

ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September – 3 October 2003

Agenda Item 6: Aeronautical navigation issues

PROPOSALS FOR THE FUTURE DEVELOPMENT OF GNSS NAVIGATION SYSTEMS

(presented by *¿?*, Colombia)

SUMMARY

This paper describes the current status and the progress made in the CAR/SAM Regions regarding the conduction of trials and the development of implementation plans for the GNSS navigation system, highlighting the facts and aspects of this regional process that require the attention, co-operation and participation of the States and the Regions. Also, paragraph 11 describes the action suggested to the Conference in order to provide better guidance on the planning, implementation and development of the GNSS and its augmentation systems.

1. INTRODUCTION

1.1 CAR/SAM States, as well as other Regions of the world, have been participating actively in research, development, analysis and study tasks aimed at the implementation and use of GNSS systems in our airspaces. These tasks have been based on the guidance provided by the Third CAR/SAM Regional Air Navigation Meeting (CAR/SAM/3 RAN), held in Buenos Aires, Argentina, on 5-15 October 1999, and on the conclusions of the CAR/SAM Regional Planning and Implementation Group (GREPECAS), in keeping with the Global Air Navigation Plan for CNS/ATM Systems, and taking into account ICAO standards and available guidelines.

1.2 The aforementioned tasks have been characterised by the introduction of GNSS GBAS and SBAS implementation requirements in Table CNS 3 – *Radio Navigation Aids Table* of the CAR/SAM ANP FASID; the issuance by the States of the corresponding legislation/regulations authorising the use of the GNSS in their respective airspaces; the use of available GNSS signals for area navigation and other applications; and the conduction of demonstrations and trials related to GNSS augmentation systems.

2. GNSS TRIALS IN THE CAR/SAM REGIONS

2.1 Pursuant to conclusions 8/36, 11/45 and 11/46 of GREPECAS, two SBAS-type GNSS augmentation trial projects are being carried out in the CAR/SAM Regions: one on WAAS-type SBAS augmentation trials, and the other on EGNOS-type SBAS augmentation trials.

GNSS SBAS-WAAS trials in the CAR/SAM Regions

2.2 WAAS-type SBAS trials in the CAR/SAM Regions, denominated CSTB (CAR/SAM Test Bed), are being conducted under an ICAO-UNDP regional technical co-operation project for Latin America and the Caribbean (RLA/00/009). This project is being executed thanks to the co-operation of the United States government, through the FAA, with the participation and co-operation of the following States and Organisations: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Panama, United States, Venezuela and COCESNA. ICAO signed a memorandum of understanding with the FAA to borrow the equipment required for the trials, and to obtain the support necessary for training and trial analyses.

2.3 The CSTB trial platform consists of 13 reference stations, two master stations, and one ground station for linkage to the geostationary satellite. This platform has been fully installed, and only the earth station for the satellite link is pending. Since the beginning of the project (June 2001), important trials have been conducted that have led to significant results for the CAR/SAM Regions, which will contribute to the implementation of a regional SBAS augmentation system to support some air navigation phases (en-route and NPA). Furthermore, personnel from the aeronautical administrations involved in the project have received training on installation of reference stations, data processing, SBAS performance analysis, and management of data processing tools (FAA GPSsolution), since this is a new technology. The project is expected to be completed by mid 2004.

