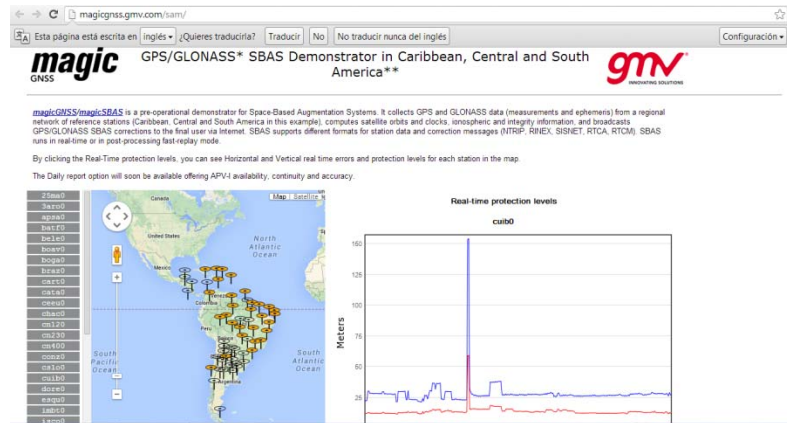


Figure 3
Reference stations source of the magic SBAS

2.12 The Project closing event, RCC/10 consisted of a workshop to show the results, the SACCSA study and the Coordination Committee of Project RLA/03/902 (RCC) Meeting, where the following items were dealt with:

- Review of the Project status and the study final documentation
- Activities carried out by the technical coordination of AENA and the Project progress
- Review delivered work packages
- Financial status
- Final evaluation Project

2.13 The Project members recognized ICAO leadership in this study and the importance and future usefulness of the study for the Project members and the CAR/SAM Regions.

2.14 Each member of the Project received a copy of the SACCSA study. Phases I to III are breakdown in different work packages. The benefits obtained with the participation in SACCSA are presented in **Appendix A** to this paper. **Appendix B** provides a more detailed overview of the SACCSA Project outcomes.

3. Conclusion

3.1 The SACCSA Project RLA/03/902 has completed its works with the delivery of an own SBAS system technical feasibility study for the CAR/SAM Regions, which benefits will allow States with a better understanding of the advantages and feasibility of implementing a SBAS system, as well as the use of them for GNSS future activities at each State level, as at the CAR/SAM Regions level.

APPENDIX A
BENEFITS OBTAINED WITH THE PARTICIPATION IN SACCSA

1.1 Two advanced GNSS courses/seminars (Mexico and Costa Rica), where GNSS high-level training in general, SBAS-SACCSA in particular and the use of GNSS in the aeronautical and multimodal sector were provided. These courses serve as a reference for States to prepare their own internal courses in their training plans, material and instruction of a very high level in GNSS technologies.

1.2 As result of the work Packages delivered, documentation on a SBAS components, with a depth description of elements and sub-elements forming it, including the functional and operative description was prepared, being significant the subject of the control centres (Process and Control centres) because of the complexity it entails, having a level of detail equivalent to those of EGNOS or WAAS.

1.3 Ionospheric studies have been delivered to the CAR/SAM Regions with a GNSS perspective to a level never realized until now, covering maximum and minimum solar periods, and that can be used for SACCSA as for other applications that the States deemed convenient.

1.4 Ionospheric algorithms have been defined in order to implement SACCSA, because those developed by WAAS and EGNOS are not applicable to the CAR/SAM Regions.

1.5 A design of the complete SBAS solution for SACCSA, applicable to the CAR/SAM Regions, has been delivered.

1.6 Financing, system operation, management, training needs, models and diagrammes that allow establishing the structure of the future system have been delivered.

1.7 Needs of communications in order to implement the SACCSA operational system have been defined, besides the necessary ground network reference stations.

1.8 SBAS approaches in Bogota, Cartagena de Indias, Havana, San Andres and Tegucigalpa were carried out during the EDISA tests.

1.9 A testbed in real time provided by GMV is available, where the SACCSA performance is being analyzed through the GMV magic SBAS and Magic Gemini tools (<http://magicgnss.gmv.com/sam/>), carrying out a continuous follow-up of what can be obtained with the system and the LPV or APV I operative areas. States could see this performance and have access to the SBAS/SACCSA messages through the network.

