EGNOS (GNSS-I) Evaluation for Its Application in a Vehicle Driving Support System

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Abstract

This paper will present the results obtained within the evaluation of EGNOS signal in the context of the MIMICS project (Mobile Intelligent Model incorporating Independent Control and Sensorisation) financed by the Spanish Ministerio de Fomento which aims is to provide solutions in the field of intelligent transport systems, more specifically in area of intelligent vehicles. The main aim is to develop a prototype of an intelligent vehicle, where to test the integration of different sensors specially those related to location and awareness.

To minimize the problem of the poor visibility of the AOR-E satellite an option of sending the corrections using Internet (the ESA SISNeT project) has been evaluated as part of vehicle Testbed.

1. Introduction

The future trends in road transport is clear: More electronic intelligent on board the vehicles, wide use of cellular wireless broadband communications systems with global coverage and minimum roadside support. The use of GNSS navigation sensor, basically GPS based, are actually the core of majority navigation services in road transport. But new applications are possible making use of better accuracy and availability in the measurements that the Satellite Based Augmentation Systems, SBAS, offer. This systems joined to 2.5G cellular mobile telephony will play a essential role in the future few years of ITS developments, just until the European Galileo and new GPS arrive.

The European Commission, through the ESA, is promoting the Galileo Project, however, the first phase, denominated GNSS-1 or the EGNOS Project, will boost the performance of already existing GPS and GLONASS systems.

The EGNOS System Test Bed (ESTB) is the prototype which is broadcasting a Signal in Space (SIS) since February 2000. It is used to support and test the development of the EGNOS system, to demonstrate EGNOS to potential users, to prepare for the introduction of EGNOS and to test the possibility of expanding this system outside Europe. The ESTB provides users with a GPS-augmentation signal that enables them to calculate their position to an accuracy of within a few metres.

In this paper we present the results obtained in the evaluation with European EGNOS Test Bed, ESTB, as part of our researches in autonomous driving, safety management and automatic tolling. The MIMICS project (Mobile Intelligent Model incorporating Independent Control and Sensorisation) financed by the Spanish Ministerio de Fomento, was our point of start.

The vehicle that was used for our test include the next electronic equipment:

- High end GPS receiver with WAAS/EGNOS compatibility.
- FMCW Frontal radar to detect and avoid obstacles.
- Wireless communications unit.
- A system of intelligent control to aid driving.

Figure 1 depicts the automated COMARTH model S1-50 vehicle.

Figure 1. Automated COMARTH S1-50 prototype

This vehicle, with an automatic gear box, incorporates the following specially designed systems in a modified version of the original: electrically assisted steering, electronic accelerator and electrical breaking. The bodywork and dash were also modified to hold the sensorisation and monitoring systems, as was the interior distribution of components so that the actuators and electronics could be accommodated. Another embedded sensor are the frontal millimeter radar, an electronic compass and odometric system based on the ABS sensors. The communication unit are based on 802.11b WLAN for short range coverage and Cellular Network GPRS based for wide one.

By means of the IEEE 802.11b WLAN, the vehicle transmit data control and positioning information to a base station designed to collect information from vehicles and allow to a possible control of the car.

2. EGNOS Evaluation

One of the main interest of this research has been the use of satellite based augmentation system as main on board sensor for SPS and navigation systems in the vehicle safety driving application. Some geo-stationary satellites act as one more PRN in the GPS constellation. That is, send signals in L1 band with navigation and corrections messages to the users, in accordance with the RTCA document, MOPS DO-229A.

This document was accepted by ICAO for SARPS in aerial navigation, but a further aim of the European Commission is that Galileo will be available to a wider group of transport interests. In this context, MIMICS attempts to evaluate the SBAS/EGNOS in road transport ITS, taking in mind that vertical guidance is not our problem.

2.1 Static measurements

With a high end Egnos sensor, Novatel millennium OEM-3 working in single band, L1, we are make measurements initially in a static placement for to get conclusions about the accuracy, availability an integrity of the ESTB SIS in this geographic area.

The first task was to log 4855 measurements at 1Hz data rate. That is about 1h20min. Next, we proceed to analyse the accuracy and precision in the position obtained.

Figure 2 show histograms for horizontal position error, HPE, and horizontal protection level, HPL, defined in MOPS for precision approach. The accuracy obtained in majority of our measurements was similar : good accuracy of HPE (CEP=1.2m), and good precision (1σ=0.456 m). However, the integrity parameter, HPL, present a good accuracy , Err50%=21.15 m) and poor dispersion, (1σ=35.93 m).

