The European Space Agency Free SBAS Software Developments: Learning, Practising and Accessing the EGNOS Performances in Real-Time

A. R. Mathur, F. Toran, C. A. Pandele
EGNOS Project Office
European Space Agency (ESA)
Toulouse, France

M. Houdek, J. Doubek
Iguassu Software Systems
Prague, Czech Republic

***Abstract*— Since 2002, the European Space Agency (ESA) has introduced two important data access elements. First, the SISNeT (Signal-In-Space over the interNET) data server, and later, in 2003, the EMS (EGNOS Message Server) data server, offering real-time and online access to the messages transmitted by the European Space Agency (ESA) EGNOS System, respectively. In addition to the wide mosaic of applications that SISNeT has opened and the potential of EMS in the context of EGNOS performance qualification and monitoring, ESA has found a remarkable potential oriented to SBAS Education behind those two services. Therefore, ESA is working, since 2002, on the development of five tools which support not only SBAS performance monitoring, but also SBAS Education. All of them are available for free download, with no additional constraints or conditions. These tools are widely used in different contexts, including post-graduate courses in European universities, R&D activities in technical centers, European SBAS-related projects, etc. These tools are mainly based on the exploitation of the potential offered by SISNeT and EMS.**

Keywords EGNOS, software tools, SBAS education

I. INTRODUCTION

GNSS generally, and SBAS in particular, are large, complex and highly technical systems with a long history of research and development.

Aiming at providing the fundamentals of SBAS systems (EGNOS in particular), ESA has concentrated in the development of a number of public and free of charge tools designed to ease the exploitation of the EGNOS information for the training and education of future GNSS professionals .

The ESA SISNeT service is available since 2002. It became an important complement to EGNOS providing its wide-area differential correction and integrity information, as well as other added value services, to users over the Internet.

SISNeT and related resources such as the EGNOS Message Server (EMS) constitutes the main pillars for the development of a wide variety of tools with the only objective of teaching SBAS and making EGNOS more accessible to new users.

In the following sections it will be presented a brief description of the developed SBAS educational resources.

II. SISNET USER APPLICATION SOFTWARE (UAS)

The ESA SISNeT technology has become an important complement to EGNOS. It provides users with the messages in the EGNOS SIS via the internet in real time. The UAS tool interfaces with SISNeT and enables straightforward graphical analysis of the EGNOS messages. In the classroom, user friendly access and graphical display of real-time EGNOS broadcast messages is a considerable aid in the understanding of EGNOS.

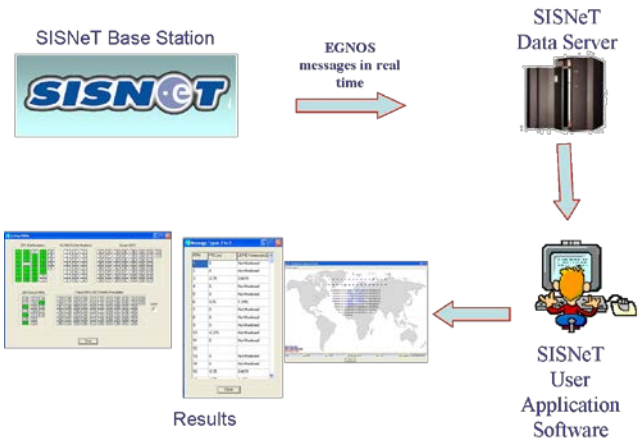

Figure 1 SISNeT UAS environment

The version 3.2 of the SISNeT UAS tool, supports real time analysis of all the message types currently broadcasted by all three geostationary satellites of EGNOS. Through its graphical user interface SISNeT UAS 3.2 makes the EGNOS SIS real time broadcast messages and their analysis available to a wide range of users, including those with little experience in SBAS. It is now available as a free download from the internet. More information can be found at http://www.egnos-pro.esa.int/sisnet/uas.html

