

AVANT: A WIDE RANGE UTILITY FOR GPS-EGNOS NAVIGATION SYSTEM USERS

Cristina Sotomayor¹, Rafael Toledo¹, Benito Úbeda¹, José Santa¹

¹ Department of Information and Communication Engineering. Computer Science Faculty. University of Murcia, Campus de Espinardo, 30071 Murcia, Spain.
e-mail: csotomayor@dif.um.es | bubeda@um.es | josesanta@dif.um.es

The development of tools and facilities for vehicle navigation has many benefits for the navigation world. Promoting the education in Navigation Systems, developing user applications for Location Based Services (LBS) or testing receivers and other sensor devices are just a few of them. This paper is to present the AVANT application, a hardware/software utility for a wide range of users. On one hand, this software utility offers detailed information useful for a GPS/EGNOS expert, bringing the possibility of studying the implementation of LBS according to their own requirements. On the other hand, non-experienced users will find the application intuitive and easy-to-learn. No special knowledge in ITS (Intelligent Transport Systems) is required to run the application in a simple way as a useful tool to ease the driving.

1. STATE OF THE ART AND INTRODUCTION

Nowadays, there is a large variety of applications for testing GNSS and SBAS features, and simulating complex future systems. The simulation tools can be classified according to their main function in:

- Design of solutions for navigation problems.
- Demonstration and mission analysis.
- System validation for defined user requirements.
- Critical safety applications.

Regarding the design tools, it is worth mentioning the EETES simulator (EGNOS End-To-End Simulator), developed under the EGNOS project. EETES is a signal simulator capable to model EGNOS components such as satellites, receivers, terrestrial communications, and ionospheric and tropospheric delays. EETES also performs analysis of the simulated results

[1] [2]. Polaris, a facility developed by GMV and founded by ESA (European Space Agency), could be classified in the demonstration and mission analysis group, enabling the evaluation of selected navigation systems by displaying integrity and availability information for a defined scenario [3]. Originally oriented to GALILEO, can test GPS, SBAS, DGNSS (differential GNSS), pseudolites and radio mobile (GSM/GPRS/UMTS) systems, and supports the implementation of positioning aiding sensors, such as gyroscopes and odometers [1] [2]. An example of the system validation group can be found in the ASQF facility, developed under the EGNOS project, with the objective of supporting the qualification of multi-modal applications. It is composed of a number of tools that together allow the acquisition of field trials data, the archiving of those data, comparison with reference user data and the carrying out of comprehensive performance assessments. The ASQF simulation capabilities also make it possible to predict performance and to compare the results of real data with the results of simulators [4].

The AVANT application shown in this paper has been developed as a wide range utility for GPS/EGNOS navigation system users. On one hand, it works as a friendly navigator for non-expert users. The vehicle is located on a GIS map, the current road identified and some services based on its location, such as nearby gas stations, hospitals, etc., are offered. On the other hand, AVANT can be a design and validation tool for an expert user, allowing its execution in both perception and simulation modes. As a design tool, AVANT enables the selection of different sets of sensors through defined scenarios. For validating purposes, a complete set of integrity parameters are supplied. Additionally, AVANT can be also used in the Educational branch as a comprehensive tool for introducing the GPS/EGNOS features.

2. THE NAVIGATION SYSTEM

The navigation system installed in our vehicle prototype fuses the information coming from an EGNOS-capable GPS receiver, inertial sensors, and odometry captors with an Extended Kalman Filter. Additional sensors, such as an electronic compass or more GNSS receivers can be also supported by the software application. A loosely coupled filter architecture implementation maximizes the flexibility of the navigation system configuration. Finally, different vehicle models are used in the filtering, depending on the set of sensors selected by the user.

In addition, the on board unit includes a communication unit, enabling the information exchange with the vehicle computer via Bluetooth, UMTS and WIFI links, and the EGNOS corrections by using SISNeT. Further details on the navigation system can be found in [5].

3. THE AVANT APPLICATION

The main window of the AVANT application displays basic information to the user (Fig. 1). Additional information can be displayed by navigation through the application menus.

