

GMV's *gmvBRAVE*: a powerful tool to evaluate SBAS performances

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Nowadays, combining Global Satellite Navigation Systems (GNSS) and augmentation systems is required in order to improve accuracy and assure integrity for safety-of-life services. In particular, Satellite-Based Augmentation Systems (SBAS) are used in civil aviation, maritime and road. Over the recent years, the usage of SBAS has spread world-wide and its demand has risen in many other different sectors such as agriculture, geodesy or construction, among many others, where high-precision navigation services are also requested.

The European SBAS, the so-called European Geostationary Navigation Overlay Service (EGNOS), together with WAAS in the USA, MSAS in Japan and GAGAN in India are the current four SBAS systems in operation around the world. The appearance of new GNSS constellations in addition to GPS and GLONASS, such as Galileo from Europe and BeiDou from China, and the introduction of the GPS civil L5 signal are imminent. In parallel, EGNOS system prepares for its next step forward, EGNOS V3 evolution, which will turn it into a Dual-Frequency Multi-Constellation (DFMC) system. Furthermore, the future EGNOS expansion to African regions (ASECNA), and the development of other SBAS systems (SDCM in Russia and SNAS in China), some of them already being deployed in test mode (e.g., Test-Bed in Australia and New Zealand), will mark a new milestone in the SBAS history. For all of that, the fact of having an easy but powerful tool that allows developers to analyze and assess the performance of any SBAS system, from its design to its operational stages, has become a necessity. And now, GMV has covered this need thanks to *gmvBRAVE*.

GMV, with its experience over more than twenty years in GNSS and SBAS projects, has gathered the needed knowledge and expertise to develop a valuable tool for SBAS engineering: the *Brief Report for Analysis, Validation and Engineering platform (gmvBRAVE)*¹.

gmvBRAVE allows developers to automatize the execution of SBAS algorithms and analysis tools, and provides the results in the form of graphs, statistics and reports through a web interface designed to seamlessly and visually organize all data

¹ <https://www.gmv.com/en/Products/brave/>

generated during the different phases any SBAS goes through: design, requirements consolidation, validation and maintenance.

Its internal structure allows development and maintenance teams to track any single issue and modify every single feature of the execution in a simple and straightforward way, simplifying its maintenance.

gmvBRAVE's main functionalities and capabilities are:

- Support to SBAS development activities by means of:
 - The coupling of different analysis tools under a unique platform;
 - The automation of different SBAS engineering activities such as algorithm execution or qualification test campaigns;
 - The possibility of executing scenarios using synthetic or real data (e.g. from the Internet archived data, etc.);
 - The testing and validation of algorithmic experimental versions in long-time-period scenarios (covering several months or years) with barely any effort (only the additional cost of hardware, storage and computing power resources);
- Performance analysis by means of:
 - The comparison at a glance of system performances (at pseudorange, user or algorithmic level) between different SBAS algorithm versions, including legacy (GPS L1) and DFMC, and for different configurations, for instance in order to test safety barriers against feared events;
 - The monitoring of operational daily performances in terms of integrity, continuity, accuracy and availability, for several service levels (APV-I, LPV-200, etc.), through a user-friendly web interface;
 - The generation of daily reports with a configurable subset of information;
 - The possibility of analyzing directly the SBAS messages from Signal in Space;
 - The generation and storage of a historical archive of performances.

All these functionalities and capabilities are achieved by combining several other tools and services;

- SBAS algorithms: responsible of the computation of the corrections and integrity information characteristic of a SBAS. It would correspond to the corrections generation and integrity algorithms of an operational (e.g. the CPFPS in the case of EGNOS), to the test-bed (e.g. *magicSBAS*²) or to any in-development SBAS system ready to be tested and validated.
- *eclayr*³: an analysis tool, fully developed and commercialized by GMV, which assesses and analyzes the performance of a SBAS system in terms of integrity, continuity, accuracy and availability. It processes SBAS information and reference real data to generate performance assessment reports.
- Additional analysis utilities: customizable analysis tools which process internal data from SBAS algorithms and *eclayr* performance analysis.

² <https://www.gmv.com/en/Products/magicSBAS/>

³ <https://www.gmv.com/en/Products/eclayr/>

- Interface to GNSS archive systems (e.g. EGNOS Data Access Service [EDAS]) through FTP, NTRIP, etc.

Another of the multiple possibilities offered by *gmvBRAVE* is the generation of a performance analysis report that it can be consulted and downloaded through a web interface. *gmvBRAVE*'s core process communicates constantly with an own online platform, in which uploads and structures in a very visual way all analysis figures in the website. A remarkable feature is that development and maintenance teams can be notified at the end of the analysis via e-mail, which collects a summary of the daily analysis performance being this completely customizable according to the user's needs.

In general, the website interface offers:

- User-friendly design;
- Welcome page with a list of all available scenarios, including for each of them a calendar to preview all archived daily analyses;
- Summary of analyzed performance for each day, with the possibility for customizing displayed information with availability maps, satellite and IGP monitoring figures, integrity ratios and more;
- Launch information including selected tools used in the execution;
- Comparison between SBAS algorithmic versions at a glance;
- Comparison with real system performances;
- Detection of hazardous events in a few mouse clicks;
- Easy navigation tabs to choose between different analysis categories (at pseudorange, user or algorithmic level) and services (APV-I, LPV200, NPA, etc.).
- Possibility of checking data from independent satellites, including GEO satellites, and the possibility of moving between different constellations;
- Live information of main execution and *eclayr* queues status;
- Access to daily reports;
- Possibility of attaching own internal analysis reports performed by the development and maintenance teams;
- Computation of global scenario statistics over long time periods, shown in form of interactive graphs and data tables;
- Additional scenario information: algorithmic versions used over time and featured days (e.g. days where a satellite mask change or the attachment of an internal analysis report were done) emphasized with colours.

In the current paper, the main features of *gmvBRAVE* as well as practical cases of its usage will be presented. In particular, *gmvBRAVE* will be employed to assess in different real scenarios the performance of the EGNOS system, one of the SBAS systems on operation. All these examples will serve to prove the potential benefits that *gmvBRAVE* can provide as a tool for engineering and performance analysis for the current and future development, deployment and maintenance of any SBAS system.