ESPADA 3.0: An Innovative EGNOS Simulation Tool Based on Real Data

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Résumé

Depuis Janvier 2000, ESA dispose d'un nouveau moyen pour expérimenter, tester et valider les services du futur système d'augmentation européen EGNOS. En effet, un signal dans l'espace est aujourd'hui disponible grâce au EGNOS Test Bed, une plateforme pré-operationnelle, représentative du système final. Afin de contrôler les performances de précision et d'intégrité presque en temps réel, l'ESA a développé ESPADA 3.0, un logiciel puissant sur lequel des données collectées à l'aide d'un récepteur peuvent être traitées et comparées à des modèles de simulation, utilisés jusqu'à présent dans la conception et l'optimisation de l'architecture du système complet.

Introduction

The European Tripartite Group - composed of ESA, the European Commission and EUROCONTROL - is implementing, through the EGNOS project, the European contribution to the Global Navigation Satellite System (GNSS-1). EGNOS, aimed at augmenting GPS and Glonass navigation, will provide and guarantee navigation signals for aeronautical, maritime and land mobile Trans-European network applications. ESA is responsible for the system design and development, and also for the qualification of an Advanced Operational Capability of the EGNOS system (Ref. 1). EGNOS is the first step of the European Satellite Navigation strategy and a major stepping stone towards Galileo, future Europe's own global satellite navigation system. EGNOS is becoming a reality since a pre-operational version of the future EGNOS signal has been available since January 2000 through the EGNOS Test Bed (ESTB; Ref. 2).

The EGNOS Test Bed is an excellent means of performing application demonstrations and acquiring a good understanding of EGNOS's potential performance. Aiming at improving the means for test-bed performance monitoring, an important step forward has been made with the development of the ESA ESPADA 3.0 software. The key features of this software, which provides (in quasi-real time) the availability performances of EGNOS test-bed navigation services all over Europe, are addressed in this article.

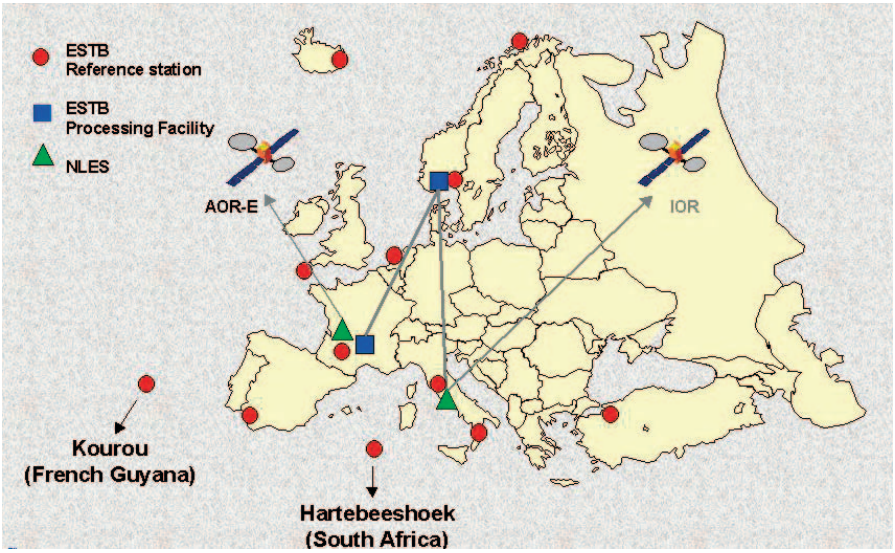
The EGNOS System Test Bed

The EGNOS Test Bed (ESTB), a pre-operational EGNOS signal, has been available since early 2000 for navigation demonstrations and service trials (Ref. 2). The main objectives of the ESTB are to:

- have an assessment of the global performance that EGNOS can achieve
- analyse in detail critical design issues or trade-offs between several options
- develop and validate system test methods
- demonstrate the system's operation to potential end-users
- provide a representative tool for Civil Aviation.

The EGNOS Test Bed architecture is shown in Figure 1.

Figure 1. EGNOS Test Bed architecture



ESPADA 3.0: simulations using real ESTB data

The EGNOS Simulation Tool for Performance Assessment and Design Analysis (ESPADA) is an ESA internal tool for system-level analysis of the EGNOS architecture. The initial objective in developing ESPADA was to provide the ESA GNSS-1 project team with an independent tool with which to assess EGNOS navigation service performances. A first version (ESPADA 2.0) was developed during the period 1996-1998 (Ref. 3). This version has been used extensively during last three years by the ESA GNSS-1 team in complementing industry system trade-offs on the EGNOS architecture, supporting validation of industry developed simulators, assessing sensitivity of user performances versus design parameters, assessing EGNOS expansion possibilities beyond Europe and complementing interoperability tests with other equivalent world-wide navigation systems (e.g. WAAS in the USA, and MSAS in Japan).