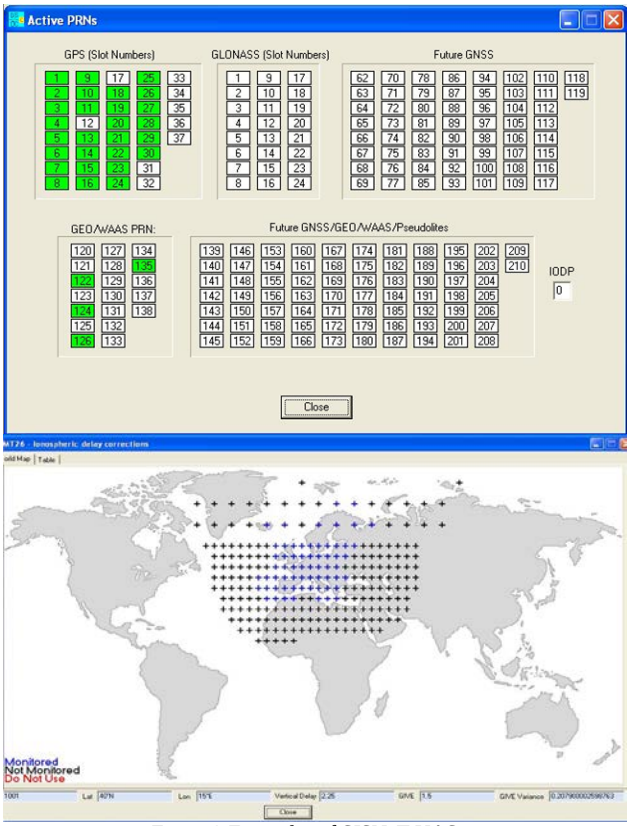

Figure 2 Examples of SISNeT UAS outputs

III. SISNETLAB

An important part of the rationale for SISNeT is to make the service it provides accessible to inexperienced users, especially those in schools and Universities. Aside from students, SISNeT can also benefit research scientists, Small and Medium Enterprises and other GNSS Engineering staff. The SISNeTlab tool provides these users with hands-on experience of the information broadcast by SBAS systems.

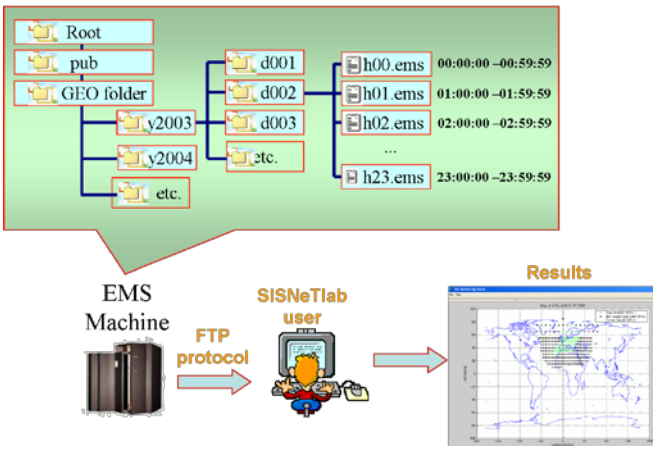

Figure 3 SISNeTlab environment

The SISNeTlab project was developed by ESA during the second half of the year 2004 and made available worldwide in April 2005.

The SISNeTlab tool allows selection and download of historical SBAS broadcast messages from the EMS server. This tool complements the download of real time EGNOS broadcast data by the SISNeT UAS tool discussed in the previous section.

SISNeTlab is designed to be very user-friendly, allowing quick and easy performance assessments of the various SBAS systems. The user inputs a desired time period, SISNeTlab then downloads the data from that interval. SISNeTlab presents that analysis in easily understood graphs and diagrams.

For any given SBAS satellite, SISNeTlab enables post-processing and analysis of:

- Occurrence distribution of message types.
- Message refresh rate.
- Message loss analysis.
- Ionospheric analysis.
- User Differential Range Error (UDRE) and Fast corrections analysis.
- Satellite monitoring status.
- Satellite long term corrections
- Fast correction degradation factors
- Fast corrections Timout Analysis
- Ionospheric error analysis
- Troposheric error analysis
- Residual error analysis
- Total corrections analysis
- XPL analysis
- Safety Index analysis

ESA conceived SISNeTlab as a modular tool, allowing to expand the capabilities by programming new applications in any programming language. If you are interested in contributing with a module, please contact us at SISNET@esa.int.To download SISNeTlab software, visit: http://www.egnos-pro.esa.int/sisnetlab.

