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SOME INTEROPEARBILITY PROBLEMS OF EUROPEAN ELECTRONIC TOLLING SERVICE

The paper refers to some problems of the European electronic tolling service. The existing EETS systems in the European Union member states are not interoperable due to many differences. European Commission has taken bold steps to address that issue. The first one was Directive 2004/52/EC on the interoperability in the Community. The second was decision to launch Europe's own Galileo system. The third was EC decision from 6 October 2009 based on CESARE and RCI projects. Furthermore, the Motor Transport Institute researches in mentioned matters have been presented too.

PROBLEMY INTEROPERACYJNOŚCI W ZAKRESIE EUROPEJSKIEJ USŁUGI OPŁATY ELEKTRONICZNEJ

W referacie przedstawiono problemy interoperacyjności europejskiej usługi opłaty elektronicznej. Istniejące systemy opłat drogowych w państwach członkowskich Unii Europejskie nie są interoperacyjne z wielu powodów. Komisja Europejska podjęła ważne kroki w tym zakresie. Pierwszym była dyrektywa 2004/52/WE, dotycząca interoperacyjności we Wspólnocie. Drugim była decyzja o wdrożeniu systemu Galileo. Trzecim decyzja z dnia 6 października 2009 r., na podstawie wyników projektów CESARE oraz RCI. Ponadto wyniki badań, prowadzonych przez Instytut Transportu Samochodowego w powyższym obszarze, zostały także przedstawione.

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1. INTRODUCTION

There are two different types of European Electronic Tolling Service (EETS): Dedicated Short Range Communication (DSRC) and GPS/GSM based systems.

The first system (DSRC) is typically used as the primary method of charging where a charge is to be applied at one of a discrete number of specific points, such as a toll plaza (an area where tollbooths are located) or a location on the open highway. All electronic tall systems using microwave technology all over the world have the same structure, which utilize vehicles equipped with transponders (electronic tags), toll and control gantries, in-road/roadside detection and classification sensors, computerized system (hardware and software) and wireless communication (5,8 GHz nearly all over the world, only 5,9 GHz in USA), as well as enforcement technologies.

The second system is based on an innovative combination of mobile telecommunications technology (GSM) and the satellite-based Global Positioning System (GPS). The main element of the automatic log-on system is the On-Board Unit (OBU). With the aid of GPS satellite signals and other positioning sensors, the OBU automatically determines how many kilometers have already been driven on the toll route, calculates the toll based on the vehicle and toll rate information that has been entered, and transmits this information to the computer centre for further processing. Software will be supported with electronic road maps and data of users registered as well as data charges of highways and expressways.

The electronic toll collection systems in the European Union member states are not interoperable due to differences in charging concepts, technology standards, classification and tariff structure, legal and institutional backgrounds. European Commission has taken bold steps to address that issue. The first one was Directive 2004/52/EC of the European Parliament and of the Council of 29 April 2004 on the interoperability of electronic road toll systems in the Community [2]. The second was decision to launch Europe's own Galileo system, that is predicted to improve upon both the accuracy and reliability of GPS. On June 26, 2004, the US and EU signed an agreement to coordinate Galileo and GPS.

The requirements of that directive will be implemented in Poland based on the Act from 7 of November 2008 and some other acts [5]. It stressed that toll collecting charge institutions should be able to carry out electronic toll transactions from 1 of July 2011.

Interoperability of road charging solutions is a long-term objective of the EC and as mentioned earlier, the directive 2004/52/EC of the European Parliament and Council on the interoperability of electronic road toll systems in the Community was adopted in April 2004. The new road charging service that is interoperable throughout Europe on the basis of one or more of the mentioned technologies is called the European Electronic Tolling Service (EETS).

2. TECHNICAL AND ECONOMICAL ASPECTS OF EETS

According to data presented by EFKON AG[4] the implementation costs of Electronic Toll Collection System using GPS/GSM technology are a little more (abort 20 %) than Dedicated Short range System (DSRC) in the beginning implementation including roadways below 1000 km and assumption of 300 000 on-board units (OBU's).

[4] Andreas Weiss, Director Business Line Toll. EFKON AG. Presentation in General Department of National Roads and Motorways, 8 May 2009.