As commented, AVANT can be run in perception and simulation mode. A visualization mode is also available. In these three modes, a large variety of information is supplied to the user. On the upper right side of the window, sensor status and measurement data are shown. Below, the vehicle position in latitude/longitude format, the vehicle orientation and information of the current road and the traveled distance are displayed. Both the position and the orientation of the vehicle are outputs of the Extended Kalman Filter implemented. On the lowest part, the city map select option and some driving assistance services, such as hospitals or hotels, are displayed. The map selected by the user is plotted on the central part of the

window, and the checked services located on the map. By default, the position filter output and the GNSS UTM measurements keep plotted on the map during the whole trajectory. The vehicle 2D orientation is shown by a yellow arrow. The map can be scrolled by clicking the arrows surrounding the map. Below the map, a bar supplies information of the pointer UTM coordinates and the representation scale (selectable by the user), while the lowest bar indicates the execution status of the application.

On the upper left side of the window, the selection of the execution mode can be done. AVANT can work not only as a real time navigator, but also as a postprocess simulator with real measurements. The visualization mode displays a previous logged output, reproducing the vehicle's trajectory and displaying the sensor measurements and parameters on the screen, but it does not execute the filter, so no changes can be done in the navigation system configuration running this mode. By displacing the slider besides the execution mode checkpoints, the reproduction rate can be changed while running the simulation and visualization modes. Finally, a Run/Stop button starts and stops the execution in progress.

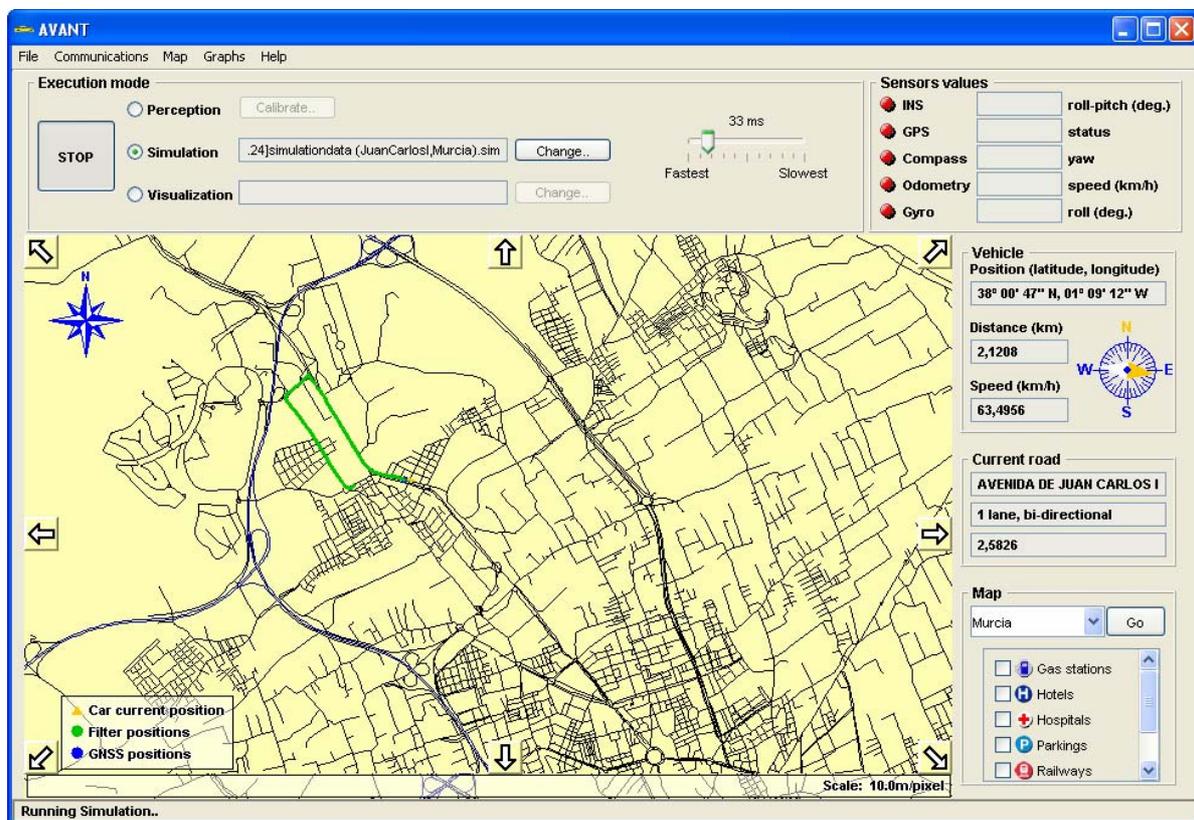


Fig.1: The Avant utility.