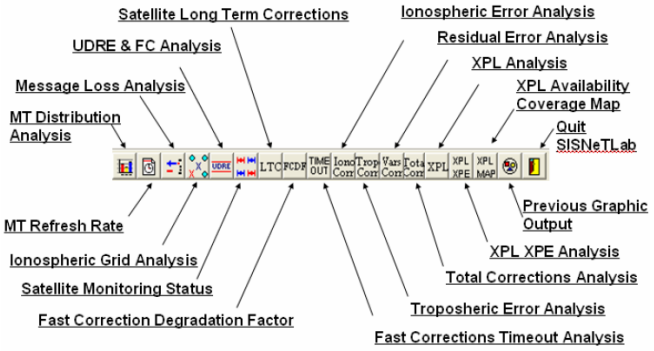

Figure 4 SISNeTlab GUI toolbar

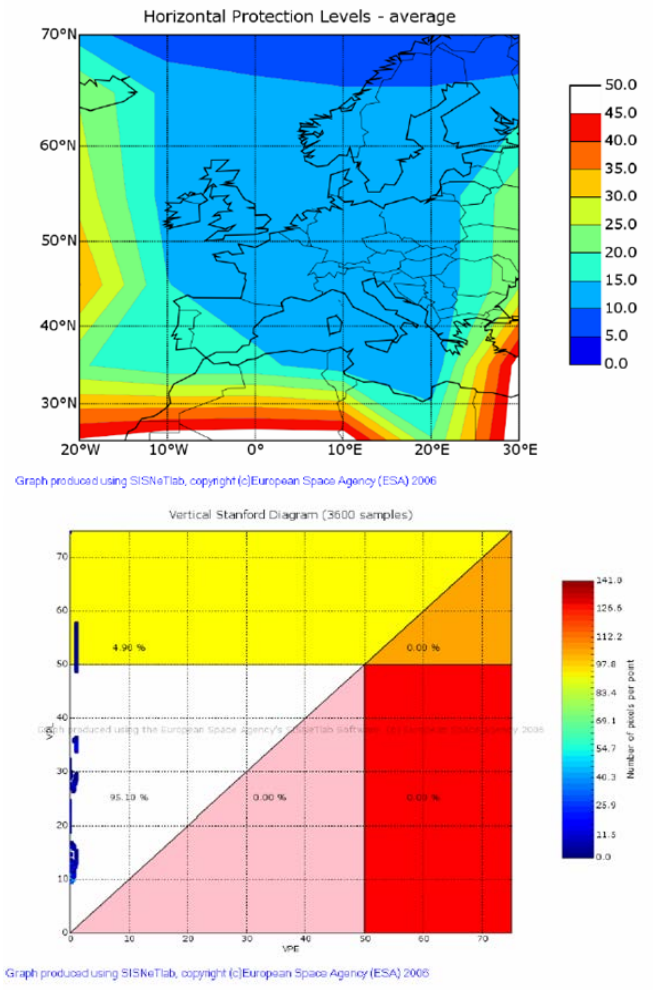

Figure 5 Examples of SISNeTlab outputs

IV. SBAS TEACHER

The SBAS Tool for Education And Contributor to Harness EGNOS Research (SBAS TeACHER) was developed by Iguassu Software Systems for ESA with the objective to make the broadcast EGNOS messages more intuitive for the users.

SBAS message definitions are highly optimized in terms of low bandwidth requirements – they have to be because of the relatively low data bandwidth in the EGNOS SIS broadcast. But this means that for the EGNOS uninitiated, deciphering what a message actually means for the first time represents an uphill struggle.

SBAS TeACHER constitutes a visual encoder / decoder of the SBAS messages. Thanks to SBAS TeACHER, message encoding and decoding is performed through a user-friendly interface. This tool becomes very useful not only for SBAS professionals, but also in the frame of SBAS education, in order to learn about the SBAS message types, its contents, etc.. As with the case of SISNeTlab, SBAS TeACHER makes use of the of historical SBAS broadcast messages from the EMS server (coded in hexadecimal format) and decodes them producing easy and quick to understand snapshots for each message. Users can also define what they want to broadcast via a geographic "point and click" interface and then to generate the correct message content just pressing a button. Either of these features would be a huge boost for students struggling to understand the SBAS message definitions.

To download the SBAS TeACHER software, visit: http://www.egnos-pro.esa.int/sbasteacher