The CEP=1.2 m, may be adequate for broad range of ITS applications, especially if we need to know in what motorway lane are driving same vehicle or in what street cross the vehicle need to turn right or left.

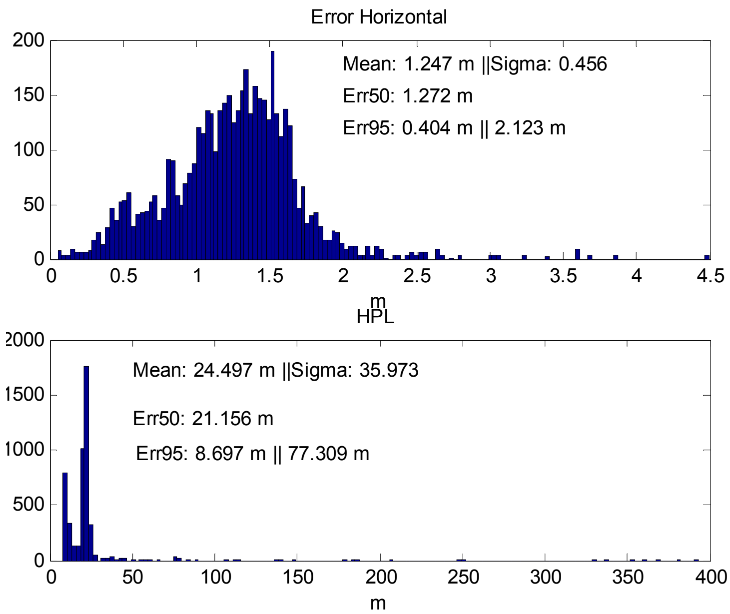

Figure 2

The discontinuities in HPL parameter and the mathematical calculation necessary to get it may be an obstacle to development economic embedded sensor for vehicles. Perhaps it is necessary to redefine it for ITS.

2.2 *Dynamic trajectories*

We are configured an on board unit, OBU, with the GPS receiver, antenna, personal computer and auxiliary material. We are install the OBU in the MIMICS vehicle an we are proceed to acquire some log's for trajectories around the Espinardo Campus of Murcia University.:

Figure 3 show how clearly the trajectory along the two lanes are recorded likewise the maneuver of 90º turn to parking entrance and exit are correctly logged.

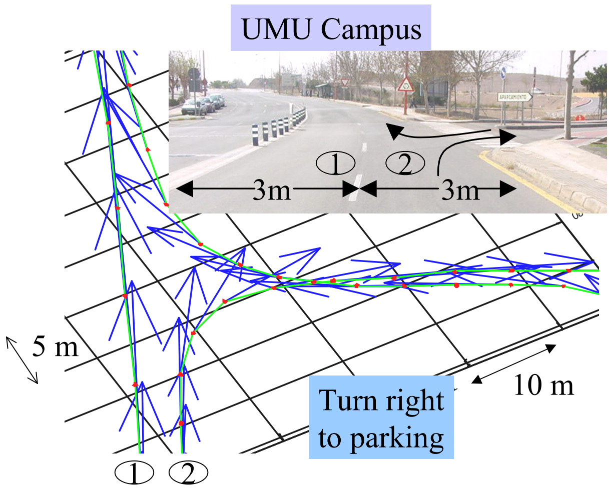

Figure 3. Trajectory recording

In the photograph we show the lane width, about 3m, the minimum for a motorway. The system may discriminate both trajectories along two lanes, useful for black box data recorder application in traffic accident.

3. SISNeT Application

In road ITS applications, usually there are situations in which the L1 band downlink from geo satellite to receiver antenna may be obstruct by high constructions or contingencies of any other type. In this case differentials corrections provide for EGNOS will be lost.

SISNeT is a new application developed by the European Space Agency (ESA) that makes correction messages of ESTB accessible via the Internet. Anyone with an Internet connection can tap into this service. For road ITS, the cellular network GPRS will play an important role in the mobile access to Internet meanwhile wireless LAN will be suitable in some specific short range locations.

The information broadcast in real time across the Internet is basically the same that PRN120 or PRN 131 geo satellites are broadcasting by L1 band. SISNeT don't provide pseudorange measurements, that is, don't increment availability but provide more accuracy and precision that GPS in single-point positioning.

3.1 Measurements for evaluate SISNeT viability

Some tests have been made to evaluate SISNeT performances. In this paper we report some conclusions based in our experience with this application. As an example of his behaviour we show one typical log's when the receiver antenna is placed at static point.

