Multiple Use of GNSS On Board Units:

Electronic Tolling and other Mandatory Services

Norbert Schindler
Global Sales Manager, Siemens Electronic Tolling
Siemensstrasse 90, 1210 Vienna, Austria
norbert.m.schindler@siemens.com

Abstract
In recent years, the mandatory use of solutions based on Global Navigation Satellite System (GNSS) technology to meet various regulations of European states has grown significantly. This is especially the case for Heavy Goods Vehicles (HGVs), which are required to pay distance-based tolling fees in an increasing number of European countries. Also on the rise are requirements for tracking the transportation of specific goods, such as livestock or dangerous materials. In an increasing number of countries, Customs and Tax Authorities are starting to use GNSS-based solutions to track the transportation of all products being imported, exported, or in transit – also to identify tax fraud. We present the ability of a new generation of GNSS On Board Units (OBUs) which are cost-effective, easy to install, and provide high position accuracy in order to address the demanding requirements of electronic tolling systems and other mandatory services.

Keywords:
Global Navigation Satellite System, Electronic Toll Collection, On Board Unit.

Introduction

Since the launch of the nationwide truck tolling scheme in Germany ten years ago, Europe has witnessed a rapid growth in satellite-based solutions installed in vehicles for a variety of applications. Although a large majority of these position-based services are chosen for convenience, the installation of GNSS-based hardware in vehicles to comply with mandatory legislation is growing significantly. Heavy Goods Vehicles are now required to pay distance-based tolling fees in a growing number of European states. Furthermore, there are an increasing number of regulations that require tracking the transportation of various goods, such as livestock or dangerous materials [1]. Until now, various satellite-based solutions have been implemented to address these required regulations. As the deployment of automotive devices using GNSS-based technology is becoming more widespread, particularly with the growth of distance-based road user charging schemes, there is an increased motivation to find

a common hardware platform that is both robust and flexible enough to address the diversity of requirements of these GNSS solutions. Based on the experience of four generations of the GNSS-based OBUs for electronic tolling [2], we have developed a GNSS platform which delivers very high position accuracy due to the combined use of GPS, GLONASS, EGNOS, and now also GALILEO [3]. This GNSS platform is suitable for providing applications that address a variety of regulations throughout Europe, most particularly:

- tracking and tracing of dangerous good vehicles;
- tracking and tracing of livestock;
- tracking and tracing of transit vehicles and of goods entering and leaving the country.

Figure 1 – Three Generations of GNSS OBUs in deployed in Europe for Tolling

The Spread of GNSS Technology in Electronic Tolling

New truck tolling schemes have been implemented in Slovakia and Hungary based on GNSS technology, and currently Belgium and Russia are implementing satellite-based solutions of their own. In the European Union, the vision of the initiative for European Electronic Tolling Service (EETS) has led to the development of Hybrid GNSS solutions which will enable a vast majority of trucks travelling throughout the Union to have a single installed device that enable compliant and automated electronic tolling in all member states [4]. Since GNSS OBU technology will be deployed in an increasing majority of heavy goods vehicles in the coming years, there are a number of valuable GNSS-based services that can take advantage of this wide installation base of GNSS hardware which will become interoperable throughout Europe.

Tracking and Tracing of Dangerous Goods Vehicles

The European Agreement on the International Carriage of Dangerous Goods requires the monitoring of the transport of dangerous goods. The European Directive 2008/68/EC of 24 September 2008 on the inland transport of dangerous goods does not specify the use of a tracking and tracing system, but recommends the use of GNSS-based solutions. The advantage of using GNSS positioning is clear; consequently there is a growing demand for this technology for organizations trying to comply to this agreement effectively. In Italy alone, thousands of GNSS-based tracking devices have been deployed for this reason.

In addition to increasing safety, transport operators make use of GNSS tracking and tracing systems to continuously supervise and monitor their vehicle fleet. GNSS devices are installed in the vehicle that regularly transmit position coordinates to a monitoring center in order to ensure that the position, time, speed, and the route are maintained without deviations with respect to the predefined route.