The costs of mentioned systems are equal in roadways total number of 1000 km. Furthermore, above 1000 km, the costs of GPS/GSM based system are getting definitely decreased (to 60 % with total number of roadways – 3000 km), but the costs of DSRC system are decreased only a few percent (fig 1).

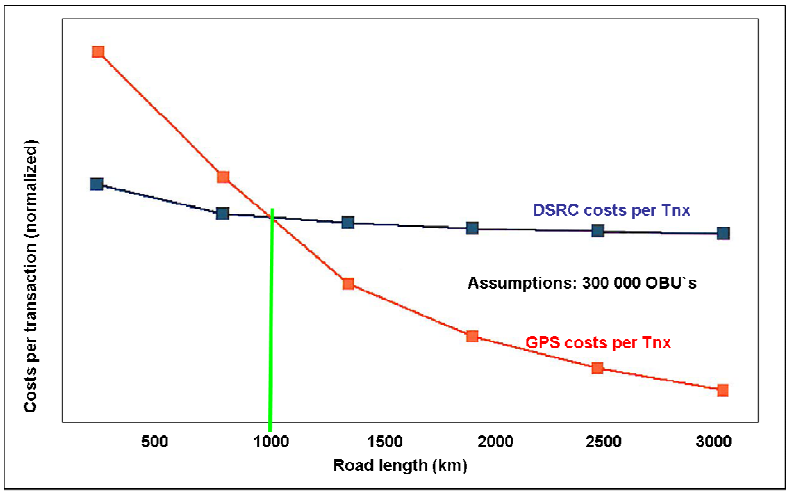

Fig. 1. EETS implementation costs comparison between DSRC and GPS/GSM systems

For road networks >1000 km European Electronic Toll Service using GPS/GSM technology is higher cost-efficient. Charging secondary roads/extending network with using GPS/GSM technology is the choice.

The profit of Electronic Toll Collection System (DSRC) in Czech Republic implementation was 213 million Euros in 2007 and 236 millions Euros in 2008. There were 357 000 registered OBU`s in 2008, and 380 000 OBU`s in the beginning of 2009. The daily profit of using DSRC system in Czech Republic is 740 000 Euros. Based on analyzes it is known that profit of operating system will be 2,5 billion Euros by 10 years[5].

The implementation cost of Toll Collect System in Germany was about 1 billion Euros. Yearly profit from system is 3,5 billion Euros.

One of reasons to introduce Toll Collect in Germany was problem to check exactly routine of trucks, especially invaders and mistakes in fee calculations. The monitoring data: who, when and why goes this way no other in DSRC system depends on many persons and more time, what increases cost of operating system.

Furthermore in free space microwaves (5,8 GHz) travel in straight lines as do optical waves. Near the Earth, however, the atmosphere has an index of refraction which normally decreases with distance above the Earth and causes the wave to travel in a circular path which bends slightly toward the Earth. Microwaves are reflected and refracted by objects just as are optical waves.

[5] Václav Černý, Transport Ministry. Presentation on International Congres ITS, Prague 29 March – 1 April 2009.

Taking into consideration problems of microwave propagation, especially in urban and mountain areas, Czech Republic Government signed new contract with Kapsch in 2008 to implement hybrid system, which includes DSRC technology in actual roadways (972 km) and new GPS/GSM technology on new motorways and expressways.

Tab.1. Comparative study of Electronic Toll Collection Systems in Europe

Characterization	Austria[6]	Czech[7]	Germany[8]
Introduction date	01.01.2004	01.01.2007	01.01.2005
Admissible weight	> 3,5 tony	> 3,5 tony	> 12 ton
System cost	1010 M€[9]	780 M€[10]	1240 M€[11]
Technology	DSRC	DSRC	GPS/GSM
Tariff/km	0,155 € 0,217 € 0,325 €	0,068 € 0,11 € 0,15 € 0,21 €	0,09 € 0,10 € 0,11 € 0,12 € 0,13 € 0,14 €
Average charge	0,26 €	0,124 €	0,115 €
Budget revenues (2008)	825 M€ 12 %	236 M€ 5 %	3,5 B€ 22 %

Source: Based on Markus Liechti, Nina Renshaw, A Price Worth Paying. A guide to the new EU rules for road tolls for lorries. European Federation for Transport and Environment.

