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 4: Tentative programme of Project activities for the 2013-2014 period

THE MULTIMODAL APPROACH - DEMONSTRATION

(Presented by the Secretariat)

SUMMARY

This working paper summarises the multiple benefits that States could derive from the use of SACCSA technology outside the aeronautical sector.

ICAO Strategic Objectives	*This working paper is related to Strategic Objectives:* *A. Safety* *C. Environmental protection and sustainable use of air transport*

1. Introduction

1.1 This working paper summarises the benefits that States could derive from the use of SACCSA technology outside the aeronautical sector.

1.2 This paper is divided into the following sections:

- A first section presents the problems in the CAR/SAM Regions
- The next section summarises multimodal approaches
- A final section presents the proposed solution within the SACCSA context.

2. Problems in the CAR/SAM Regions

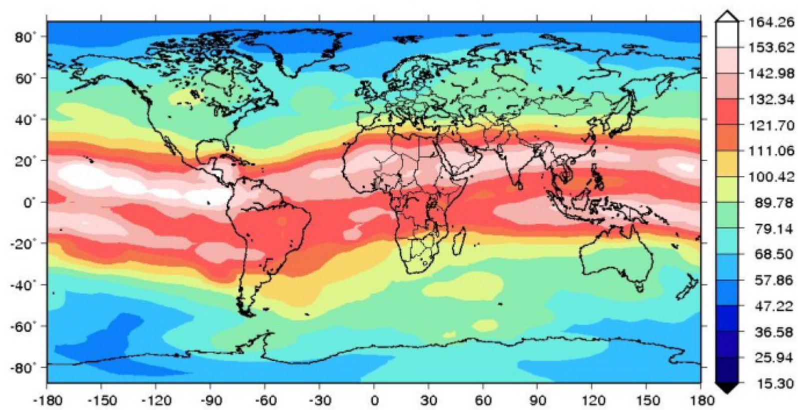
2.1 GNSS systems are affected, to a greater or lesser extent, by the presence of different types of disturbances, those caused by the **ionosphere** being the most complicated and severe. Currently, there are several operational solutions, but they are only valid for medium latitudes, and their use is not advisable for equatorial regions. Specific ionosphere algorithms/models have been developed for equatorial regions, customising them to their particular ionosphere characteristics, as is the case of SACCSA in the CAR/SAM Regions.

2.2 SBAS systems are **especially vulnerable to the effects of the equatorial ionosphere**, since they were initially developed for medium latitudes. The following figure, obtained within the framework of the SACCSA project, shows the maximum ionosphere value (in TEC units, TECUs) for the previous solar cycle (considering 3 days per month for 12 years). This figure clearly shows the problem of the ionosphere throughout the world. As a general rule, and from a qualitative point of view:

- Regions in red are equatorial ionosphere regions (with respect to the geomagnetic equator). In these regions, SBAS systems designed and developed for medium latitudes will have serious limitations. It is essential to adapt them to the equatorial ionosphere, and their technical feasibility may depend on that.

- Regions in orange and yellow, depending on their design, might have problems during periods of high solar activity.

- Regions in green and blue are those where GNSS limitations due to the ionosphere are not expected (except ionosphere storms and specific effects in polar areas).

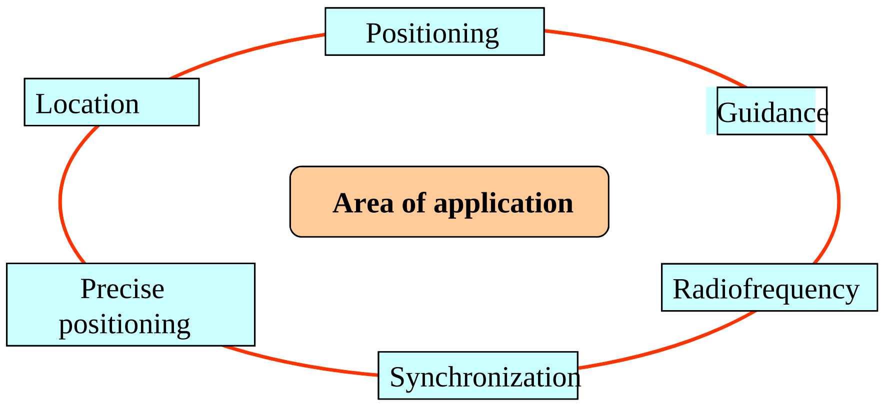


Maximum ionosphere values (in TECUs) for the previous solar cycle (analysis conducted 3 days per month for 12 years).