GNSS SBAS-EGNOS trials in the CAR/SAM Regions

2.4 The second SBAS augmentation trial project is related to the EGNOS, using the EDISA platform. It is being executed thanks to the co-operation of the European Community, through ESA, and of the participating States/International Organisations. EGNOS-type SBAS trials, denominated EDISA, are also being carried out through an ICAO/UNDP regional technical co-operation project for Latin America and the Caribbean (Project RLA/02/903), with the participation of the following States and International Organisations: Colombia, Cuba, Spain, COCESNA and the European Community. Phase I of this project envisages the implementation of the EDISA platform, which consists of three reference stations (RIMS), as well as VSAT communication stations installed next to each RIM. The information collected by the RIMS is sent to a master station in Europe for processing and issuance of the augmentation signal through the INMARSAT AOR-E geostationary satellite. This signal can be used by duly-equipped aircraft. The project started in early 2003; the trial platform has been fully installed and flight tests for en-route, NPA and APV1 functions have been carried out in the States involved. Personnel from these States has received training on data processing and analytical tools (Pegasus plus of EUROCONTROL), and to raise an awareness among States as to the benefits of satellite navigation, the future of GNSS, and, especially, the European strategy in the GNSS field. The analysis of the data collected during Phase 1 trials is expected to be completed by November 2003, when this phase will come to an end.

2.5 This project also contemplates a second phase, which is expected to start once the first phase has been completed. It includes personnel training activities, trials with an architecture different to the one used in Phase I, collection and analysis of GNSS data, use of the Pegasus Plus tool, studies to be submitted to the GREPECAS ATM/CNS Subgroup, and other activities which will be very useful to all States for building GNSS technical capability and human resources in the CAR/SAM Regions.

3. CURRENT INFRASTRUCTURE IN THE CAR/SAM REGIONS FOR GNSS IMPLEMENTATION

3.1 A detailed knowledge of satellite navigation capabilities and systems available in CAR/SAM States will be used to make a diagnosis of these Regions *vis-a-vis* the implementation and knowledge of these technologies, and to develop a strategic plan for making good use of them when reviewing the regional GNSS plan.

3.2 To this end, as mentioned in the previous paragraphs, two trial platforms are currently available for conducting verification tests and trials of the SBAS augmentation systems. But only Brazil, Chile and Colombia have their own airborne equipment for collecting GNSS SIS flight data for conducting flight tests in the CAR/SAM Regions; other States/Organisations have used borrowed equipment. Likewise, as a result of co-operation projects on GNSS augmentation, the CAR/SAM Regions have software tools for data processing and analysis: the FAA GPSsolution and Pegasus plus of EUROCONTROL.

3.3 The results of SBAS tests conducted in the CAR/SAM States will be taken into account and will be part of the inventory of GNSS capabilities and tasks in these Regions.

3.4 The databases with historical information on the behaviour of GNSS signals, obtained both in flight and on the ground, will be integrated and included in the study and diagnosis of the GNSS status in the CAR/SAM Regions.

3.5 GREPECAS, through the CNS Committee of the ATM/CNS Subgroup, will review all the elements mentioned in the preceding paragraphs in order to update and improve the CAR/SAM GNSS navaid plan.

4. ANALYSIS AND DEFINITION OF THE GNSS ARCHITECTURE FOR THE CAR/SAM REGIONS

4.1 Based on the results of the trials of the two aforementioned test platforms and of the studies carried out by both projects, GREPECAS will have an idea of the level of service of the individual and joint operation of the systems in the CAR/SAM Regions. It will also be able to analyse and recommend to the CAR/SAM States the SBAS system concept and composition to support flight operations, as well as the back-up system for this service.

4.2 States that have not done so yet would be urged to equip their aircraft with in-flight GNSS data collection capabilities and, together with those that already have such capabilities, to collect data during traditional routine flights, and during radio aid or aircraft movement inspection flights. This, combined with the establishment of simple earth stations, consisting of GNSS receivers and data storage units, and existing GNSS SIS analysis software tools, would constitute a very cost-effective way of having a sound regional database that would enable a more precise appraisal of the GNSS in the Regions (WAAS, CSTB, EGNOS, stand alone GPS, GALILEO, etc.), in keeping with ICAO SARPs and guidelines.

4.3 Likewise, the Caribbean and South American Regions are planning to get seriously involved in GNSS interoperability issues by participating as members in the corresponding panels (IWG among others). In working for the development and testing of a future SBAS augmentation system, the Regions are obliged to be informed on the subject and to develop strategies and approaches that will contribute to the achievement of this particular objective.