[6] Friedrich Schwarz-Herda, Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT). *Interurban road pricing: The Austrian Experience*, presentation to IMPRINT-NET group, Brussels, 2006.
[7] Václav Černý, Transport Ministry. Presentation on International Congres ITS, Prague 29 March – 1 April 2009.
[8] According to German Ministry of Transport, Construction and Urban Development: www.bmvbs.de
[9] The company ASFINAG, responsible for the introduction of the EFC system, decided finally for the Italian motorway operator Autostrade S.p.a. as the best bidder in the evaluation process. Autostrade, respectively its Austrian subsidiary EUROPPASS signed a contract. The contract has an equivalent value of 750 million Euro. The operator users for Toll collection a microwave based DSRC technology, 5,8 GHz compatible to the CEN standard with road-side radio-antennas on each motorway section between junctions. The implementation of the system took 18 months as it was requested in the tender. Source: *PIARC Seminar on Road Pricing with emphasis on Financing , Regulation and Equity.* Cancun, Mexico, 2005, April 11-13 1/8. Additional Construction cost of the nationwide truck toll system for Austria is about $340m (E260m) using 2005-03 exchange rate $1.3=E1. Source: Toll Road News.
[10] The Transportation Ministry announced in early October (2005) that the system has cost 780 Million Euros for the Czech Republic, and was promised to give return on investment by 2010. The consortium of Ascom Fela, Damovo and ABD group presented the lowest bid. The consortium requested 15 billion Kč (530 Million Euros) with which to build and run the electronic toll system for 10 years. Meanwhile, Autostrade has offered its system for 17.5 billion Kč (620 Million Euros), Kapsch/PVT has asked for 22 billion Kč (780 Million Euros); and a consortium of A-WAY, AZD Praha, Efkon and EGIS Projects proposed 33.7 billion Kč (1200 Million Euros) to build and run the system. The system has cost 780 Million Euros for the Czech Republic, and was promised to give return on investment by 2010.
[11] Based on: www.bmvbs.de

3. ROAD CHARGING INTEROPERABILITY (RCI) PROJECT

Within the framework of EETS researches the three-year (2005 – 2008) Road Charging Interoperability (RCI) project, which is partially funded by the DG Energy and Transport of the European Commission, was developed by Consortium currently consisting of 27 partners, including toll operators, suppliers, truck makers, representatives of both the DSRC and the GNSS[12] communities, and some specialist companies providing expertise on the relevant research issues [3].

RCI Project was implemented and tested this framework in field trials at six sites as follows: Austria (ASFINAG), Germany (TOLL COLLECT), Italy (TELEPASS), France (TIS PL), Spain (VIA-T), Switzerland (LSVA).

The EC co-funds the Road Charging Interoperability (RCI) project to demonstrate and validate how RCI interoperable prototypes seamlessly, and without user intervention, adapt functional behaviour when crossing the border according to the rules that apply for the German, Swiss, French, Spanish, Italian and Austrian tolling schemes. This contracted RCI mission was to be based on specifications that would be provided by the EC-coordinated expert groups (EFC) and the European Committee for Standardization (CEN). Although the EFC and CEN have delivered a specification for a number of important elements of the EETS, there has not been a clear definition or architecture for the EETS and several of the specifications needed are still missing. RCI therefore defined itself a high-level architecture for interoperability that is based upon work of the CEN and ISO standardization committees and the ASECAP[13] tolling operators' and Member States' Stockholm Group role model (CESARE III). The RCI architecture defines the technical detail of the interfaces for road charging systems that are interoperable in a manner that they correspond to the interfaces between the business entities that together operate the service: the Toll Charger, the Toll Service Provider and the Service User (fig.2).

In the RCI architecture two charging principles for a tolled infrastructure are supported by DSRC-based tolled infrastructure (charging data is generated in a real-time DSRC communication between the OBU and roadside microwave beacons) and GNSS enabled tolled infrastructure (data enabling GNSS tolling is generated in the OBU autonomously and the GNSS charge data is forwarded via the central system of the EETS).