2.3 As may be noted, a significant portion of the CAR/SAM Regions is located in the equatorial region and, therefore, ionosphere issues related to SBAS must be addressed with caution and rigour. In these equatorial regions, like the CAR/SAM Regions, any receiver (GPS-GNSS) will be affected by the ionosphere, and subject to a significant degradation in precision--up to 30m--in high solar activity periods. Augmentation solutions, such as SACCSA, reduce this error to less than 1m, providing significant benefits to many non-aeronautical sectors.

3. Multimodal approaches

3.1 There are many areas of application for augmentation systems, which can be summarised in any application related to positioning, guidance, location, radio frequency, synchronization, as shown in the following figure:



3.2 The main applications are listed below, detailing some of them by way of illustration.

- **Applications in transportation:**
  - Aeronautical:
    - En-route, terminal, and approach operations
    - Training
    - In-flight and airport surveillance
    - Alert, search and rescue
  - Maritime:
    - Off-shore and coastal navigation, and docking
    - Cargo management (containers)
    - Fishing
    - Alert, search and rescue
    - Traffic and fleet control
    - Manoeuvring in ports and narrow canals
    - River navigation
    - Discharge control
    - Electronic charts
    - Hazard location (banks, etc.)
    - Automation of guidance and collision alerts
  - Ground:
    - Integrated information systems
    - Fleet management systems
    - Public transportation systems
    - Railroad applications, in which navigation systems are already being introduced for various applications:
      - Emergency management and communication
      - Signalling and position control
      - Integrity
      - Information to passengers
      - Train management
      - Cargo tracking
      - Track maps
      - Wagon assignment and location
      - A.V. train control

- **Other applications:**

- Agriculture:
  - Precision farming:
    - Automatic harvesting
    - Production levels
    - Surface control
    - Fumigation
    - Fertilization
  - Surveying
  - Land registry
- Cattle raising:
  - Herd control
  - Product traceability
- Mining
- Oil applications:
  - Platform control and position
  - Oil pipe control
  - Truck fleet control
  - Tanker truck position control
  - Helicopter guidance
  - Production tracking
  - Location of elements and components
- Power:
  - Infrastructure deployment/ maintenance
  - Synchronization of electric power networks
  - Structure monitoring
  - Production control
- Geographic information systems
- Infrastructure and construction
- Public works:
  - Structure monitoring
  - Measuring and marking of points
  - Machinery location and management
  - Heavy machinery guidance
  - Positioning and map
  - Road and bridge maintenance
  - Topography
- Architecture
- Synchronization
  - Time bases
  - Bank networks
  - Security systems
  - Communication networks
- Sports
- Public services (police, fire department, civil protection, meteorology, health, etc.)
- Social affairs / security:
  - Guidance for the blind
  - People tracking
  - Restraining orders, prisoner control
  - Personal / school transportation security
  - Security forces

- Rescue and emergencies
  - Layout of canine search areas
  - Guidance for emergency services
  - Rescue resource optimization
  - Reduced operation time
  - Quick location of the emergency site
  - Emergency control systems
- Science:
  - Ocean and wave height
  - Tracking of fauna
  - Seismic studies and volcanoes
  - Atmospheric studies
  - Altitude determination
  - Earth crust movements
- Leisure:
  - Trekking
  - Golf
  - Entertainment
  - Tourist information
  - Photography
  - Games

4. Proposed solution in SACCSA

4.1 Since global GNSS systems (GPS, GLONASS) do not offer the necessary services for many of the aforementioned applications/sectors (and their evolution is too slow and expensive and lacking integrity), augmentation is needed to meet the needs of these sectors. Augmentation permits the following:

- Bring user needs closer to what GNSS provides
- More dynamic and less expensive evolution
- Adapt better to user needs and their evolution

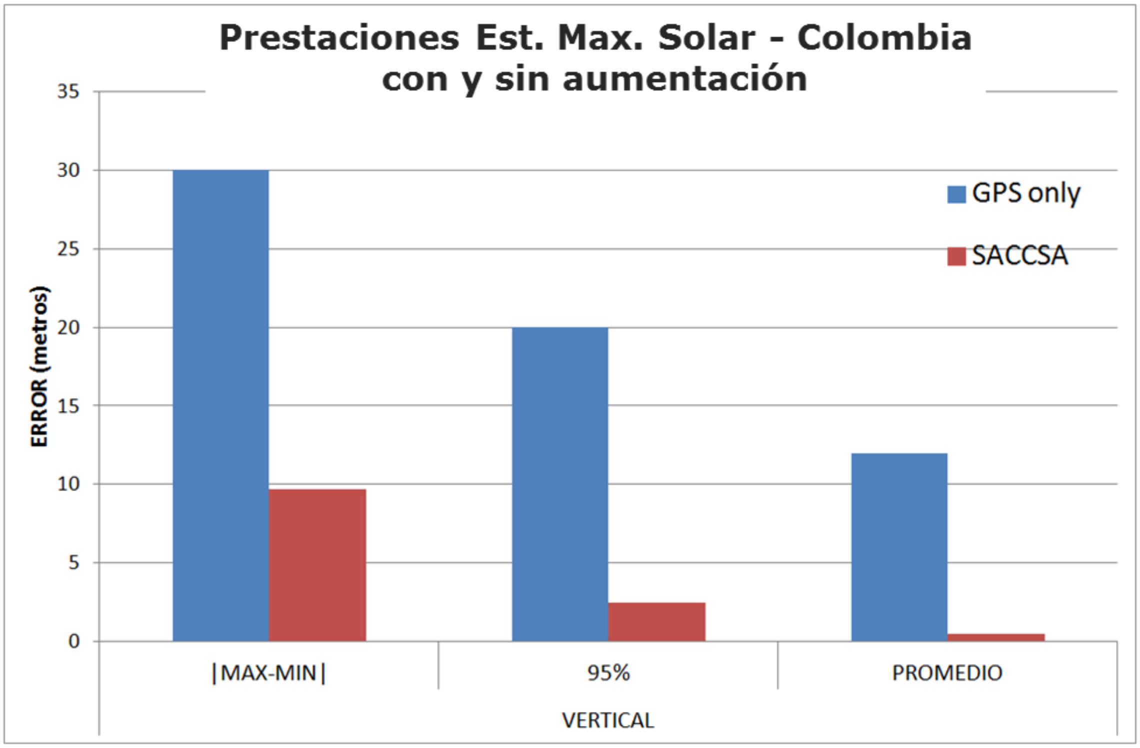
4.2 Augmentations can:

- Be local or regional
- Have different precision levels: Metric, sub-metric, centimetric
- Adapt to different types of receivers (cost): code and phase, noise of measures, multi-constellation.
- Be of different types: satellite, Internet, radio, etc.

4.3 As previously stated, the implementation of an augmentation system that significantly reduces cost (at a cost-benefit analysis level), improves precision and increases security (due to integrity provided), will permit the proliferation of new applications and services in line with those listed in the previous section and limited only by our imagination, thus contributing significantly to the development of the region.

4.4 At present, most receivers are single-frequency (aviation and mass-market). Receivers used in high-precision applications are very expensive and dual-frequency. As previously stated, the performance of single-frequency receivers in the CAR/SAM Regions is seriously degraded by solar activity. With the SACCSA solution, this can improve significantly, with no need for extremely expensive receivers, thus significantly reducing operational costs for users and end applications.