5. CAR/SAM REQUIREMENTS FOR GNSS IMPLEMENTATION

5.1 The availability of geostationary satellites to correct the signals from the satellite constellation in the CAR/SAM Regions is a latent need since the existing geostationary satellites that cover these regions would not be sufficient to transmit the correction signals over such a broad area as the Caribbean and South America, in addition to the initial target areas of the systems currently providing coverage, *i.e.*, WAAS and EGNOS.

5.2 It should also be noted that communication systems such as the MEVA and REDDIG digital networks support the communication requirements of a future SBAS system. However, if we take into account the compliance of GNSS SIS availability as specified in the SARPs and the number of stations required for an operational SBAS architecture in the CAR/SAM Regions, VSAT channels and stations currently envisaged would not meet the corresponding requirements.

5.3 The CAR/SAM Regions have mainly conducted SBAS trials, but lack experience working with GNSS ABAS augmentation and ground augmentation (GBAS and GRAS).

5.4 Systems like the GRAS also merit the attention of the Regions, which should consider conducting the corresponding GRAS tests and trials in the most appropriate airspaces, with a view to an enriched analysis of the implementation and adoption of the aforementioned system once it has been included in the ICAO SARPs.

5.5 Lack of personnel duly trained in the verification of signals in the GNSS SIS space, on the basis of SARPs values, which, in turn, are based on air safety considerations, is a factor that should be taken into account in order to properly conduct a GNSS performance analysis and research.

5.6 Lack of personnel highly trained in satellite navigation issues in the aeronautical entities points to the need to train experts to the same or higher level of expertise than they currently have with respect to conventional systems, so that they may duly implement the GNSS, in keeping with the SARPs, as established by ICAO safety guidelines. Similarly, operational personnel with training in the design of GNSS procedures is scarce.

5.7 Likewise, adequate on-board and ground equipment for GNSS verification is lacking, together with SBAS service volume simulation tools. Consequently, this is another task to carry out.

6. RELATIONSHIP WITH OTHER ECONOMIC SECTORS OF THE STATE

6.1 State aeronautical entities, in their transition to the GNSS, should consider that, unlike conventional navigation systems, improvements and developments introduced in satellite navigation will benefit all economic sectors of the State. Therefore, the involvement of the other development sectors of the State should be considered of great importance for obtaining greater institutional, financial, economic and technical support for upgrading, developing and implementing the GNSS. Finally, transportation and communication authorities, mapping institutes and other national agencies of the State should be included and engaged in this process.

6.2 The promotion of national and international GNSS management bodies and associations would permit a more significant development and greater support for investments and for the transition to the GNSS.

7 REGIONAL CO-OPERATION

7.1 The States should get more involved in regional co-operation efforts aimed at research and development. Projects such as the ionospheric research project being implemented by Brazil should permit this integration and the development of mechanisms so that scientists from other States may participate in specific tasks that will enable a more consistent participation by all States, so as to ensure the transfer of the GNSS knowledge required by the Regions. Similarly, issues such as the completion of the WGS 84 survey and the regional communication network should be addressed to support the SBAS.

8. INTER-REGIONAL CO-OPERATION

8.1 Mechanisms for co-operation with States from other regions that are in similar latitudes and show a ionospheric behaviour similar to that of CAR/SAM States should be improved, so as to join efforts and exchange information for the development of more appropriate algorithms and reduce the cost of obtaining such a necessary product for SBAS systems.

8.2 As a result of the recent implementation of the WAAS system in the United States, CAR/SAM States, particularly those in the Caribbean and the north part of South America, have the task of assessing the level of service and the possibilities of using the WAAS system as a means of navigation that provides a better level of service than the one obtained with ABAS (Ranging, status of satellites and basic differential corrections) alone. The solution involving the ABAS + WAAS and message 27 should be assessed against SARP requirements for the different flight stages and traffic volumes supported.