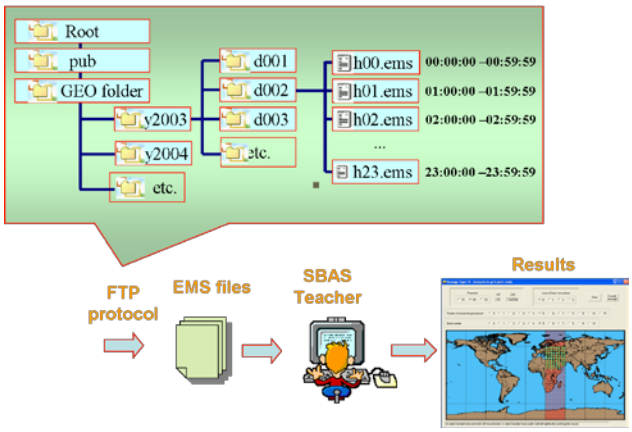

Figure 6 SBAS TeACHER environment

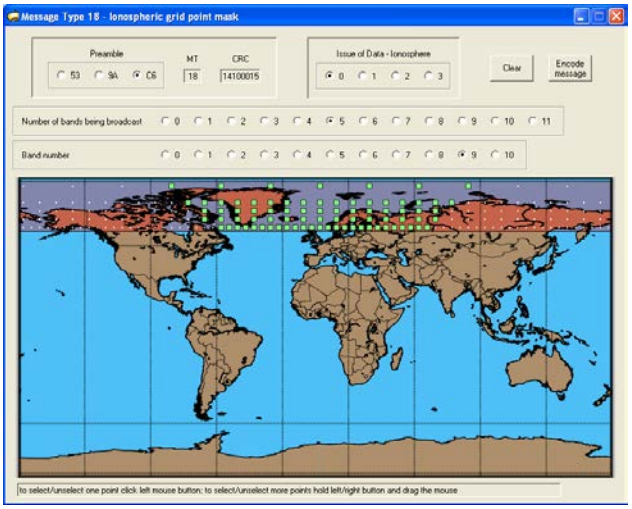

Figure 7 Example of SBAS TeACHER output

V. SBAS MENTOR

ESA in association with Iguassu software systems has developed a simple tool, aptly named the SBAS MeNTOR (SBAS MEssage GENeraTOR). This tool is an evolution of the SBAS TeACHER and allows creating or decoding a sequence of SBAS messages over a selected time period.

While the SBAS TeACHER allows encoding or decoding one SBAS message at a time, the SBAS MeNTOR can work with EMS like files for data over a period of time. This allows the user to modify recorded EMS files in order to be used with performance analysis software (ECLAYR, PEGASUS) for assessing the SBAS performance with different nominal settings (IGP mask, PRN mask, etc).

To download the SBAS MeNTOR software: http://www.egnos-pro.esa.int/sbasmentor

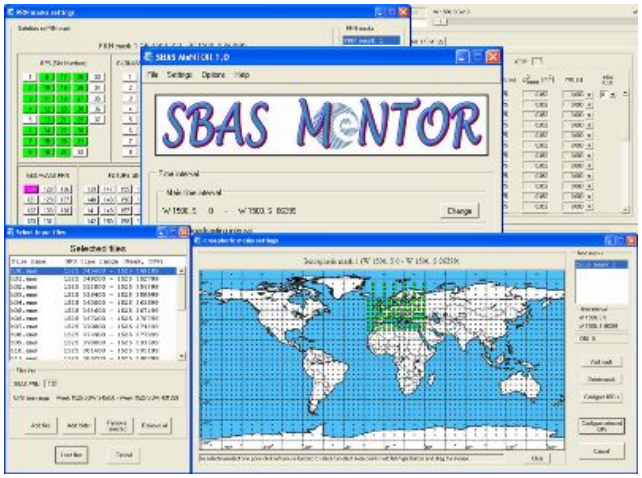

Figure 8 SBAS MeNTOR

VI. SBAS SIMULATOR

SBAS Simulator is a new opportunity for GNSS professionals, application developers, researchers and students to learn about the workings of SBAS systems. The tool has been developed in collaboration between ESA and IGUASSU Software Systems. This has resulted in a user friendly tool with sophisticated capabilities.

The SBAS simulator tool provides many of the simulation capabilities available within ESA to a wide range of those interested in EGNOS and SBAS. Looking into the tool it is clear that it will be a powerful aid in understanding and educating on SBAS systems, while offering EGNOS professionals simulation capabilities for a wide variety of scenarios without usage constraints.

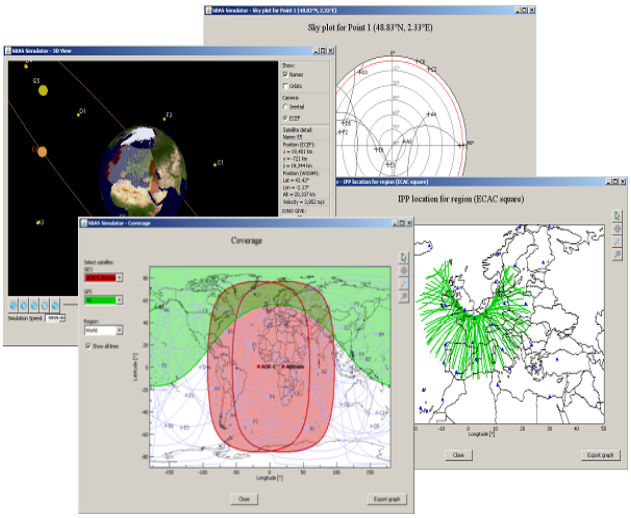

Figure 9 SBAS Simulator outputs

Clicking through the functions reveals that the tool supports SBAS simulations for GPS, Galileo, GLONASS and GEO constellations, as well allowing the user to define their own constellations. Investigating the analysis tabs reveals a high level of flexibility and configurability. The wide range of analysis available includes:

- Protection Level simulations;
- Ionospheric simulations.
- Navigation system error;
- Coverage of satellites;
- Satellite ground tracks;
- Sky plot and 3D simulations;
- Inverse Depth of Coverage;
- Extended Depth of Coverage;
- Availability of the Depth of coverage;

The wide range of results can be produced quickly and provide an intuitive understanding of SBAS performance.

The simulation results are based on emulating the System defined by ground RIMS stations and system errors. Interestingly, there is also the option to use real SBAS messages for NSE and XPL analysis.

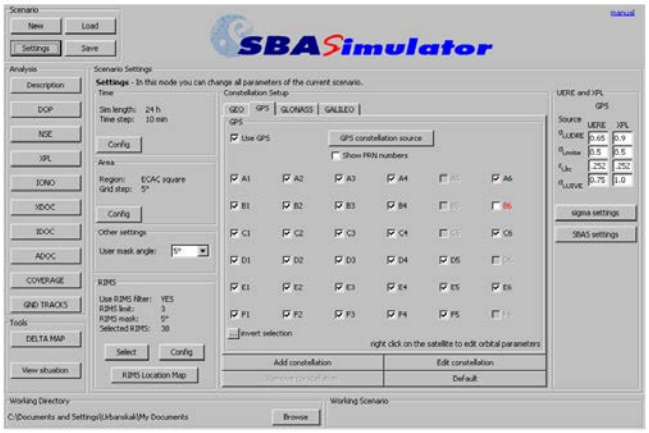

Figure 10 SBAS Simulator main GUI

The software operates as a system volume simulator and provides performance based on simplified macro models for the ECAC region. The performances over regions are only an approximation with no guarantee of the obtained results.

The SBAS simulator is just the latest tool available from ESA's website. This new addition to the portfolio of tools provides even more opportunities to learn and exploit SBAS systems. It can now be accessed on ESA's 'EGNOS for Professionals' website www.egnos-pro.esa.int/sbassimulator

VII. CONCLUSIONS

ESA in collaboration with IGUASSU Software Systems have produced an array of software tools available free-of-charge, allowing the real-time and non-real-time visual analysis of the EGNOS broadcasted messages, as well as their visual encoding and decoding. These tools have a great potential both for SBAS performance evaluation and SBAS education. They

are being continuously updated and additional functionalities are integrated. One of the current main objectives is to prepare them for future multi constellation, multi frequency needs in EGNOS V3.

It is believed by the Authors that the presented resources will provide a useful contribution to the GNSS Education and professional community.

[1] Torán-Martí, F et al, ESA Free Resources for SBAS Education: Learning, Practicing, and Accessing the EGNOS Performances in Real-Time, *ION NTM 2008, San Diego, California*

[2] J. Ventura-Traveset, D. Flament (editors), EGNOS The European Geostationary Navigation Overlay System –A cornerstone of Galileo, ESA SP-1303, ESA Publications Division, ESTEC, Noordwijk, The Netherlands, December 2006.

[3] Torán-Martí, F. and Ventura-Traveset, J. (2006). Status and Evolution of the ESA SISNeT Technology. *Proc. of the European Navigation Conference 2006.*

[4] Torán-Martí, F. Ventura-Traveset, J. Gonzalez, E. Toledo, M. Catalina, A. Barredo, C. and Salonico, A. (2004). Positioning Via Internet: SISNeT Catches GPS in Urban Canyons. GPS World, April 2004.

[5] Torán-Martí F. Ventura-Traveset, J. and Chen, R. (2002). The ESA SISNeT Technology: Access to the EGNOS Services through Wireless Networks and the Internet, Proc. of ION GPS 2002, Portland (Oregon).I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[6] Torán-Martí F. Ventura-Traveset, J. and de Mateo, J.C. (2002). Satellite Navigation and the Internet: Introducing the SISNET Technology, *Dr. Dobb's Journal*, March 2002, 17-26.

[7] ESA EGNOS Message Server Official Website. Available at http://www.esa.int/navigation/ems.