The RCI architecture, presented to the EC in February 2007, represented a first European technical reference for DSRC- and GNSS-enabled road charging solutions that is accepted by the principal stakeholders (suppliers, toll operators and Toll Service Providers). Through demonstration, validation, consultation and awareness-increasing workshops, the RCI project intends to contribute to the further work on the EETS specification (and eventual standardization) and help to avoid delays in the future deployment of road charging systems or barriers to the introduction of interoperability.

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[12] GNSS (Global Navigation Satellite System) is the standard generic term for satellite navigation systems that provide autonomous geo-spatial positioning with global coverage. GNSS-1 is the first generation system and the combination of GPS and GLONASS**.** GNSS-2 is the second generation of systems that independently provides a full civilian satellite navigation system, exemplified by the European Galileo positioning system.

[13] ASECAP is the European professional Association of Operators of Toll Road Infrastructures. It gathers and represents 17 Full Members (France, Italy, Spain, Portugal, Greece, Norway, Austria, Hungary, Croatia, Serbia, Belgium, the Netherlands, the United Kingdom, Poland, Denmark, Slovenia, and Ireland) and 4 Associate Members (Germany, Morocco, the Slovak Republic and the Czech Republic).

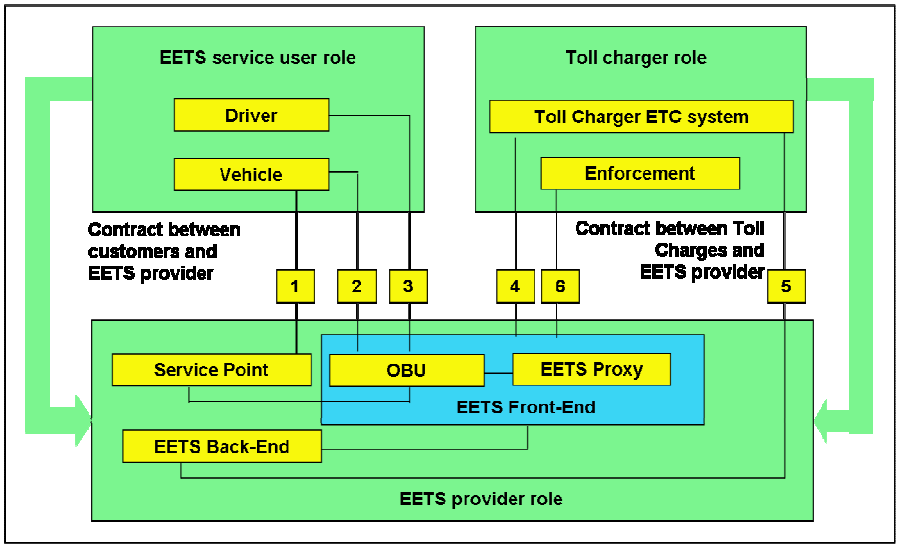

Fig. 2. RCI Project architecture [2]

The RCI architecture includes 6 interfaces. Interface 1 provides an in-vehicle access point for the servicing and maintenance of road charging OBU. Interface 2 defines how the OBU can be installed in a vehicle. Based on high-level toll assurance needs, the operation of EETS requires a tamper-detecting fitting of the OBE in the vehicle. Furthermore, such an interface can clear the way to additional applications like VAS (Value Added Services) or allow for the easy use of already available (pre-/line fitted) vehicle components like antennas for GNSS/DSRC etc. Interface 3 provides access to the OBU for human interaction. Interface 4 enables sending toll charge data (also called use data) from the EETS Provider's Front-End to the Toll Charger's back-office. This interface can also be used for localization support via (augmentation) support beacons but only if the operation of location support beacons is considered the responsibility of the Toll Chargers. Interface 5 enables the exchange of the specifications that define the specification of the Toll Chargers' tolled infrastructure (charge objects, charge events, tariff structure) and the expected behaviour of the EETS Providers systems when transmitting data (GNSS Charge Data format, frequency). Interface 6 enables the Toll Charger to carry out enforcement and compliance checking transactions with the OBU.

