

GNSSmeter

GNSS-based metering for vehicle applications and value added road services

Technical Paper

Authors:

Klaus Aichhorn, kaichhorn@teleconsult-austria.at¹⁾
Preet Khalsa, pkhalsa@skymetercorp.com (*Presenting Author*)²⁾
Jürgen Seybold, jseybold@teleconsult-austria.at¹⁾

1) TeleConsult Austria GmbH, Graz, Austria, www.tca.at

2) Skymeter Ltd, London, United Kingdom, www.skymetercorp.com

Summary / highlights

In the FP7 project GNSSmeter funded by the European Commission and managed by GSA (European GNSS Supervisory Authority), a road and parking pricing system based on vehicle on-board technology that can be integrated rapidly into an existing market product currently offered, is developed. The project is coordinated by TeleConsult Austria GmbH and the development is carried out with the partners Skymeter Ltd, CTAE – Aerospace Research & Technology Centre, DKE Aerospace Swiss GmbH, and the subcontractor NavCert GmbH.

At present, GPS is used as the primary positioning technology and is the key enabler of the present application. Within GNSSmeter, the existing system concept is extended by integrating EGNOS (European Geostationary Navigation Overlay Service) / EDAS (EGNOS Data Access System) integrity and augmentation data as well as Galileo measurements.

The first Galileo signals will be processed and in the near future significantly increase the ability for metering calculation especially in urban canyons. Thus, the existing GPS-only receiver chipset will be replaced by an innovative miniaturised GPS/EGNOS/Galileo chipset supporting a tailored acquisition aiding functionality. Furthermore, PVT (Position, Velocity, Time) software which incorporates GPS, EGNOS and Galileo raw measurements, will handle and process several satellite signals and additionally will carry out several integrity checks to improve the necessary charging integrity which is required for liability critical services (such as parking pricing applications). The PVT solution will incorporate augmentation data from EGNOS signal in space as well as EDAS and consider regional ERDS (EGNOS Regional Data System) data in a communication link. The regional augmentation data has the advantage that it improves the standard EDAS data by the use of regional corrections in order to further improve the quality of the augmentation data. The metering calculation software will use the GNSS (GPS/EGNOS/Galileo) raw data forwarded by the PVT software for the metering calculation which is further used for road and parking pricing calculation. The calculated position, velocity, and time from the PVT software will be used to validate the extended metering calculation software in order to provide a redundancy check. Thus, the project proposes some significant advantages over the status quo.

The project partner Skymeter Ltd will guarantee a customer related and straight forward development work of the new system and a rapid market penetration. Skymeter already can offer direct user access data from its proprietary GPS-based metering system. The market potential analysis, the system development roadmap and a high level business plan will enable a fast turn into market readiness and commercial success.

NavCert GmbH as subcontractor will upgrade project work with a certification road map. This organisation has broad experience with certification process in the field of GNSS applications. Thus, a quality and independently approved prototype will be a result of the project GNSSmeter.

System overview and technological challenges

In general, GNSSmeter is a service that is comprised of parallel, overlaid, voluntary FGPS (Financial-Grade GPS) based TDP/VMT (Time, Distance, Place / Vehicle Miles Travelled) tolling system. Its core is an on-board unit (OBU – road meter) that resides in a vehicle and transmits driving positioning information allowing the user to pay per kilometre. As a mature business, it has additional add-on pay-per-use services, such as parking

pricing, insurance, and emissions services. The GNSSmeter system is conceived to be fair, private, and easy to use.