Tracking and Tracing of Livestock

The use of GNSS for tracking and tracing vehicles that transport livestock is mandatory according to European Council Regulation (EC) No 1/2005 on the protection of animals during transportation. This legislation requires that the GNSS tracking and tracing systems are used to monitor travel times and stops, for example, to ensure compliance with the regulations. The GNSS OBUs installed in the vehicles are connected to a communication network, such as GSM, to provide positioning data to the monitoring centre which supervises the transport.

In order to comply with these European regulations on tracking and tracing, domain-specific GNSS-based solutions have been developed [5]. With the anticipated spread of mandatory satellite-based tolling solutions for HGVs in Europe [6], it would be advantageous (particularly with respect to implementation and operational costs) to establish a common platform in which GNSS-based solutions that support all regulatory requirements for position monitoring.

New GNSS-Based Monitoring System along Transport Corridors

The Customs Union of Belarus, Kazakhstan and Russia is currently investing $28 million in a comprehensive pilot project for the management of the international transport corridors located on the territories of these countries. The international transport corridors in the Customs Union, more than 5,600 km in length, provide significant international cargo and passenger transportation between separate geographical areas. The current project involves the design, development and creation of a hardware-software complex for the management of these transport corridors. Road authorities as well as users of these corridors (i.e. transport companies) should be provided with detailed information on the state of the transport

infrastructure, i.e. the individual roads in the network, as well as statistics which can be used by organizations responsible for the condition and safety of transport corridors [7]. Using the Siemens GNSS platform as a basis, new hardware and software extensions will be developed with partners in Belarus having the ability of:

- remote monitoring of the transportation of goods, also in demanding environments with respect to GNSS signal reception, such as canyons and dense urban areas;
- monitoring weather conditions in the area of the transport corridor, and providing information and alerts of adverse conditions via the platform;
- remote monitoring of damages to road infrastructure (such as dams, bridges, tunnels, viaducts, protective structures).

Electronic Public Road Trade Control System

Missing trader fraud, i.e. the theft of Value Added Tax (VAT), has become a growing concern within the EU since the movement of goods between of EU member states is VAT-free. An organization committing this crime charges VAT on the sale of goods and absconds with the VAT rather than handing it over to the state's tax collection authority. Or fraudulent tax declarations may be made to "re-claim" the VAT within the country for products that it claims originated from another member state although the products were produced domestically. According to a BBC report, missing trader fraud is estimated to cost European governments up to €240 billion per year. [10].