The final and ultimate task within the project was the demonstration phase (also called the Operational Testing): two trucks, each equipped with one interoperable OBU that seamlessly, and without user intervention, adapts functional behaviour when crossing borders, according to the rules that apply to the Germany, Switzerland, France, Spain, Italy and Austria tolling schemes. OBU TRIPON EU (fig. 3) from FELA was tested within the of RCI project.

The final report stresses that RCI technical architecture should include the interfaces 4, 5 and 6, and sufficient to provide the levels of interoperability required for the EETS. RCI has been in close cooperation with CEN TC 278 WG1 which is working on finalizing

the standards which will provide the definitions for the key interfaces 4, 5 and 6. These standards will be fully open and available.

Fig. 3. OBU - TRIPON EU (http://www.fela.ch/) (OBU presented and accepted in 12 November 2008 in Brussels in RCI frame)

RCI final report makes recommendations to [3]:

- continue and finalize the standardization of the interfaces (CEN) and the work on the contractual aspects,
- take into consideration the open issues (who defines charge objects' coordinates, who is responsible for augmentation systems and privacy),
- define the technical EETS architecture and the interfaces, which are necessary for interoperability as elements in the EETS definition,
- determine the responsibility of the EETS Provider for the EETS Front-End (including the OBU) must be stated very clearly in the EETS architecture,
- initialize/coordinate activity envisaging the tools needed for performance monitoring that can help establishing trust, beyond EC marking,
- prepare for the EETS (industrial development, pilots, improvements),
- work with all stakeholders on a clear European roadmap of how progress will be made in the three years after the decision is finalized. This roadmap should make clear how the private sector can take its responsibility in the context of Member State action, European coordination and EC involvement.

4. THE EUROPEAN COMMISSION DECISION PROPOSITION OF EETS

Based on RCI program researches, Commission of the European Communities has implemented Decision on the definition of the European Electronic Toll Service (EETS) and its technical elements [1]. EETS sets out the necessary technical specifications and requirements for that purpose, and contractual rules relating to EETS provision. Decision lays down obligations on EETS Providers, Toll Chargers and EETS Users. EETS domain means a toll domain falling under the scope of Directive 2004/52/EC.

EETS Provider means a legal entity fulfilling the requirements and registered in a Member State where it is established, which grants access to EETS to an EETS User.

Toll Charger means a public or private organization which levies tolls for the circulation of vehicles in an EETS domain.

EETS User means a (natural or legal) person who subscribes a contract with an EETS Provider in order to have access to EETS.

On-board equipment means the complete set of hardware and software components required for providing EETS which is installed on board a vehicle in order to collect, store, process and remotely receive/transmit data.

Interoperability constituents means any elementary component, group of components, subassembly or complete assembly of equipment incorporated or intended to be incorporated into EETS upon which the interoperability of the service depends directly or indirectly, including both tangible objects and intangible objects such as software.

EETS Users do not interact directly with Toll Chargers as part of EETS. Interactions between EETS Users and EETS Providers (or their OBE) can be specific to each EETS Provider without compromising EETS interoperability.

Electronic interfaces between EETS Providers and Toll Chargers fall into two categories: Electronic interfaces at the roadside between the EETS Provider's OBE and the Toll Charger's fixed or mobile equipment, and electronic interfaces between the respective back office systems.

As a minimum, the following standardized back office interfaces must be implemented by all EETS Providers. Toll Chargers must implement each interface, but can choose only to support either the GNSS or DSRC charging process:

- Exchange of toll declaration data between EETS Providers and Toll Chargers, specifically: submission and validation of claims for toll payment based on DSRC charging transactions, submission and validation of GNSS toll declarations;
- Invoicing / settlement;
- Exchange of information to support exception handling: in the DSRC charging process, in the GNSS charging process;
- Exchange of EETS blacklists and trust objects;
- Sending of Toll Context Data[14] from Toll Chargers to EETS Providers.

The EETS architecture for interoperability is based upon work of the CEN and ISO standardization committees and Member States' Stockholm Group role model (CESARE III) and the ASECAP tolling operators. ASECAP and its members are committed to exchanging information and experience, participating in research programs and further developing and enhancing the direct "user/payer" toll system as an instrument of a sustainable, safe and environmentally friendly transport policy, strengthening the efficiency of their networks and permanently improving the level of services provided to the European citizens, by keeping up with the latest technology developments and the best operational practices.

