

SISNeT as a source of EGNOS information

Overview of functionalities and applications.

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Abstract — The poster presents functionalities, applications and methods of SISNeT utilization. The information about SISNeT software and applications provided in this poster is generic and does not cover SISNeT technology in detail but highlights the potential impact of the SISNeT software and applications on the dissemination of EGNOS augmentation technology. SISNeT online services are sources of EGNOS messages distributed by the SISNeT Data Server. SISNeT User Application Software allows decoding and visual presentation of content of EGNOS messages flowing from SISNeT Data Server in real time. Prototype GETPOS function implemented on SISNeT Data Server side determines user position with SISNeT corrections. A next-step idea for positioning with SISNeT capability is SISNeT Plug-in Application that allows correcting user position provided by any type of receiver.

Non real time SISNeT information distributed by SISNeT Data Server is available as EGNOS Message Server files. EMS constitutes an enhancement of possibilities offered by SISNeT technology: while SISNeT allows accessing the EGNOS messages in real-time, EMS permits an offline access to a huge archive of messages. SISNeT educational software tools are taking advantage of EMS. SBAS TeACHER educational tool for students allows decoding and encoding different EGNOS messages in post processing mode. The evolution of the SBAS TeACHER software led to SBAS MeNTOR (SBAS MESSage GENerator) belonging to SISNeT educational tools family. Yet another SISNeT tool based on the ESA EGNOS Message Server (EMS) is SISNeTlab. Although not addressed in detail, the poster presents possibilities of using SISNeT information and ideas for monitoring EGNOS performance in real time with utilization of SISNeT tools.

SISNeT was also used to define and develop applications for forestry inventory purposes and its concept was utilized in the frame of technology demonstrator projects that aimed at providing integrity for liability applications, developing automatic road-tolling services, vessel monitoring and developing mobile terminals for receiving SISNeT information.

SISNeT; EGNOS applications; SISNeTlab, SISNeT Plug-in, Forestry, GETPOS

I. INTRODUCTION

EGNOS, the European Geostationary Navigation Overlay Service, is the first step on the European contribution to the Global Navigation Satellite System (GNSS), and a fundamental stepping-stone towards GALILEO, Europe's own Global Navigation Satellite System. EGNOS is an augmentation system to the GPS and GLONASS Satellite Navigation systems, which provides and guarantees navigation signals for aeronautical, maritime and land applications. In this context, the European Space Agency (ESA) launched a project to provide access to the EGNOS messages in real time through the Internet. The product of this project has been the technology, called SISNeT (Signal in Space through the Internet).

SISNeT combines the capabilities of satellite navigation and the Internet. Specifically, SISNeT provides access to wide-area differential corrections and the integrity information of EGNOS over the Internet. For users to access EGNOS data Internet stream a set of software is freely available on ESA websites.

The poster presents possibilities of using SISNeT information and ideas for monitoring EGNOS performance in real time with utilization of SISNeT tools. Many research projects demonstrated capabilities of online access to EGNOS information. SISNeT was used to define and develop applications for forest inventory, crisis management and other purposes. SISNeT corrections can be applied to position determination in the demanding environments. Additional SISNeT data received by the SISNeT software help in more precise and more reliable localization. SISNeT concept was also utilized in the frame of technology demonstrator projects that aimed at providing integrity for liability applications,

developing automatic road-tolling services, vessel monitoring and developing mobile terminals for receiving SISNeT information.

II. SISNeT DATA SERVER REAL TIME FUNCTIONALITIES AND UTILITIES

A. SISNeT Data Server

SISNeT online services are sources of EGNOS messages distributed by the SISNeT Data Server – a server side application called Data Server Software (DSS). The DSS implements two server processes:

- The SIS2DS Server, linking the Data Server with the EGNOS messages Base Station.
- The DS2DC Server, linking the Data Server with users.

Before sending the EGNOS messages to the users, a data compression algorithm (called SINCA) is applied by the SISNeT Data Server. The length of the EGNOS message being transferred is always less than 67 bytes. The compression algorithm frequently reduces the data size to 25% of the original size.



Figure 1. SISNeT Data Server - Graphical User Interface.

B. SISNeT User Application Software

SISNeT User Application Software (UAS) is an ESA internal tool existing since the early days of SISNeT. Indeed, it was the first implementation of the SISNeT UAS concept ever made, and provided a preliminary demonstration of the SISNeT concept feasibility.