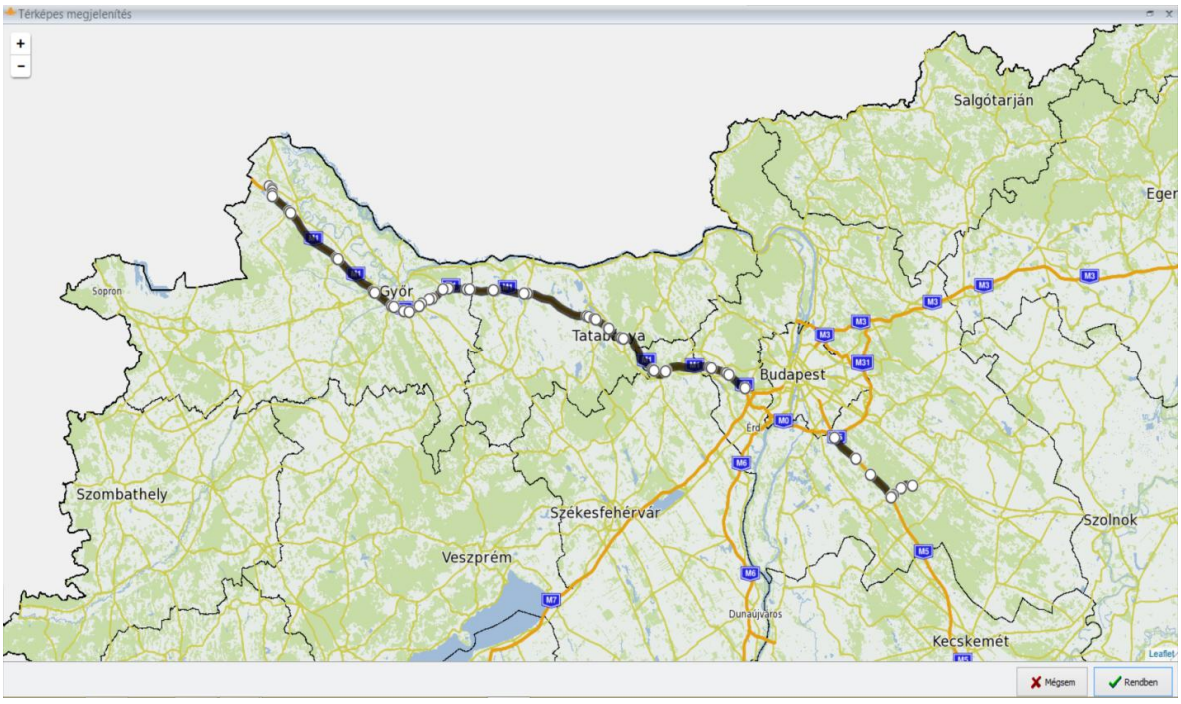

Figure 2 – Tracking Results of Hungary's Electronic Public Road Trade Control System

At the beginning of 2015, an Electronic Public Road Trade Control system was launched in Hungary to enforce VAT tax laws. By using this new system, the actual route of the goods can be tracked since transport-related data is registered in a central electronic system before the transport commences, as illustrated in Figure 2. Thus, the actual delivery of goods to and from specific warehouses where import and/or export has been declared, can be monitored.

Such a detailed monitoring system requires a high level of technological complexity and, one might think, a significant investment. However, since Hungary introduced GNSS-based electronic tolling system on all of its major transit routes in 2013, the new Electronic Public Road Trade Control system could take advantage of the existing tolling infrastructure for monitoring the movement of all transport vehicles. The required capital investment for this system was so minimal, that it paid for itself with a few weeks. In fact, the VAT surplus during the first 6 months of system operation (compared to the same period in the previous year) approached nearly €500 million, which is approximately the income generated by nationwide truck tolling scheme on the tolled road network of 6,690 km over the period of 12 months.

Multiple Services on a Single Platform

As illustrated in Figure 3, an open GNSS platform, using the European Electronic Tolling System (EETS) as basis, could be extended to include the kinds of multiple services described above. In addition to the toll charging data, the Front End (either the OBU or the Proxy) can also be configured to send positioning data.

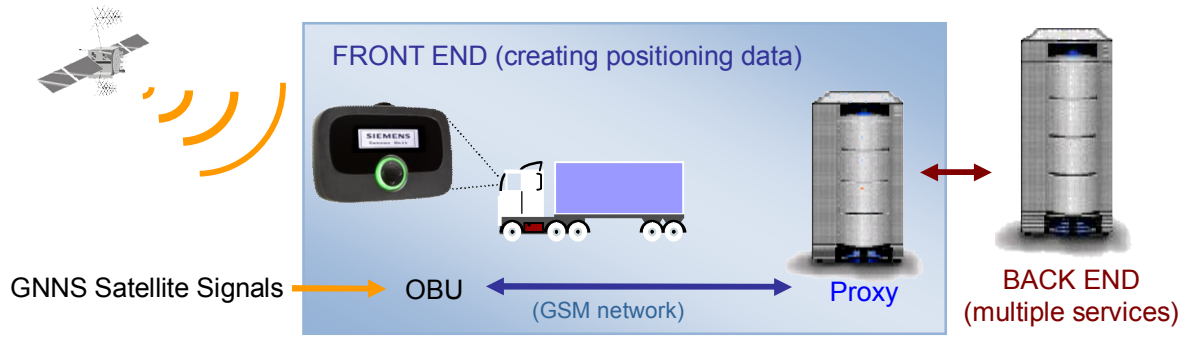

Figure 3 – Common Platform for Multiple Positioning Services

Information provided by the OBU can be used as the basis for individual or global services. Depending on the service definition, these services may be based on personal or anonymous data. Aggregation of information may open up a range of new services that can serve the interest of the public [8].

The multi-purpose GNSS-based OBU captures Road Usage Data from every vehicle and transmits the data to the back office for further processing. Consequently, the OBU which until now has been the key component of satellite-based Electronic Toll Collection systems also forms the centerpiece of all mandatory (and optional) GNSS-based services.