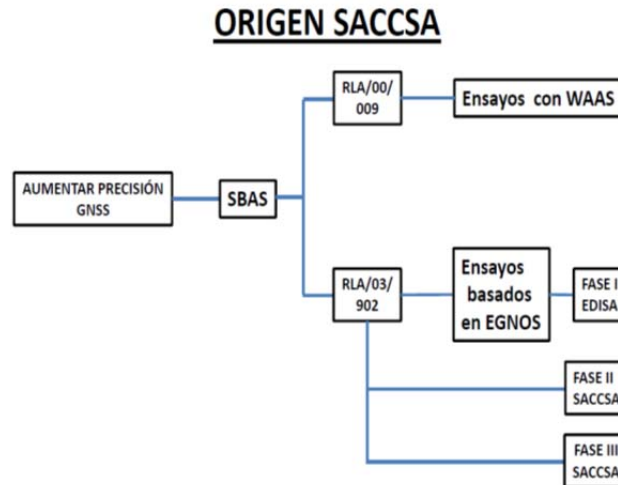
1.10 For the first time, a real SBAS signal in the CAR/SAM Regions with SACCSA algorithms using the GMV magic SBAS testbed and the Inmarsat Geostationary satellite was broadcasted.

1.11 Indications of the use of the SACCSA system by other users have been provided. A workshop where the benefits that could be obtained with a SACCSA solution applied to other sectors not aeronautical and critical for the States was carried out.

1.12 Presentations have been made on the way to create business models through the use of services based on GNSS.

APPENDIX B
EXECUTIVE SUMMARY ON THE CLOSURE OF TECHNICAL COOPERATION PROJECT
RLA/03/902 - SACCSA (AUGMENTATION SOLUTION FOR THE CARIBBEAN, CENTRAL
AND SOUTH AMERICA)

1. Background



Based on trials conducted in the CAR/SAM Regions with WAAS (Wide Area Augmentation System) and EGNOS (European Geostationary Navigation Overlay Service) augmentation systems, it was determined that the extension of these systems was not feasible due to the particular ionospheric behaviour experienced in these regions. Accordingly, it was suggested that an SBAS system called “*Augmentation solution for the Caribbean, Central and South America*” – SACCSA be developed, with algorithms adapted to the needs of the CAR/SAM Regions.

Through the ICAO Technical Cooperation Bureau, project RLA/03/902 was launched with the participation of some CAR/SAM member States and AENA (*Aeropuertos Españoles y Navegación Aérea*) (currently ENAIRE) as contributor and Technical Coordinator of the project. This project has been developed in three phases, through which its technical feasibility has been demonstrated.

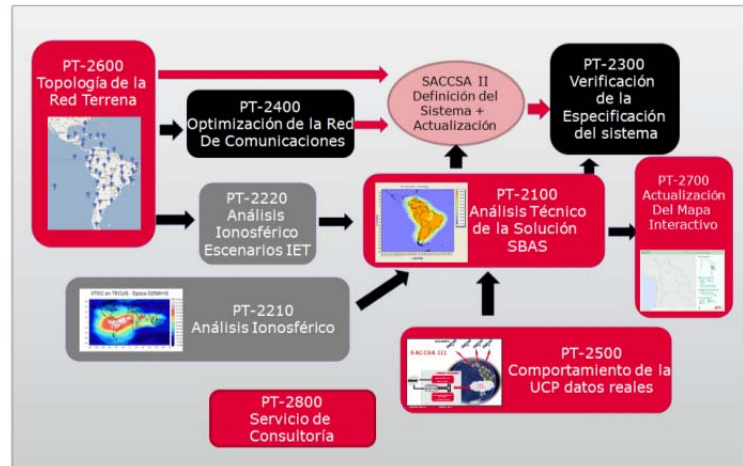
2. Purpose of the Project

The purpose of Project RLA/03/902 is to provide the technical, financial, operational and institutional studies related to the implementation of a satellite-based augmentation system (SBAS) for the CAR/SAM Regions.