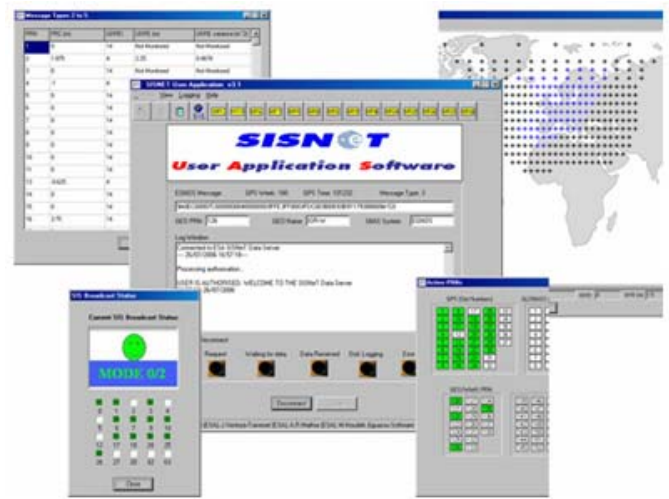


Figure 2. SISNeT User Application Software.

SISNeT User Application Software allows decoding and visual presentation of the content of EGNOS messages flowing from the SISNeT Data Server in real time. In first versions, the UAS included the capability to analyze, in real-time, a few of the SBAS messages types broadcasted by the ESTB (EGNOS System Test Bed), these messages being obtained via SISNeT in real-time. The current version 3.2.2 is prepared to analyze all the SBAS messages currently broadcasted by EGNOS. This new version is optimized to take benefit from the features introduced in the SISNeT User Interface Document (UID) version 3.1 of the SISNeT platform.

The SISNeT User Application Software that accomplishes the SISNeT interface specifications is able to obtain the EGNOS messages in real time (1 message per second or 250 bps) from the SISNeT Data Server. Moreover, the UAS can access and apply the present and future additional SISNeT services. Each specific application of the SISNeT platform is defined by a particular implementation of the UAS. The software can be embedded in different kinds of computers and electronic devices.

ESA considers the UAS 3.2.2 software as a relevant tool in support to GNSS Education (complementing SISNeTlab). The UAS is also considered relevant in several other domains; for instance, it may constitute a valuable resource for receiver manufacturers, as support to the test of SBAS receivers. The ESA UAS has been enhanced significantly allowing processing most of the SBAS messages defined in RTCA MOPS DO229C, and presenting their contents in a user-friendly form.

C. GETPOS function

GETPOS command is an idea of adjusting SISNeT Data Server function to online real time positioning functionality. This extension includes modification of positioning algorithms and adaptation of SISNeT Data Server to apply Ntrip additional corrections in RTCM format. The main innovation in adaptation of GETPOS algorithms was Pseudorange Controlling mechanism.

Prototype GETPOS function developed in the frame of the SISNeT Application project (Polish PECS contract) and implemented on SISNeT Data Server side determines user position with SISNeT corrections. Replacing pseudorange corrections by differential corrections from EUPOS network extends capability of GETPOS command and increases positioning accuracy of online services.

To achieve stable results suitable in local environment and to make use of local differential GPS corrections with SISNeT information, different types of GETPOS command (SISNTRIP) in SISNeT Data Server were applied.

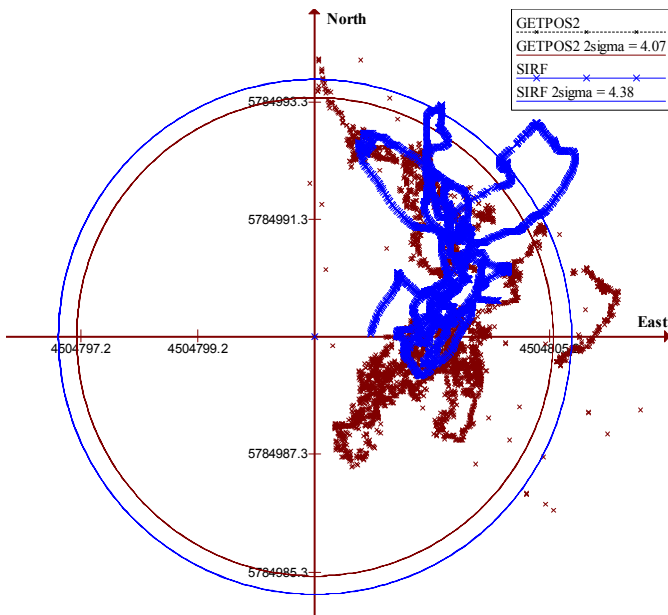


Figure 3. Comparison of GETPOS and GPS results in low urban environment.