4.5 As an example, the following figure shows the precision expected under maximum solar activity conditions, with and without the SACCSA system, in this case applied to a station in Colombia:



4.6 There are many benefits to be derived in multimodal applications where their use would provide substantial improvements. From the technical and operational viewpoint, there are two key factors on which most benefits of multimodal SACCSA applications are based:

- **Enhanced precision**: in equatorial regions, the error can go from 30m in high solar activity to a metric or even sub-metric solution.
- **Reliability/integrity**: in addition to improving precision, the SACCSA solution can provide integrity and/or reliability parameters that provide service assurance, which is essential for many applications.

4.7 Improved precision (no need to invest in expensive receivers at the level of the application) and service assurance result in cost reduction and increased security, allowing for the proliferation of new services and applications, driving the development of the States that adopt the SACCSA solution.

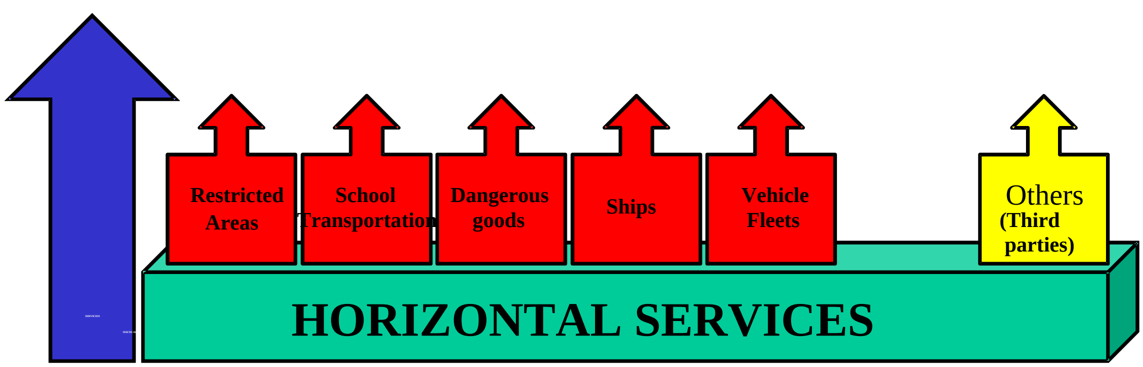
4.8 SACCSA proposes a basic solution for use in the aforementioned applications.

4.9 There are several management models that could be considered in SACCSA for the provision of services and applications. Services are identified as horizontal and vertical.

- **Horizontal services,** that provide right of access and use of the mobile and fixed infrastructure needed for:
  - Determining the position/velocity of mobile agents in TR:
    - Latency
    - Frequency (time, distance)
    - Events (warnings/alarms)
    - Auxiliary mobile agent data
  - Determining the past position/velocity of mobile agents
    - Frequency (time, distance)
    - Events
    - Auxiliary mobile agent data
  - Determining the position in geographic terms
  - Accessing mapping GIS
    - Scope
    - Content
    - Scale

- **Vertical services,** supported on horizontal services, specifically designed for each type of user. They can be provided by the horizontal service provider or by third parties. They are applicable to mobile and fixed users. According to the type of user:
  - They can have different levels of security and confidentiality
  - They can be of an open or integrated type

  Furthermore:
  - They can be provided by private or public entities (regardless if the latter hire it from a private entity)
  - These services are provided by contract, renewable for defined periods.



5. Conclusions

5.1 The use of SBAS technology provides many benefits, not only in civil aviation but also in other sectors. Benefits in the multimodal (not aeronautical) sector are based mainly on two factors: improved precision as compared to GPS alone, and the introduction of integrity or reliability. These benefits are especially appealing in equatorial regions, since errors with a GPS solution, without augmentation, can reach 30m in maximum solar activity. The SACCSA solution would permit horizontal precisions of about 1m, without the need for professional geodetic receivers (which are expensive), thus significantly reducing the implementation and operation costs of multimodal applications. Likewise, SACCSA would provide benefits in terms of integrity (or reliability) without any additional cost to the user, thus providing service and security assurance, which is essential for many important sectors in the CAR/SAM States.

6. Suggested action

6.1 States are invited to:

a) take note of the information provided in this working paper; and

b) identify and analyse the multimodal applications and uses that could benefit from SACCSA in their State.

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