To this end, several activities were proposed, as shown in the figure below.



These activities were carried out as work packages, as illustrated in the following figure.



3. SACCSA Participants

ICAO

ENAI (formerly AENA)

U.A.E. de Aeronáutica Civil Colombia

COCESNA

Autoridad Aeronáutica Civil de Panamá

Trinidad and Tobago Civil Aviation Authority

Instituto Nacional de Aeronáutica Civil de Venezuela

It should be noted that Argentina, Bolivia, Costa Rica, Cuba, and Guatemala participated during Phases I and II.

4. Project Development

a) PHASE I: EDISA

Project RLA/03/902 was initiated as a result of the launching of the EDISA Programme by the European Union, whose objective was to show the feasibility of implementing an SBAS system in the CAR/SAM Regions. To that end, three reference stations were installed in Bogota, Havana, and Tegucigalpa and an SBAS navigation message was generated based on the EGNOS test signal. At the same time, a series of flights were planned for receiving and analysing said signal, which were conducted at Bogota, Cartagena de Indias, Havana, San Andrés, and Tegucigalpa. The trials demonstrated that it was possible to have an SBAS system in the CAR/SAM Regions, but that it had to be independent and autonomous from other SBAS systems (EGNOS or WAAS), since the need for ionospheric models and specific algorithms made it unfeasible to extend the coverage of existing systems. Subsequently, the Federal Aviation Administration (FAA) endorsed this decision with respect to WAAS.

b) PHASE II

Based on these conclusions, the so-called PHASE II was launched, where the system to be defined received the name of SACCSA (Augmentation Solution for the Caribbean, Central and South America). Its purpose was to perform the necessary studies and developments to confirm the feasibility of implementing an SBAS system in the CAR/SAM Regions, and develop the necessary algorithms to resolve problems in the ionosphere and conduct in-depth studies thereof. Furthermore, the different elements of the system were defined and work was done on financial, cost-benefit and operational issues, based on the following work packages:

- PT 1000: Information on users and service providers.
- PT 2000: Analysis of SACCSA services.
- PT 3000: Study of an SBAS for the CAR/SAM Regions.
- PT 4000: Ionospheric analyses.
- PT 5000: SACCSA specifications.
- PT 7000: Management/Operation.
- PT 8000: Human resources and training.
- PT 9000: Economic and financial feasibility.
- PT 10000: Planning of project phases.

c) PHASE III

Based on the promising results of PHASE II, it was decided to launch PHASE III, in which the necessary adjustments and simulations would be carried out to define the system for its subsequent development and deployment, minimising risks and, thus, reducing development and implementation costs. Given the complexity of the tasks, a competitive international bidding process was established for this phase, in which the contract was awarded to a consortium led by GMV. This phase consisted of the following work packages:

- PT 1000: Monitoring network and control thereof.
- PT 2000: Completion of PHASE II studies.
- PT 3000: SACCSA UCP prototype.
- PT 4000: Definition of activities in support of system validation and certification.
- PT 5000: Analysis of other supplementary options.
- PT 6000: Website.

5. Project Management

The different phases have been financed through direct contributions by the States and in-kind contributions by States and enterprises.

Phase I was mainly funded by the European Union and the European Space Agency for a total of 178,052 USD, of which 35,000 USD were provided by Cuba, 35,000 USD by COCESNA, 35,000 USD by Colombia and 27,237 USD by AENA. This phase meant a total investment of 178,052 USD, to which we should add the in-kind contribution equivalent to 26,220 USD by AENA. The total for this phase was 207,272 USD.

PHASE II was financed by the participating States, at a rate of 25,000 USD by each State, and an extraordinary contribution by AENA for 464,760 USD. This Phase meant an investment of 589,760 USD. In this phase, AENA made an in-kind contribution for 306,498 USD, raising the total to 896,258 USD.

In Phase III, a contribution of 75,000 USD was set for each participating State, in addition to an additional fee of US\$ 27,500, agreed at the eighth coordination meeting of the project (RCC8). AENA made an extraordinary contribution of 841,216 USD. In-kind contributions to date reach 163,444 USD from AENA and 310,000 USD from GMV. Accordingly, contributions for this phase total 1,687,955 USD so far.