Running the perception mode, the measurements captured by the sensors and their timestamps are logged. The simulation mode will use these values to reproduce another filter execution. In this way, the consequences of disabling sensors or changing algorithm parameters can be analyzed. Both execution modes log the UTM position outputs and additional information during the vehicle trajectory, creating the input files for the visualization mode.

Due to the size restrictions of this paper, a selection of the application options will be done. It is worth mentioning the possibilities of the Graph menu for an expert user.

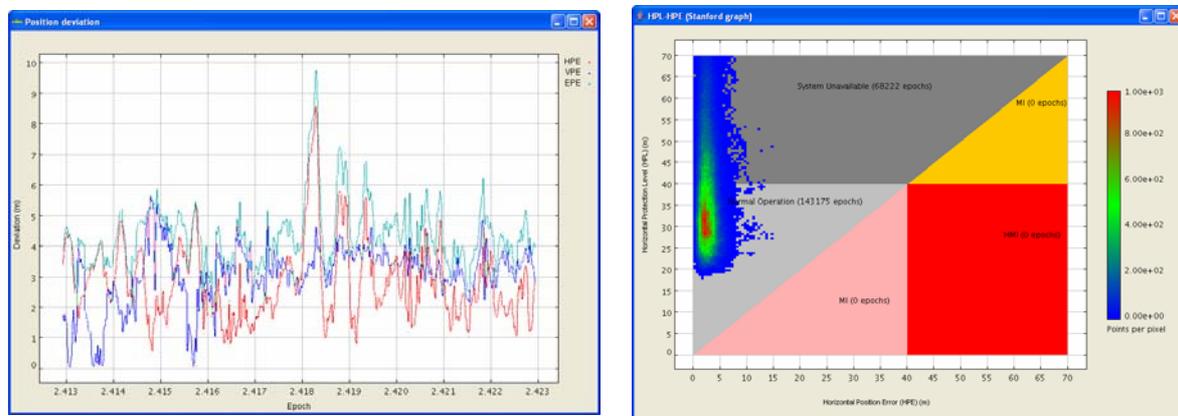
GPS/EGNOS UTM coordinates, satellite constellation status or the HPL integrity factor can be displayed by selecting the proper graph.



a) Detailed information in text mode

b) Polar diagram of the satellites in view

Fig. 2: Satellite constellation status.



a) HPE and VPE position deviation

b) HPL/HPE Stanford Graph in Non-Precision approach

Fig. 3: Integrity parameter windows of the Avant application.

The satellite constellation information windows can be seen in Fig. 2. Figure 2.a shows detailed satellite information parameters at the current time. The angular position, the pseudorange corrections and whether the satellite is used or not in the position calculation are some of them. The polar diagram shown in Fig. 2.b, presents the elevation and azimuth angles for each visible satellite at the current time. Red ones are those rejected from the solution, the white one is the geostationary satellite used by EGNOS, and the green trails show the displacement direction of each satellite.

Figure 3 presents two useful graphs in static tests. Fig. 3.a shows the position deviation values HPE (Horizontal Position Error), VPE (Vertical Position Error), and the absolute error. The HPE and VPE calculations are based on the Euclidean distance between the current position and the real one (entered by the user). The HPL_{SBAS} calculation (Fig. 3.b) requires satellite and receiver situation information and the precision of the pseudorange measurements. This information is included into the EGNOS messages.