The “plug and play” OBU illustrated in Figure 4 can be installed by the driver within a few minutes by a connected to the windshield (either with suction cups or with a glued holder). The OBU is permanently connected to the vehicle’s power supply, either through a cigarette lighter connection or by fixed cabling. Once installed, the OBU operates completely on its own, establishing a communication link to the Proxy. The OBU is automatically switched on and off either through the connection to the ignition or by a movement detector (when the power connection is made via the cigarette lighter). A built-in backup battery ensures that the OBU remains functional in case the main power connection is interrupted.

Figure 4: Plug and Play GNNS-Based OBU

In addition to the toll charging data, the Front End (either the OBU or the Proxy) can also be configured to send positioning data for other mandatory services. This could include the transmission of data depending on the location (i.e. data sent at specific locations of interest) or depending on certain events (e.g. when the driver presses a button on the OBU).

Furthermore, information can be provided that can be used for other services, such as events recorded or determined by the front-end which can be used for detecting accelerations

exceeding certain limits (e.g. resulting in crash warnings) or the monitoring of GSM coverage for the detection of blind spots.

Information provided by the OBU can be used as the basis for individual or global services. Depending on the service definition and the agreements of the affected persons, these services may be based on personal or anonymous data. Aggregation of information may open up a range of services in the interest of the public.

Summary

After many years of deployment experience, the robust, cost-effective, and user-friendly GNSS platform for distance-based road user charging lends itself to become the basis of more diverse and more demanding applications, particularly in domains in which regulations require tracking of positioning data. The demand for tracking and tracing grows constantly – both at the European level and within European states. The Hungarian Customs Authority has established the Electronic Public Road Trade Control System to control the flow of goods entering and leaving the country in order to combat the level of cross-border tax fraud. This Control System has been relatively easy to implement since the all trucks travelling in Hungary are obliged to declare and to pay a distance-based fee on a large majority of the road network (including the border crossings). The synergies of applications based on GNSS positioning are obvious and have until now been exploited only minimally. Through the current research and development projects described above, new opportunities will unfold not only with respect to creating more cost-effective solutions, but also to establish the technological basis upon which to provide a completely new generation of services and applications in road traffic [9].

References

1. Diana, F., et al. (2012). EGNOS2ROAD: Assessing Benefits for Road Applications. In Proceedings *International Week on Space Applications*, Toulouse. Centre National d'Etudes Spatiales.
2. Schindler, N. (2009). Fourth Generation On Board Unit for Cost-Effective Automated Electronic Tolling. In Proceedings *16th World ITS Congress*, Stockholm. ERTICO (ITS Europe).
3. Schindler, N. (2012). Combined Use of GLONASS and GPS in Electronic Tolling. In Proceedings *19th World ITS Congress*, Vienna. ERTICO (ITS Europe).

4. Schindler, N. (2013). On Board Unit for the European Electronic Tolling Service. In Proceedings *9th ITS European Congress*, Dublin. ERTICO (ITS Europe).

5. Kalden, O., et al. (2013) Nutzung des EGNOS Data Access Service (EDAS) im Straßenverkehr. In Proceedings *POSNAV ITS*, Berlin. Deutsche Gesellschaft für Ortung und Navigation.

6. Tschulik, P., Schindler, N. (2014). New Hardware Platform Supporting Interoperability of European Electronic Tolling System. In Proceedings *10th ITS European Congress*, Helsinki. ERTICO (ITS Europe).

7. Busel, A.V., Kazakov, V.V. (2014). Creation of hardware and software for management of international transport corridors to ensure traffic safety. In Proceedings *MNPC Safe Roads*, Moscow, 22 April, 2014.

8. Schindler, N. (2013). Hybrid Electronic Tolling Solution for France. In Proceedings *20th World ITS Congress*, Vienna. ERTICO (ITS Europe).

9. Seppo, Ö., Pöyry, E. (2014). Government and industry joint effort: Enabling next generation services and applications in road traffic. In Proceedings *10th ITS European Congress*, Helsinki. ERTICO (ITS Europe).

10. Kemp, P. (2008-10-04). "Fraudster's 'pop star' lifestyle", BBC News.