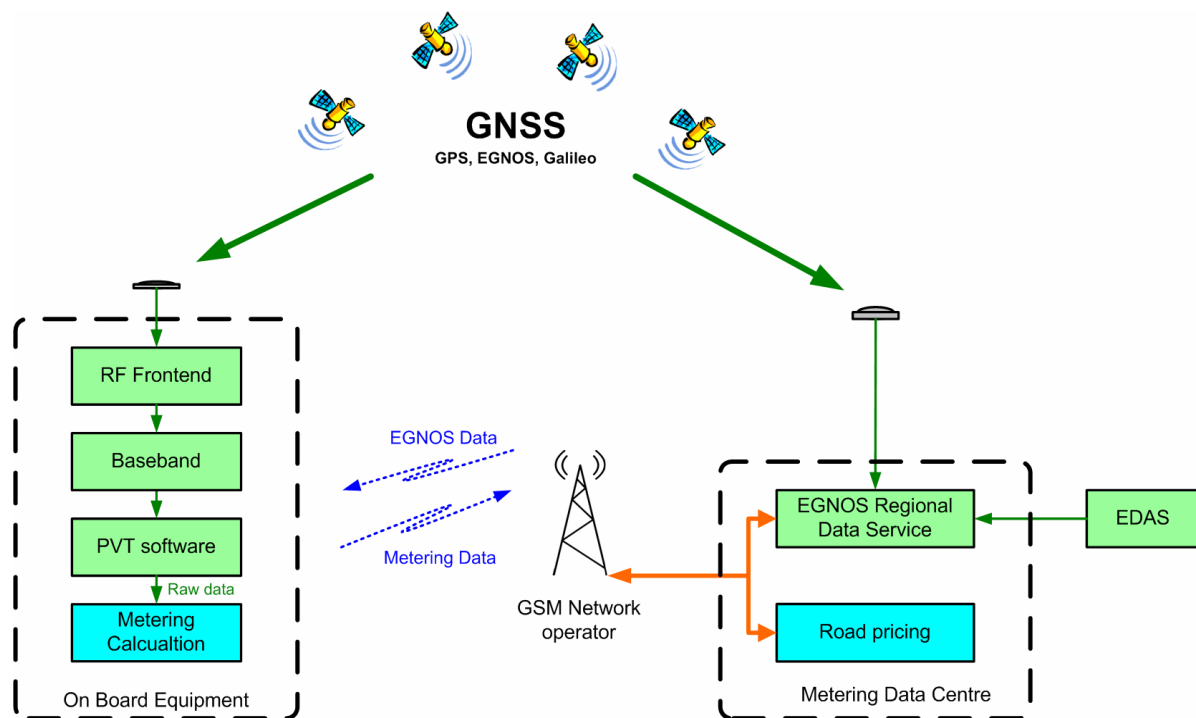


Figure 1: System concept

Parking Pricing and Road User Charging have the similar main requirements, accuracy, evidence, cost, privacy, and charging availability and are thus the target applications in the GNSSmeter project. With the exception of privacy, all of these can be addressed by GNSSmeter. The privacy requirement can be already fulfilled by the present system of Skymeter and is thus out of the scope of the project.

The most important requirement for Parking Pricing and Road User Charging is accuracy, since a sufficient positioning accuracy is the basis for the charging accuracy. The Parking Pricing requires a positioning accuracy of 2-3m which shall be achieved by EGNOS/EDAS integration into the GNSSmeter concept. For Road User Charging, the positioning accuracy requirement is about 10m. Nevertheless, RUC requires 99% accuracy in distance travelled with no more than 0.1% on overestimates and thus, the use of the EGNOS/EDAS data in the metering software can improve the current situation significantly.

When looking at the accuracy of positioning and the cause of inaccuracies, in open sky the largest component of error are ionospheric effects. This will be especially true in the coming years due to the impending solar maximum. During this time, solar storms will cause wide-spread increase in measurement error and even disruption of service due to their effect on the ionosphere. In urban areas, multipath is also critical. The purpose of EGNOS and its network of monitoring stations is to correct among others for ionospheric errors. By comparing the monitoring stations' distance measurements to the theoretical, known, distance to the satellite, the stations can deduce measurement errors, and transmit them to the geostationary satellites for re-broadcasting to users. Relying on the fact that measurement errors are temporally and spatially correlated, this information can be used by user receivers to correct their position solution.

The use of geostationary satellites, however, imposes a limit on the system that in mid and high latitude areas, the satellites will be low elevation. Since the system was mainly intended for safety of life in aviation, low elevation is not a major concern. This is not the case for ground users, especially in urban areas, where urban canyons and other obstructions often block large areas of the sky. To overcome this limitation, EDAS can be used in Europe. This system allows any user to access the EGNOS wide-area differential corrections globally, via VPN. As Skymeter hardware is equipped with a GSM module, corrections can be obtained in real-time as needed.

Evidence in general is what is used in court to prove that a charge is valid. As example, in the RUC use case, if our confidence in the position is such that the user can be in one of two zones, the cheaper zone has to be charged. Increased accuracy and better confidence improves financial performance and defending in court. Thus, "the charge is too high" argument can be refuted. Since there are no court precedents on this yet, Skymeter is making guesses based on previous history and through independent validation by NavCert.

