

**INTERNATIONAL CIVIL AVIATION ORGANIZATION**

**Seventh Meeting of Civil Aviation Authorities of the SAM Region (RAAC/7)**

(Salvador, Bahia, Brazil, 1-3 July 2002)

**Agenda Item 4: Transition to the CNS/ATM systems**

**d) GNSS augmentation trials in the CAR/SAM Region (CSTB)**

(presented by the Secretariat)

**Summary**

This working paper describes the architecture of the trial platform of the regional GNSS augmentation project, together with the objectives, current status and future of said trial.

**References:**

- RLA/00/009 Project document;
- Report of the Coordination Meeting on the GNSS augmentation trials of the RLA/00/009 Project (Santiago, Chile, 1-3 August 2001); and
- Sixth Meeting of Civil Aviation Authorities of the South American Region (Panama, 18-20 August 1999).

**1. Introduction**

1.1. In keeping with the ICAO policy, transition to the use of satellite technology in air navigation is a matter of high priority for the States/International Organisations of the CAR/SAM Regions. Logically, the first step in this transition is the establishment of a CAR/SAM regional trial platform to facilitate efforts to investigate, develop and implement an operational air navigation system.

1.2. Among the regional CNS/ATM activities mentioned at the Sixth Meeting of Civil Aviation Authorities of the SAM Region (RAAC/6, Panama, 18–20 August 1999) were the future trials of the satellite-based augmentation systems (SBAS) to be conducted in the CAR/SAM Regions. On that occasion, information was provided on the offers of the European Tripartite Group (ETG) and the United States Federal Aviation Administration, to conduct tests of the EGNOS and WAAS systems, and their possible implementation through common agreement among the CAR/SAM States, thus contributing to the establishment of an operational SBAS model. It was also noted that the trials would be carried out through Technical Cooperation Projects, starting with the implementation of a WAAS-type SBAS system. The FAA would contribute with the loaning, installation, training on and operation of the necessary equipment.

1.3. The aforementioned project is currently being implemented under the title “*Regional GNSS augmentation trials (CSTB)*” (RLA/00/009 Project). Its main objective is to develop a plan for testing and assessment of the technical and operational benefits of the GNSS augmentation system in the CAR/SAM Regions, so that it may contribute to the establishment of the operational model of GNSS augmentation systems being developed by the GREPECAS ATM/CNS Subgroup. This UNDP-ICAO technical cooperation project was launched with the signing of Memorandum of Understanding Nat-I-9015 between the FAA and ICAO (4 June 2001). Its participants are States and Organisations in the CAR/SAM Regions (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Panama, Peru, Venezuela and COCESNA). The duration of the project is three years as of the aforementioned signing date.

## 2. **Regional GNSS augmentation trial, RLA/00/009 Project**

### **Trial platform**

2.1. The trial platform is made up of a ground segment and an air segment. The ground segment consists of reference stations, master stations, a satellite link station and a ground communications network for communications between reference stations and master stations, as well as between master stations and the satellite link station. The air segment consists of the avionics that will be used for the in-flight verification of the trials.

### **Ground segment**

#### **Trial reference stations (TRS)**

2.2. The system consists of 13 TRS stations installed in the following States: one in Argentina, one in Bolivia, five in Brazil, three in Chile, one in Colombia, one in Peru and one in Honduras.

2.3. Each TRS is made up of a GPS receiver, a rubidium oscillator, a processing station and a communication router. The basic function of these stations is to determine any possible errors in the GPS signal (orbit, time, ionosphere).

#### **Trial master stations (TMS)**

2.4. The trial platform also consists of two TMS stations, one in Santiago, Chile and the other in Rio de Janeiro, to which the reference stations are interlinked. The TRSs in Argentina, Peru and Bolivia are interconnected with the master station in Chile, while those located in Colombia and Honduras will be interconnected with the master station in Brazil.

2.5. The TMSs are made up basically of a processor, a server for disseminating the augmentation information, a recording device and a communication router. The basic function of the master station is to receive the signal with errors from reference stations, process it and make the corrections for the specific geographic area, as well as to determine the integrity in the use of signals from the GPS satellite constellation.

### **Satellite link station**

2.6. The system will have a single Satellite Link station that will be located in Brazil. The satellite link station will receive the information processed by the TMS containing the corrected information for the GPS signal and will broadcast it over the same GPS frequency (L1), using the INMARSAT III geostationary satellite.