8.3 In this sense, consideration should be given to aspects such as co-operation and participation by the FAA through the provision of said service to the aforementioned regions, mechanisms for the generation of the corresponding NOTAMs, and any other co-ordination required, such as signal monitoring tools in the cited area.

8.4 On the other hand, co-operation with Europe should continue in order to proceed to the subsequent phases of EDISA, and the use of EGNOS should be assessed once it is operational.

9 AIR NAVIGATION PLAN

9.1 CAR/SAM States are developing CNS/ATM transition plans which require mutual integration. The exchange of information among States concerning their transition plans and their co-ordinated work will permit the definition of plans which are more consistent with the reality of an implementation.

9.2 Since the future GNSS will have multiple constellations and signals, special attention will need to be paid to the implementation of the Regional Plan, to GREPECAS guidelines, compliance with the SARPs and international co-operation. In order to co-ordinate the implementation of GNSS systems at the regional level, GREPECAS, based on the work being carried out by the ATM/CNS Subgroup with the support of regional GNSS augmentation projects, will define a plan for the implementation of a GNSS system that is suitable for the CAR/SAM Regions, based on operational requirements.

9.3 Also, as a result of the emergence of new approach modalities, such as APV 1 and 2, Volume II (FASID) of the CAR/SAM ANP (Documento 8733) would need to be modified to include these and probably other functions to enable the identification, by State, of the airports which, based on operational requirements, need this type of approach. Furthermore, the ANP dictates the use of SBAS systems for NPA approach operations, and GBAS systems for precision approach systems. APV1 and 2 approach modalities are NPA-type. FASID Table CNS3 would be modified to indicate the runways identified as NPA in APV1 or APV 2, depending on the type of operation. Accordingly, and taking into account the latest performance results for the SBAS system, the corresponding modifications will have to be made to the expected service levels for SBAS (APV 1, APV 2) and GBAS systems.

10. CONCLUSIONS

10.1 The active work being carried out in the CAR/SAM Regions for the implementation and development of satellite navigation generates the following ideas which might be useful for all the Regions.

- a) Activities of great significance for regional and global satellite navigation can be carried out with a small investment and the committed participation of the States of a region.
- b) Concrete technological and institutional tools (databases, trained personnel, earth stations, equipped aircraft, software tools, etc.) should be available, and be integrated and assessed in order to have a thorough knowledge of the GNSS and to establish concrete strategies for improving satellite navigation.
- c) Once regional trials have been completed, the corresponding PIRG would have sufficient information to draft an initial regional air navigation plan.
- d) Nevertheless, the Regions still face serious technological and human resource training challenges, and must address GNSS implementation and development issues at the national and regional level.
- e) Concrete commitments are required concerning the provision of the GNSS service by the States, Organisations and Regions that have a higher level of development in these systems. Therefore, the States, Regions, and users should be urged to cooperate and work together in the implementation of the new CNS technologies, in keeping with ICAO guidelines and standards, taking into account the results of the relevant cost-benefit analysis. This will optimise resources for testing, implementation, and for the search of the best global and regional alternatives to harmonise the future navigation systems.
- f) Consider that the management of satellite navigation at the level of the State national policy and the integration of institutions and other satellite navigation projects would give more effectiveness and thrust to GNSS transition and implementation.

11. Suggested action

11.1 The conference is invited to adopt the following recommendations:

- a) take note of the information provided in this paper;
- b) review and adopt the conclusions contained in paragraph 10.1 of this paper;
- c) urge ICAO to continue assisting States in the adoption of the appropriate decisions for the implementation of the various future navigation systems, in keeping with the different scenarios, and taking into account GNSS interference and the use of multiple constellations, signals and systems, and in the conduction of institutional cost-benefit analyses of the implementation options.

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