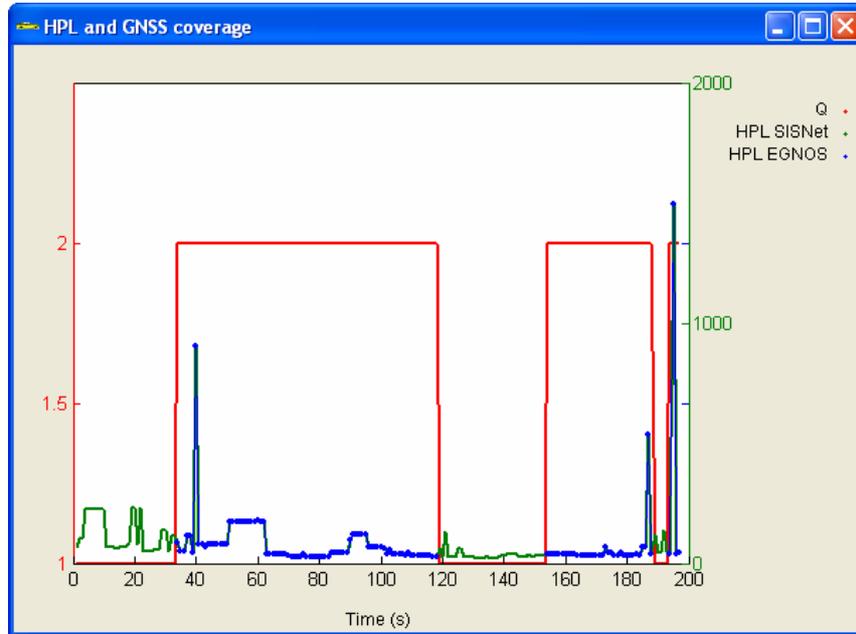


Fig. 4: HPL_{SBAS} value and GNSS coverage.

The value of the HPL parameter can be also displayed through the time (Fig. 4). This graph can be particularly interesting for integrity validation purposes. The HPL_{SBAS} value can be obtained either via SISNeT or EGNOS. In the plot shown in Fig. a, the HPL_{SBAS} parameter had been calculated via SISNeT. The position quality is shown in red, where $Q = 1$ means GPS quality (so there is no HPL_{SBAS} available without SISNeT) and $Q = 2$ means EGNOS quality. As seen, during this urban test outages of the geostationary satellite were frequent. SISNeT is proved as useful to improve the integrity availability. Nevertheless, the dependence of the GPS coverage encourages the implementation of a continuous integrity parameter, which should not be based exclusively on satellite navigation systems. Therefore, the application will include in future versions information of the HTL parameter (Horizontal Trust Level), an integrity parameter based on the filter state covariance matrix [6].

4. CONCLUSIONS

In this work, a revision of the current facilities regarding the GPS/EGNOS navigation systems has been done. The AVANT application presented in this paper, has been shown as a useful utility for a wide range of user applications, covering many of the desired functionalities required by the users.

5. ACKNOWLEDGEMENTS

The Authors would like to thank the Spanish Ministerio de Fomento, European Space Agency (ESA) and the C. A. Región de Murcia for sponsoring the research activities under the grants FOM/3595/2003, GIROADS 332599 and ISIS/2I04SU009, respectively.

REFERENCES

- [1] **GMV Team**, Simulación en GNSS: crucial en sistemas complejos, *Revista de Comunicación Corporativa GMV*, volume 26, pp. 5-6, 2005
- [2] **GMV Team**, *Presentación de GMV S.A. 2004*, In II Jornadas de Trabajo sobre Modelado y Simulación de Sistemas, pp. 6, 2004
- [3] **GMV Team**, *Polaris. Demonstrating Performance Levels of Positioning Technologies, 2004*
- [4] **ESA**, *ESA Navigation Applications Development Facilities to support new projects.* http://www.esa.int/esaNA/SEMGWDHHZTD_galileo_0.html, 2004
- [5] **Rafael Toledo, Miguel A. Zamora, Benito Úbeda and Antonio F. Gómez-Skarmeta**, An Integrity Navigation System based on GNSS/INS for Remote Services Implementation in Terrestrial Vehicles, *Proceedings of the 7th International IEEE Conference on Intelligent Transportation Systems*, pp. 477-480, 2004.
- [6] **Philipp, A. Boysen, Hugo Zunker**. Integrity Hits the Road. *GPS World* Jul 1 2005, pp. 30-36. July, 2005.