Type of test	Static point. Mask angle of 5º
Receiver	Novatel millennium OEM-3 WAAS/EGNOS (High End)
Data log	15474 sec
Localization	Latitude=38.019345º N Longitude=1.168580º W

For SISNeT usage the WAAS/EGNOS GEO channel was switch off and differential messages received by internet access was supplied trough com2 port to OEM. The internal processor of OEM make all necessary corrections in real time.

Figure 4 show the dispersion graph for horizontal position error, HPE . The horizontal circular error obtained was. CEP=1.18 m. The median for computed HPL, about 28.3 m is show also.

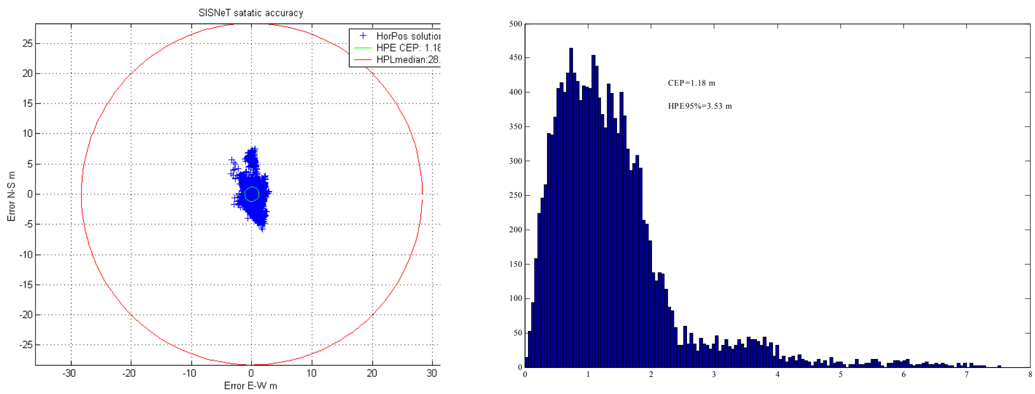

Figure 4. SISNeT HPE accuracy-precision

In figure 4, right side, we conclude with the histogram of horizontal position error. On observe that SISNeT offer a good accuracy and precision, similar to EGNOS.

In figure 5, we show the computed HPL

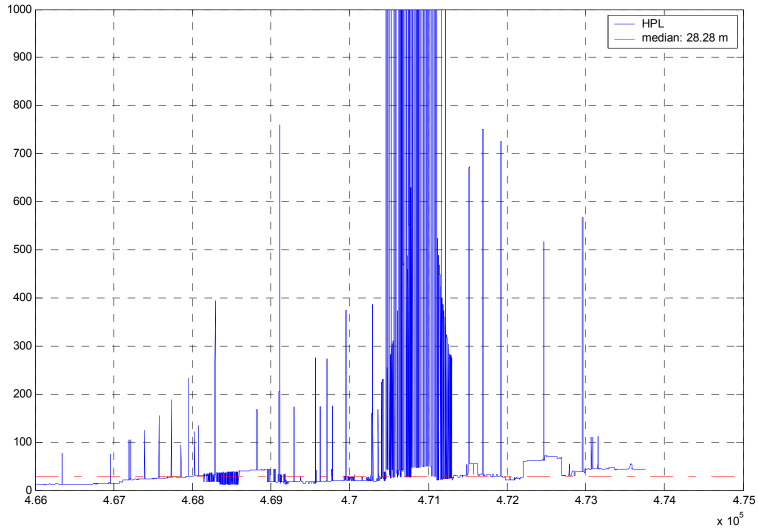

Figure 5. HPL

HPL have many peaks of very high value. The integrity alert is trigged with high probability but the HPE is usable. This data misleading is caused by internet delays. The availability of a good Internet connectivity will be important for the success of SISNeT. Today, for real time kinematics, RTK applications, this is a important problem and we conclude that integrity of SIS is not guaranteed. However it is useful for increase accuracy and precision just when geo sat SIS are not detect.

4. Conclusions

The MIMICS Project is one first step in ITS research in our group, in order to analyse the advantages new technologies can offer for the future of road transport, in which both vehicles and infrastructure will make use of the enormous possibilities offered.

The experiments presented in this paper show that the use of EGNOS signal could be of high value in the management of the vehicle movements and position control. The system is in general valid for most ITS applications, for example, autonomous driving, trajectory data loggers for vehicles accident, etc.

However there are many problems still to be solved, i.e. the availability of GPS constellation in urban areas and how to select the best communications channel to give data corrections to OBU.

SISNeT is a valuable tool for road ITS navigation services in urban areas. In application where high degree of precision and accuracy an real time is a basic necessity, SISNeT access by GPRS will be an ideal solution.

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