### **Ground communication network**

2.7. The ground communication network is the network required for communications between the TRSs and the TMSs, as well as between the TMSs and the satellite link station. The links between the TRSs and the TMSs are established through 19.2 kbps circuits. Circuits with a 9600 bits/sec capacity will be required between the TMSs and the satellite link station.

### **Air segment**

2.8. For in-flight trials, aircraft equipped with a GPS antenna capable of introducing to three subsystems, namely the user platform (CUP), the true reference station (CTR) and the navigation data acquisition platform (NAVDAC), will be used. The Aeronautical Authorities of Brazil, Chile and Colombia will supply the project with aircraft equipped with the necessary avionics to conduct the in-flight trials foreseen in the project.

2.9. The CUP consists of a GPS/WAAS receiver, a processor and a storage device. The CTR has two differential GPSs, one in the aircraft and the other on the ground, and the NAVDAC is made up of a processor and a storage unit.

2.10. It is through this segment that the augmented GPS signals and their effectiveness in the different navigation phases (initially en-route and non-precision approach) will be tested.

## **3. Main objectives of the GNSS regional augmentation trial**

3.1. The main objectives of the trial are the following:

- a) To acquire and store GPS signal data through the reference stations and the equipment used for in-flight trials, in order to analyse its behaviour in the ionosphere in the CAR/SAM Regions under study.
- b) To try out the precision of the system in operation, based on a previously designed service volume model, initially for en-route and non-precision approach applications, above all in the CAR/SAM Regions, using for this purpose:
  - long-term data acquisition and storage at all reference stations;
  - non-precision approaches at selected airports;
  - terminal area manoeuvres at selected airports and SID and STAR procedures;
  - en-route over land areas; and
  - en-route over oceanic areas.

- c) To conduct a training programme to become familiar with the operation of the different elements that comprise the system and the corresponding procedures to be used, in order to be able to understand the new satellite-based navigation systems.
- d) To foster international cooperation and contribute to the safety of the global transportation system through the sharing of information, technology, technical assistance and training among the countries.
- e) To encourage future trials with other satellite-based augmentation systems.

#### 4. **Current project phase**

4.1 The current status of the Project in each of the States involved is as follows:

##### **Argentina**

4.2 The TRS is installed and operational since December 2001 and the communication with the Master Station in Chile was completed in March 2002. At present, they are waiting for the in-flight trials for the acquisition and storage of GPS data, using, to that end, the in-flight inspection aircraft of Chile. They were expected to start on 13 May 2002.

##### **Bolivia**

4.3 Since the equipment for the reference station was sent to Bolivia in two parts and the last part was shipped in mid-April 2002, the TRS is expected to be installed and in operation by the end of the first week of May, including the establishment of the communication line between that TRS and the Santiago TMS. The in-flight trials using the inspection aircraft of Chile are scheduled to start on 16 May 2002.

##### **Brazil**

4.4 The five TRS stations, as well as the TMS station foreseen for Brazil are installed and operational since September 2001. Likewise, all of the communication links between the reference stations and the master station have been implemented. In-flight trials were conducted in January 2002 with the collaboration of FAA technical personnel for the purpose of collecting GPS data in order to analyse the behaviour of said data in the ionosphere. In March 2002, a seminar on the ionosphere was conducted, at which the results of the trial were presented.

4.5 In order to complete the regional trial platform, the communication circuits between the Rio de Janeiro master station and the reference stations in Colombia and Honduras still need to be implemented. These circuits will be implemented through the installation of VSAT stations by the Aeronautical Authority of Colombia. It is expected to be operational by mid-June 2002. Also lacking is the implementation of the communication circuit between the master station in Chile and that in Rio de Janeiro, which is scheduled to be ready by November 2002. The connection will be established through the REDDIG South American digital network.

4.6 Likewise, the satellite ground station is expected to enter into operation and the geostationary satellite for disseminating the GPS signal augmentation to be available by July of this year.

### **Chile**

4.7 The reference stations in Chile, as well as its master station, are installed and operational since 1998. As for the topology of the regional trial platform, the communication circuit between the La Paz reference station and the master station in Chile is still lacking, as is the connection between the Santiago master station and that of Rio. The implementation date for these circuits is described in sections on Bolivia and Brazil in this working paper.