The graph (Fig. 3) shows a comparison of positions and accuracy evaluated by SIRF chipset and GETPOS methods in low urban environment, and compared with results obtained in open sky environment where the influence of obstruction errors was small. Graph (Fig.3) visualizes the position distribution. The direction of position variances in time is clearly visible. Results of GETPOS were strictly linked with GPS autonomous position and only moved by value of the corrections vector. It resulted from more efficient processing of SISNeT information in GETPOS case.

D. SISNeT Plug-in Application

SISNeT Plug-in Application is an idea for real time online positioning with SISNeT capability developed in the frame of SISNeT Application project (Polish PECS contract). It allows correcting user position provided by any type of receiver. It is based on position distributed in NMEA format and uses pseudorange, ionospheric and tropospheric corrections obtained from SISNeT online stream.

The SISNeT Plug-in Application is a tool that provides a continuous capability of SISNeT corrections compliant to MOPS requirements and distributes them straight to a user's

receiver. It is dedicated to GNSS applications for utilization of SISNeT information.

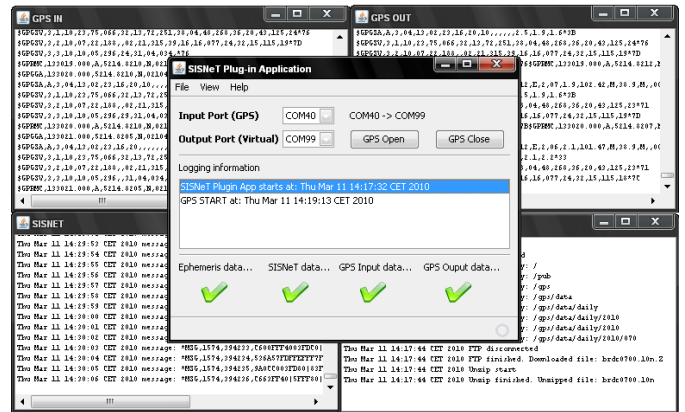


Figure 4. Running of SISNeT Plug-in Application.

The SISNeT Plug-in tool focuses principally on:

- increasing of the accuracy of positioning,
- serving as a free-of-charge tool allowing utilization of SISNeT corrections by applications that use GPS signal,
- an experimental augmentation of the positioning system using SISNeT corrections in most of GPS software available on the market,
- flexible component of SISNeT-related software allowing creation, opening and management of serial ports directly from the developed SISNeT Plug-in Application,
- implementation of SISNeT technology in a wide range of GNSS applications by using SISNeT/EGNOS signals and corrections as a base,
- high quality information about the location (position error < 3m) achieved by combining GPS and SISNeT information.

The SISNeT Plug-in Application is an advanced utility emulating RS232 serial ports (which are included in SISNeT software) providing simple and comfortable way of utilization and distribution of EGNOS corrections directly from the SISNeT Plug-in Application. A virtual port as a part of this Application is designed to communicate with external GNSS devices on RS232 connection, or through Bluetooth / USB serial interfaces. In other words, with the SISNeT Plug-in Application it is possible to create virtual serial ports and to distribute the corrected position through them.

Utilization of SISNeT corrections in the open sky environment with the SISNeT Plug-in Application produces results that are better than autonomous code measurements and increase of obtained accuracy. The position and height of coordinates with SISNeT corrections changed dynamically but in most cases values are closer to a true position over the time of measurements.

SISNeT Plug-in Application allows obtaining better accuracy and reliability of service at a level required by the user, what was confirmed by the tests. Graph (Fig. 5) depicts two data sources which were analyzed during the test. One is captured directly from the GPS receiver, another from virtual serial port with SISNeT corrections.