The following table summarises monetary and in-kind contributions and executed funds:

FASE	I-EDISA	FASE II	FASE III	TOTAL
Aportación cada Estado participantes	\$ 35,000.00	\$ 25,000.00	\$ 102,500.00	\$ 162,500.00
Aportación AENA	\$ 27,237.00	\$ 464,760.00	\$ 841,216.00	\$ 1,333,213.00
Total dinerario aportado al proyecto hasta la fecha				\$ 2,265,974.00
Aportación en especie AENA	\$ 26,220.00	\$ 306,498.00	\$ 163,444.00	\$ 496,162.00
Aportación en especie GMV			\$ 310,000.00	\$ 310,000.00
Total aportado en especie				\$ 806,162.00
Total dineraria ejecutado hasta la fecha				\$ 2,116,336.00
Total dineraria + especie ejecutado hasta la fecha				\$ 2,922,498.00

6. Study of an SBAS solution for the CAR/SAM Regions

a) *Description and results of work packages*

In general, work packages were hired to establish the technical feasibility and operational benefits of an SBAS systems for the CAR/SAM Regions, including an analysis of SACCSA services, a study of an SBAS system for the CAR/SAM Regions, system design and architecture, ionospheric analyses, SACCSA specifications, management/operation, monitoring network and control thereof, SACCSA UCP prototype, definition of activities in support of system validation and certification, analysis of areas with poor service.

The services provided by the system prototype in the CAR/SAM Regions showed that APV-I procedures could be achieved, even after analysing scenarios degraded by solar disturbances. This was demonstrated by GMV from October 2012 in San Carlos de Bariloche, Argentina, to 12 February 2015, during the Workshop held at the premises of the “*Centro de Estudios Aeronauticos de la Aeronautica Civil*” in Bogota, Colombia.

The States that have participated in the three phases have contributed a total of US\$ 162,500, totalling \$2,922,498.00 in both money and in kind. This represents a ratio of 1:18 between payments made by the State to the project and total money and in-kind contributions executed to date by the project.

b) *Project assessment and comments by Project members*

- At the project closing meeting, Colombia, Panama, Spain, Trinidad and Tobago, and COCESNA made an assessment of the project, completing a survey on management indicators and project results.
- Based on the assessment of the Project, the States felt that Project objectives had been met in all cases, highlighting the following:

— B5 —

- ✓ The main achievement of the project was the confirmation that an SBAS system for the CAR/SAM Regions was feasible.
 - ✓ It was felt that more CAR/SAM States should have participated in order to complete all work packages.
 - ✓ The proposal was made to continue conducting the testbed, the financial feasibility study and the cost-benefit analysis.
 - ✓ The results should be protected under intellectual property of the States and should not be used for commercial purposes and/or other developments by the contractor.
 - ✓ The significant contributions (both monetary and in-kind) made by AENA and Project members States were highlighted and acknowledged.
- It was also noted that the participants (financial institutions) should be aware of the terms of reference, contracts and all relevant information on the hiring of firms for the execution of this type of projects.
 - Finally, mention was made of the need to disseminate the results of the project and to invite other countries of the Region to participate so as to strengthen the SBAS.

c) Final considerations

- Definitive closure of Project RLA/03/902 GNSS/SBAS – SACCSA
- Technological (hardware and software) evolution not related to ionospheric correction in the existing SBAS/WAAS and EGNOS systems, leading to the implementation of an operational SBAS in the Region or in the States that may deem it advisable.
- Based on this study, each State or group of States could consider the implementation of an SBAS system for the Region, after completing certain tasks required for validating and confirming its feasibility, namely:
 - ✓ Testbed
 - ✓ Cost-benefit analysis
 - ✓ Financial feasibility study
- Take into account the recommendation of the multiconstellation (GPS+GLONASS) and multifrequency (dual frequency) to minimise the impact of solar activity on the ionosphere and on SBAS signals, through the implementation of the aforementioned project, as proposed by GMV.
- Consider the possibility that ICAO through its technical cooperation projects undertake future action and activities for the implementation of an SBAS for the Region or for the States that deem it advisable.

— END —