The latest version of the ESPADA software, release 3.0, incorporates an innovative enhancement, namely the ability to perform simulations using real data from the ESTB. ESPADA can now extract the real corrections broadcast by the ESTB from an EGNOS receiver, obtaining plots of protection level availability (a major parameter for assessing EGNOS system availability) over the EGNOS service area. Integrity histograms (Ref. 4) computed at the receiver location can also be obtained. These outputs constitute the most accurate representation of the ESTB performance achievable to date, since they are mainly based on the real information broadcast by the system. The replacement of mathematical models with real data makes ESPADA 3.0 a unique tool for acquiring new and more accurate knowledge of the EGNOS Test Bed.

The ESPADA Graphical User Interface (GUI) is now able to switch to 'ESTB mode', in which the simulation scenario is coherent with the ESTB simulation needs. A user-friendly step-by-step wizard guides the process of simulation.

Figure 2. A step-by-step wizard aids the process of performing simulations with real data

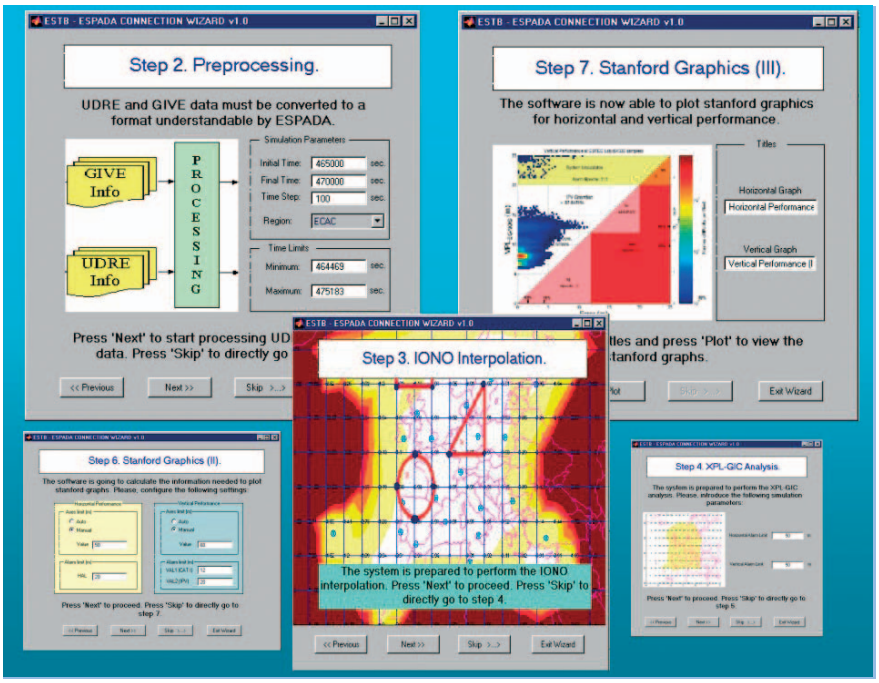
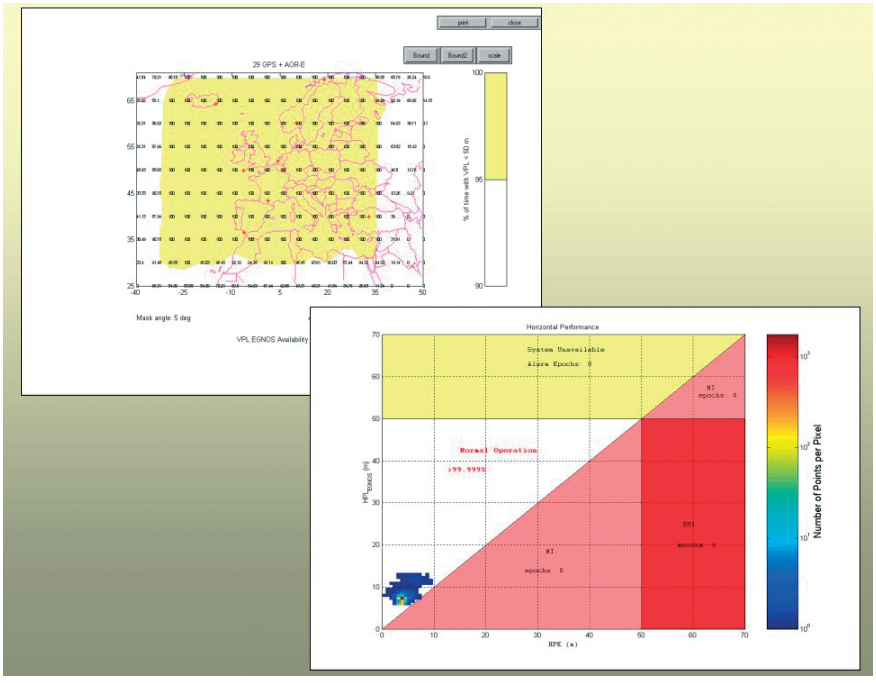