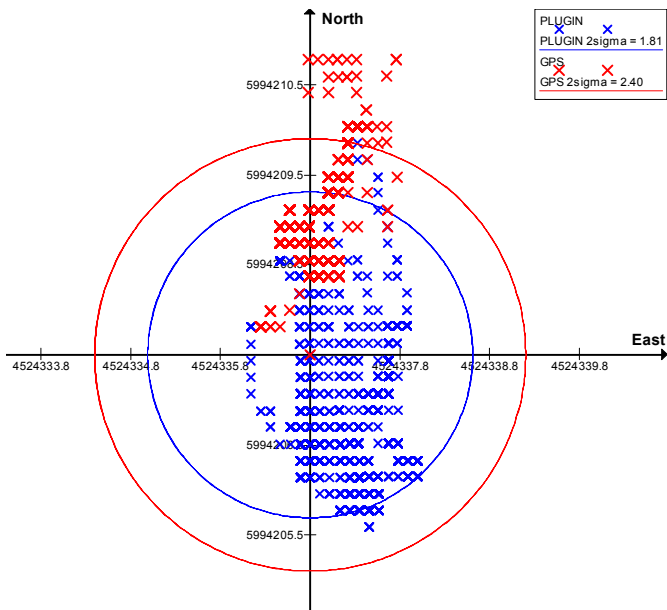


Figure 5. Comparison of input and output position.

GPS autonomous position and position with applied SISNeT corrections compared on the graph (Fig. 5) clearly shows that translation of SISNeT corrections vector changes values of position. The results of addition of SISNeT data to GPS position were caused by more accurate readings (from 2,40 m in GPS autonomous case to 1,81 m in SISNeT applied case).

III. EDUCATIONAL APPLICATION BASED ON EGNOS MESSAGE SERVER DATA (EMS FILES)

Non-real time SISNeT information distributed by SISNeT Data Server is available as EGNOS Message Server (EMS) files. SISNeT educational software tools take advantage of EMS data in post process mode.

A. EMS – EGNOS Message Server

In 2003, ESA launched the EMS (EGNOS Message Server), a 24h/24h archive of the EGNOS message broadcast through the IOR-W Geostationary satellite (PRN 126), publicly accessible via FTP. EMS constitutes an enhancement of possibilities offered by SISNeT technology: while SISNeT allows accessing the EGNOS messages in real-time, EMS permits an offline access to a huge archive of messages.

EMS stores the augmentation messages broadcasted by EGNOS in hourly text files, which are organized over a pre-defined hierarchy of directories. Each data file contains one hour of transmissions. The following organization is applied:

- Files corresponding to each day-of-year are put together into daily directories.
- Daily directories corresponding to each year are put together into yearly directories.
- Yearly directories are contained in top-level directories, each one corresponding to the transmission of a specific GEO satellite.

Since December 2004, EMS archives the SBAS messages broadcasted by GEO PRNs 120, 124, and 126 (i.e. the messages corresponding to the three EGNOS GEO satellites: AOR-E, IORW and ARTEMIS).

The EMS service demonstrates a significant potential in the independent monitoring of the EGNOS performances and the validation of SBAS receivers.

B. SISNeT Lab

SISNeT Lab software, which is available free of charge since April 2005, is a user-friendly EMS-based tool, allowing users quickly and easily assessing the performance of various SBAS systems. It gives the user a wide variety of functionalities and the graphs produced can help in comparing and better understanding the various SBAS systems.

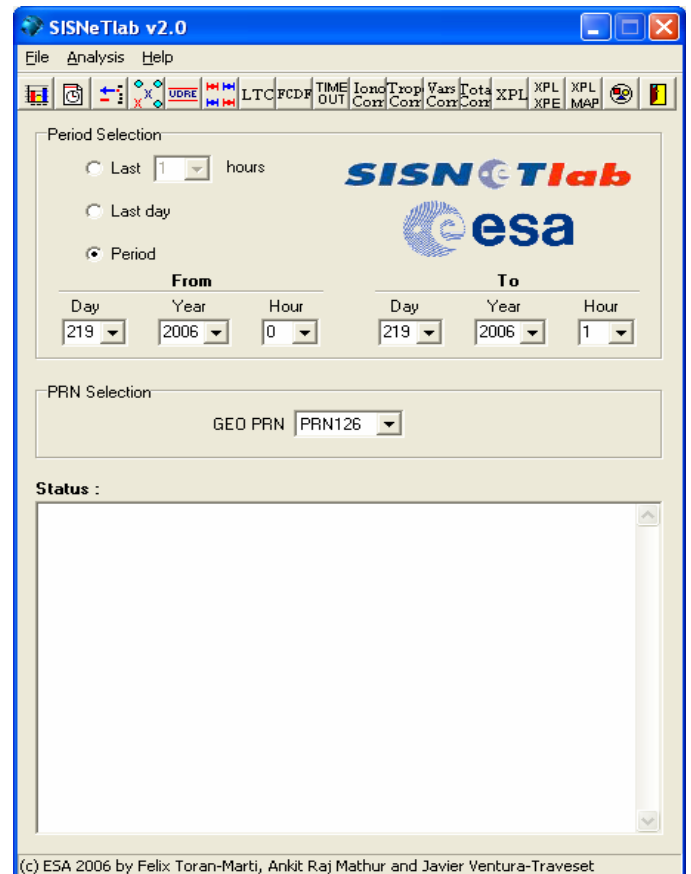


Figure 6. SISNeT Lab GUI

Main function of SISNeT Lab software is to perform various analyses on the information broadcasted in the SBAS messages