5. COUNCIL OF THE EUROPEAN UNION DIRECTIVE PROPOSAL

Proposal for a Directive of the European Parliament and of the Council amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures include some amendments [4].

[14] Toll Context Data means the information defined by the responsible Toll Charger necessary to establish the toll due for circulating a vehicle on a particular toll domain and conclude the toll transaction.

Amendment 15. Proposal for a directive – amending act Recital 22. The use of electronic tolling systems is essential to avoid disruption to the free flow of traffic and to prevent adverse effects on the local environment caused by queues at toll barriers. It is therefore appropriate to ensure that the infrastructure and external cost charges are collected by means of such a system, subject to compliance with the requirements of Directive 2004/52/EC of the European Parliament and of the Council of 29 April 2004 on the interoperability of electronic road toll systems in the Community that foresees appropriate and proportionate measures to ensure that technical, legal, commercial and data protection and privacy concerns are properly addressed in the implementation of electronic tolling. Furthermore such systems should be designed without roadside barriers and in a way which allows subsequent extension to any parallel roads at low cost. Provision should however be made for a transitional period in order to permit the necessary adaptations to take place.

Amendment 16. Proposal for a directive – amending act Recital 22 a. It is important that the objectives of this Directive should be attained in a way which does not harm the proper functioning of the internal market. Moreover, it is important to avoid heavy goods vehicle drivers in future being saddled with ever more incompatible and expensive electronic equipment in their cabs and running the risk of making errors in its use. A proliferation of technologies is unacceptable. The interoperability of the toll systems in the Community, as provided for in Directive 2004/52/EC, should therefore be achieved as quickly as possible. Efforts should be made to limit the number of devices in the vehicle to one, which makes it possible to apply the various rates which are in force in the various Member States.

Amendment 17. Proposal for a directive – amending act Recital 22 b. The Commission should take all necessary measures to ensure the rapid introduction of a truly interoperable system by the end of 2010, in accordance with Directive 2004/52/EC. Member States should be able to use the Trans-European Transport network (TE9-T) budget and the Structural Funds in order to improve transport infrastructures with a view to reducing the external costs of transport in general and implementing electronic means of collecting the charges arising from the provisions of this Directive.

6. CONCLUSIONS

DSRC systems need road-side equipment, typically mounted on a gantry, with electronic tags in the vehicles which may be read-only, read–write or smartcard-based.

A new class of ETC systems is based on a combination of mobile communications technology (GSM) and the satellite-based global positioning system (GPS). The first GPS based system advantage is an absence of the need for new road infrastructure (gantries), while the operators can keep using the existing infrastructure. System works without toll booths, extra lanes, speed restrictions or complex structures along toll roads. The second one is much greater flexibility in defining or changing payment by simply redefining the "virtual" toll areas. It means the ability to adapt easily and quickly to changes in charge parameters (road classes, vehicle types, emission levels, times slots etc). The third is the systems ability to support other value-added services on the same technology platform. These services might include fleet and vehicle engine management systems, emergency response services, pay-as-you-drive insurance services and navigation capabilities.

According to European Commission the electronic toll collection systems in the European Union member states are not interoperable, so EC has taken important step to

implement Directive 2004/52/EC on the interoperability of electronic road toll systems in the Community. Another important step is the decision on EETS definition and specifications.

A decision setting out the essential technical specifications and requirements needed to launch a European Electronic Toll Service (EETS) which will enable road users to easily pay tolls throughout the whole European Union (EU) thanks to one subscription contract with one service provider and one single on-board unit.

The Commission Decision lays down the rights and obligations of toll chargers, service providers, and users. Users will be able to subscribe to the service provider of their choice. Toll chargers will communicate the tolls due to the service providers, who will eventually invoice the users. Tolls paid via EETS may not exceed the corresponding national or local tolls.

EETS will be available within three years for all road vehicles above 3.5 tones or allowed to carry more than nine passengers, including the driver. It will be available for all other vehicles within five years.

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