Figure 3. The most representative outputs produced by ESPADA 3.0 are protection-level availability maps, and integrity histograms for horizontal/vertical performance



The wizard is composed of the following steps:

- *Step 1. Receiver file reading.*
  The corrections broadcast by ESTB are extracted from a log-file and stored on disk. The log-file is created through an EGNOS receiver and the appropriate logging software.
- *Step 2. Pre-processing.*
  ESPADA extracts the EGNOS corrections from the messages, according to the pre-defined simulation conditions. That information is stored in a format understandable by the ESPADA software.
- *Step 3. Ionospheric interpolation.*
  The vertical ionospheric correction bounds are calculated over a pre-defined grid of users, through an interpolation algorithm (explained in detail in Ref. 5).
- *Step 4. XPL-GIC simulation.*
  The horizontal and vertical protection limits (HPL and VPL) are computed at the users' locations over time. The availability of integrity (i.e. the percentage of time for which those variables are less than a certain limit) is plotted on a map.
- *Steps 5 and 6.*
  The user introduces the position of the receiver, and configures the generation of two integrity histograms (corresponding to horizontal and vertical performance). The calculations needed to obtain those representations are performed.
- *Step 7.*
  The integrity histograms are presented on the screen.

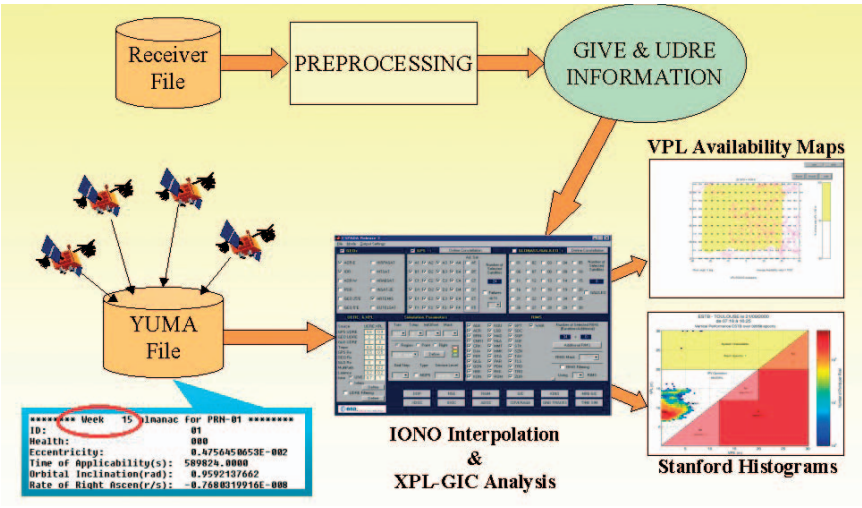
In addition, ESPADA 3.0 introduces several other enhancements such as:

- export of graphical results in PowerPoint format
- capability for storing/retrieving simulation scenarios
- ability to highlight performance differences between two analyses.

Future Work

ESPADA 3.0 is continuously improving and including new features. One already implemented is provision of the ESTB signal through the Internet (ESA SISNET Project, also described in this issue of PFF).

Figure 4. Block diagram illustrating the process of simulation with real data



With the availability of SISNET since summer 2001, any user with access to the GPS constellation and to a GSM link is able to improve their position from 15-20 to 2-4 metres using the service, and without any limitations being imposed by GEO blocking. The availability of the EGNOS signal via the Internet opens the possibility to obtain EGNOS performance maps (based on ESPADA 3.0 software) via the Internet also. This allows real-time monitoring of the ESTB performances anywhere in Europe just with an Internet link.

Conclusions

ESA is fully engaged in the development of EGNOS, the European Geostationary Navigation Overlay Service, aimed at augmenting GPS and Glonass navigation services. EGNOS is now becoming a reality as a test bed - a simplified version of the fully-fledged system has been available since January 2000. Aiming at improving ESA's means for EGNOS test-bed performance monitoring, an important step forward has been achieved by the development of the ESA ESPADA 3.0 software. The replacement of mathematical models by real data makes ESPADA 3.0 a unique tool in Europe for acquiring a more accurate knowledge of the EGNOS Test Bed's performance over the whole European service area.

References

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More information is available at: http://www.esa.int/navigation.