4.6 The in-flight inspection aircraft of Chile will conduct in-flight trials between 13 and 24 May to collect GPS data for en-route segments and non-precision approaches in Argentina, Bolivia, Chile y Peru.

### **Colombia**

4.7 It is expected that its reference station will be installed and operational by the end of May 2002 and the communication circuit between the reference station and the master station in Brazil will be implemented by the end of that June, using, for that purpose, the implementation of a VSAT station belonging to the satellite communication network of Colombia. In order to be able to analyse the data stored in the in-flight trials and from the reference stations, Colombia is proceeding to install application software for processing and presenting the results of the trials. This software is being installed thanks to the collaboration of the FAA. This same software has already been installed in Rio de Janeiro and will also be in Peru. Thanks to the collaboration of the aeronautical authorities of Brazil, Colombia and Peru, all of the data collected from all of the Project reference stations will be analysed, together with the data obtained from in-flight trials, in order to determine the precision of the system in relation to the operational procedures contemplated by the project. Furthermore, Colombia is in the process of equipping its in-flight inspection aircraft with the necessary avionics to support the in-flight trials foreseen in the project, together with the aircraft belonging to Chile and Brazil.

### **Honduras**

4.8 Honduras plans to install its reference station at the end of May 2002. This delay is due, as in the cases of Bolivia and Colombia, to the fact that the delivery of the equipment for the reference station was made by the FAA in two parts and on different dates, the last delivery was done in mid-April 2002. The physical connection between the reference station of Honduras and the master station of Brazil will be done through the implementation of VSAT stations from the satellite communication network of Colombia.

### **Panama**

4.9 The reference station is installed and operational, and is connected to the FAA master station in Atlantic City, making it part of the United States satellite-augmentation trial platform (NTSB). The information from the Panama reference station will also be interconnected with the Rio master station once the circuit between Rio de Janeiro and Atlantic City has been implemented.

### **Peru**

4.10 The reference station of Peru is installed and operational since December 2001, as is the communication circuit between the Lima reference station and the Santiago master station.

## 5. **Broadening the scope of GNSS augmentation trials in the CAR/SAM Regions**

5.1 The GNSS augmentation trials provided for in the Project are intended mainly for en-route operations and non-precision approaches. In its first implementation phase, the Project includes the collection and analysis of data as well as the performance of in-flight trials in Argentina, Bolivia, Chile and Peru, in order to validate the integrity, precision, continuity, availability and coverage of the aforementioned operations.

5.2 Once the reference stations of Colombia and COCESNA have been installed and are operational, all of the remaining communication circuits are established and the augmentation is disseminated through the geostationary satellite, the final phase of the Project will be launched. This will consist of the collection and analysis of data, as well as in-flight trials over all of the CAR/SAM Regions in order to validate the integrity, precision, continuity, availability and coverage for en-route operations and non-precision approaches. These final trials are expected to begin in late 2002 and run until 2004.

5.3 Once the trial has been completed, a detailed analysis will be available on the use of satellite-based augmentation systems for en-route operations and non-precision approaches (NPA) in the CAR/SAM Regions.

5.4 Many of the States participating in the Project have expressed interest in having it cover other operational phases that have not been considered, such as en-route navigation with a minimum vertical separation of 1000 feet and approaches that require some vertical precision, like vertical guidance approaches.

5.5 The operations cited above require some degree of vertical precision not needed for en-route navigation and NPA. In order to conduct SBAS trials requiring vertical precision in the CAR/SAM Regions, including the equatorial band between  $\pm 20^\circ$ , a study would have to be made of an ionospheric model over the entire Region.

5.6 Using this ionospheric model, the possible degree of air operation could be verified, and the appropriate corrections of the GPS signals affected by this phenomenon in these operations could be established. Some CAR/SAM States have been investigating the existence of national scientific institutions charged with studying the ionosphere and how it affects radiofrequency signals in order to obtain guidance in putting together a model of the ionosphere that would help in planning national air navigation.

5.7 In order not to duplicate efforts and to be able to work uniformly, ICAO and the States of the Region are studying the possibility of starting the necessary studies of requirements for testing air operations that require vertical precision.

## 6. **Suggested action**

6.1 The meeting is invited to take note of the information contained in this working paper.