as well as to present results in a graphical and easy to understand manner. SISNeTlab offers various analytical capabilities which include: distribution of SBAS messages, different analyses at Ionospheric Grid Points, Ionospheric and Tropospheric Error Analysis, Residual Error Analysis, Total Corrections Analysis, XPL XPE Analysis and XPL availability map. This makes SISNeTlab a tool that is especially useful for the educational purposes.

SISNeTlab downloads the data corresponding to the requested period from EMS, and performs various analyses on the information broadcasted in the SBAS messages, presenting results in a graphical and easy to understand manner. This makes SISNeTlab a tool especially useful for the Educational community and allows learning quickly about SBAS systems and understanding the information they broadcast.

For any given SBAS Geostationary satellite, and for a selected period of time, the SISNeTlab offers various analysis capabilities. These include:

- Distribution of messages
- Update intervals of each message type
- Number of messages lost, if any
- Different analyses at Ionospheric Grid Points
- UDRE and Fast corrections evolution over time
- Satellite monitoring status.

Since SISNeTlab is an EMS-based tool, it is intended for offline application; in other words, this tool allows analyzing a period of previously broadcasted SBAS messages. In order to complement SISNeTlab with real-time SBAS message analysis capabilities, ESA has distributed the SISNeT User Application Software (UAS) which was mentioned in the previous chapter.

C. SBAS TeACHER

To help students better understand the SBAS messages, ESA and Iguassu Software Systems (under Czech PECS contract) have developed a simple EMS-based tool, aptly named the SBAS TeACHER (SBAS Tool for Education And Contributor to Harness EGNOS Research). SBAS TeACHER educational tool for students allows decoding and encoding different EGNOS messages in post processing mode.

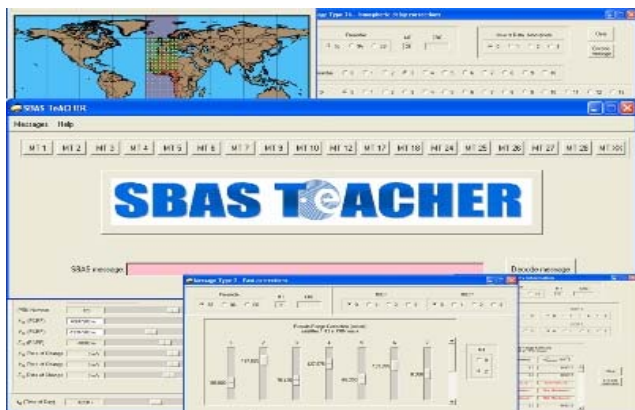


Figure 7. SBAS TeACHER educational application

One of the main objectives of the tool is to make the broadcasted EGNOS messages more clear for users. Due to the fact, that SBAS message definitions are optimized in terms of low bandwidth requirements, ability of decoding and encoding the SBAS messages in an easy way is recognized as highly advantageous. SBAS TeACHER is able to decode SBAS broadcast messages from the EMS server and to produce easy to understand snapshots for each message. The SBAS messages are displayed as a geographic plot. The SBAS TeACHER gives the possibility to define what should be broadcasted and to easily generate the correct message content.

D. SBAS MeNTOR (SBAS MESSaGE GENeRaTOR)

The evolution of the SBAS TeACHER software led to SBAS MeNTOR (SBAS MESSaGE GENeRaTOR) belonging to SISNeT educational tools family. ESA and Iguassu Software Systems (under the Czech PECS contract) have developed a simple tool, aptly named the SBAS MeNTOR.



Figure 8. SBAS MeNTOR - main software windows

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 selected time period.

IV. SISNeT DEMONSTRATION APPLICATION

Various research projects have demonstrated capabilities of online access to EGNOS information. For example, SISNeT was used to define and develop applications for forestry inventory purposes. SISNeT corrections can be applied to position determination in the demanding environments - additional data help in more precise and more reliable localization.