Satellite based augmentation eliminates the need for a ground based infrastructure and thus reduces the overall costs. This is an important element of cost within the project and the target system. Thus, GNSSmeter focuses towards the integration of EGNOS and EDAS into the overall Parking Pricing and Road User Charge concept of Skymeter. At present, the used receiver chipset in the Skymeter on-board unit only delivers GPS data and the presently used metering calculation software is only capable of processing GPS measurements. Within GNSSmeter, a GNSS module processing EGNOS data is used and the metering software is extended to be able to process EGNOS data.

The overall GNSSmeter target architecture is depicted in the following figure.

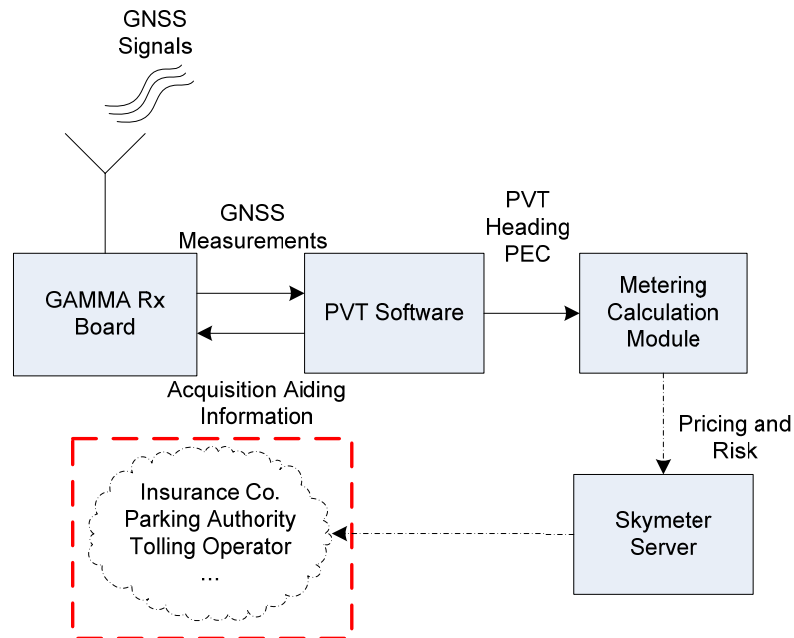


Figure 2: GNSSmeter architecture

The GNSSmeter architecture is split into a GNSS (GPS/EGNOS/Galileo) receiver board, a PVT software, a metering calculation module, a connection to the Skymeter server and subsequent connections to external parties interested in the data, shown here outlined in the red, dotted line as they are not within the scope of this project. The receiver board is responsible for the acquisition and tracking GNSS signal processing functions. Once the initial position solution and the almanac information are available, the receiver board can utilize acquisition aiding information from the PVT software module.

Technology demonstration

Parking Pricing seems to be the first application that can use the GNSSmeter system. This is because the needs for accuracy and evidence are most critical here. This is also an application that has never been addressed by GNSS and seems to be a very interesting market for EGNOS/EDAS. Skymeter has parking trials already with customers in North America and Europe and thus, would introduce the GNSSmeter improvements to these pilot implementations.

The first of these is parking in the City of Winnipeg in Canada. There are currently 25 cars equipped with a non-SBAS enabled device as part of a trial project. Based on meeting some targets, this will increase to 1,000 vehicles in 2011. There is a good relationship with the City. So we will introduce a small number of GNSSmeter devices for comparison against the previous generation using WAAS.

The City of Haarlem in the Netherlands has agreed to a 100 vehicle pilot using Skymeter's system. The first five cars will be equipped before the end of 2010. The remaining will come in 2011. As with Winnipeg, we would seek agreement to implement some GNSSmeter devices in parallel as a demonstration platform in the field.

For Road User Charging, demonstrations in the City of Barcelona are planned at present, where the overall Road User Charging functionality can be shown. For these demonstrations, the targeted customers (IBM, egis projects, Siemens, sanef, ASFINAG, and Transfield Services) for the GNSSmeter RUC application get invitations. Beside the demonstration, a GNSSmeter presentation at the above mentioned stakeholders is envisaged.