A. SISNeT Forest Inventory Application

One of the ways of SISNeT data utilization is the SISNeT Forest Inventory Application developed as a part of the SISNeT Application project in the frame of the Polish PECS.

For SISNeT Forest Inventory Application purposes, several field studies were conducted to evaluate the performance of DGPS/SISNeT positioning for fixing forest boundaries and single points elements in inventory process. In spite of the difficulties in getting accurate position data under tree canopies while using the GNSS methods - because of multipath, blocking of signal and other disturbances like temporary loss-of-lock – an effort was made to utilize SISNeT services.

In forest environment a reception of GNSS signals is disturbed as a result of trees obstruction. Influence of high trees and their canopies cause big errors of position and the inaccuracy of measurements. In many cases signals from EGNOS geostationary satellites are blocked because elevations of GEO's satellites are below 30 degrees. In these conditions utilization of SISNeT signal is a perfect form of distribution of augmented data for precise positioning and locating forest point and line objects and updating forest databases in real time.

The use of Internet connection and the combined use of GPS and SISNeT allow an accelerated and more precise relocation of the sample forest points. The SISNeT Forest Inventory Application aims at demonstrating advantages and easy handling of SISNeT as a positioning method. It allowed increasing efficiency and accuracy and decreasing costs of the inventory process. The SISNeT Forest Inventory Application demonstrates a possibility of utilization of SISNeT technology especially for:

- Maintenance and update of forest specific local maps.
- Localization of significant forestry places, especially storage places.
- Satellite based guidance of vehicles to the storage places.



Figure 9. SISNeT forest measurements on mobile devices

The core part of SISNeT Inventory Application is responsible for obtaining SISNeT information. Implemented and introduced SISNeT functionality for forest applications can deliver to foresters' software not only corrected position but also integrity data in very difficult deep forest environment. The SISNeT Inventory Application was an intermediary

application and for test purposes it was used as a logging and redistributing data tool. SISNeT software was developed for storage and redirected data to software which can not apply SISNeT data.

For test and demonstration purposes of SISNeT Inventory Application measurements were performed in forest control points. Selected points represent different types of forest environment. As a sample of line object a forest parcel was measured during demonstration. In the first test a route was marked out on the map and time of point collections was planned. Measurements were placed in various forest types and environmental conditions.

Test and demonstration of SISNeT technology and SISNeT Inventory Application usage took place in professional forest test and examination field in northern Poland. Different forms of SISNeT utilization were prepared for testing:

- First - a mobile and dynamic usage of PDA (mobile phone with Windows Mobile), where a mobile application was developed.
- Second type of equipment is based on DGPS model which accepts RTCM corrections.
- For static measurements a Septentrio PolaRx2e receiver was used.

As a reference for SISNeT Inventory Application tests and measurements, research of Dr Piotr Wężyk from University of Agriculture in Krakow was used. The SISNeT Forestry Inventory Application tests were referred to complex previous results which were compared with results of positioning with utilization of SISNeT corrections.

The concept of forest inventory software as a mobile terminal shows that the possible functionality and capability could improve the logistics management and database update. Nevertheless, the tests in the forestry pinpoint the difficulties of navigation system concept in forest environment and show that much effort has to be put into the integration process of the navigation sensors and SISNeT data for the mobile terminal.

B. Public projects SISNeT demonstrators

SISNeT concept was also utilized in the frame of technology demonstrator projects that aimed at providing integrity for liability applications, developing automatic road-tolling services, vessel monitoring and developing mobile terminals for receiving SISNeT information. Below are the examples of successfully finished SISNeT projects:

- SISNeT technology applied to urban buses fleet management systems.
- Development of a handheld SISNeT receiver.
- EGNOS Navigation Terminals – aimed to develop two land mobile terminals and one maritime terminal.
- ADVANTIS - aimed at providing integrity for liability-critical applications.
- ARMAS – the main objective was to assess the feasibility of an Intelligent Car Navigation System,

based on GNSS and cellular network technologies, and to provide a competitive solution for road tolling based on satellite positioning.

- MOMO – aimed to develop a preliminary demonstrator of a SISNeT navigation tool for blind pedestrians, integrated in a mobile phone.

Since SISNeT is operable, a number of demonstrations have been performed involving a large variety of user communities and, therefore, of user requirements. In particular, successful demonstrations were performed of mobile, civil aviation, helicopters, trains, maritime and precision farming applications.

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