SOME INTEROPERABILITY PROBLEMS OF EUROPEAN ELECTRONIC TOLLING SERVICE

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Abstract

The paper refers to some standardization and interoperability problems of European Electronic Toll Service (EETS) implementation in European Union. The EETS in the European Union member states is 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. The second was decision to launch Europe's own Galileo system. The third was EC decision from 6 October 2009 based on Research Charging Interoperability (RCI) and Common Electronic Fee Collection System for a Road Tolling European Service (CESARE) projects. 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. Motor Transport Institute researches in mentioned matters have been presented. With regard to future expansion and development, the satellite-based toll collection system will be a better solution, especially with regard to flexibility when it comes to extending toll collection to every road category, every category of vehicle and, what's more, in terms of cost efficiency in implementation and operation.

Keywords: *European Electronic Tolling Service (EETS), RCI, CESARE, interoperability, GPS/GSM, DSRC*

1. Introduction

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

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 based on a combination of mobile communications technology (GSM) and the satellite-based global positioning system (GPS) has some advantages. The first is an absence of the need for new road infrastructure (gantries), while the operators can keep using the existing infrastructure. The second is much greater flexibility in defining or changing payment by simply redefining the "virtual" toll areas. The third is the systems ability to support other value-added services on the same technology platform.

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 [3]. The second was Commission Decision of 6 October 2009 on the definition of the European Electronic Toll Service and its technical elements. The requirements of that directive will be implemented in Poland based on the Act from 7 of November 2008 and some other acts [6]. It stressed that toll collecting charge institutions should be able to carry out electronic toll transactions from 1 of July 2011.

2. Technical and economical aspects of EETS

The profit from 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 at the beginning of 2009.

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

Characterization	Austria [4]	Czech [1]	Germany[1]
Introduction date	01.01.2004	01.01.2007	01.01.2005
Admissible weight (2010)	> 3.5 ton	> 3.5 ton	> 12 ton
System cost (Government contracts)	750 M€ [5]	780 M€[2]	1240 M€[3]
Technology	DSRC	DSRC	GPS/GSM
Average charge	0.26 €	0.15 €	0.17 €
Budget revenues (2008)	1.026 B€	236 M€	3.5 B€
Operational and control costs	12 %	10 %	11.2 %

[1] According to German Ministry of Transport, Construction and Urban Development: www.bmvbs.de
[2] 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, Highway 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.
[3] Based on: www.bmvbs.de.

The daily profit from 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 for 10 years [1].

The implementation cost of Toll Collect System in Germany was about 1.24 billion Euros. Yearly profit from the system is 3.5 billion Euros – 4.022 billion Euros in 2009 (official date – Toll Collect GmbH/April 9-th 2010).

One of the reasons to introduce Toll Collect in Germany was a problem to check exactly routing of trucks, especially invaders and mistakes in fee calculations. The monitoring data: who, when and why goes this way in DSRC system depends on many persons and more time, which increases the cost of the system operation.

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.

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[1]

[1] 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.

communities, and some specialist companies providing expertise on the relevant research issues [5].

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

RCI defined itself a high-level architecture for interoperability that is based upon work of the CEN and ISO standardization committees and the ASECAP[2] tolling operators' and Member States' Stockholm Group role model (CESARE III). The RCI architecture defines the technical detail of the interfaces for the road charging systems that are interoperable in such a way that they correspond to the interfaces between the business entities that operating the service together: the Toll Charger, the Toll Service Provider and the Service User (Fig. 1).

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. 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.

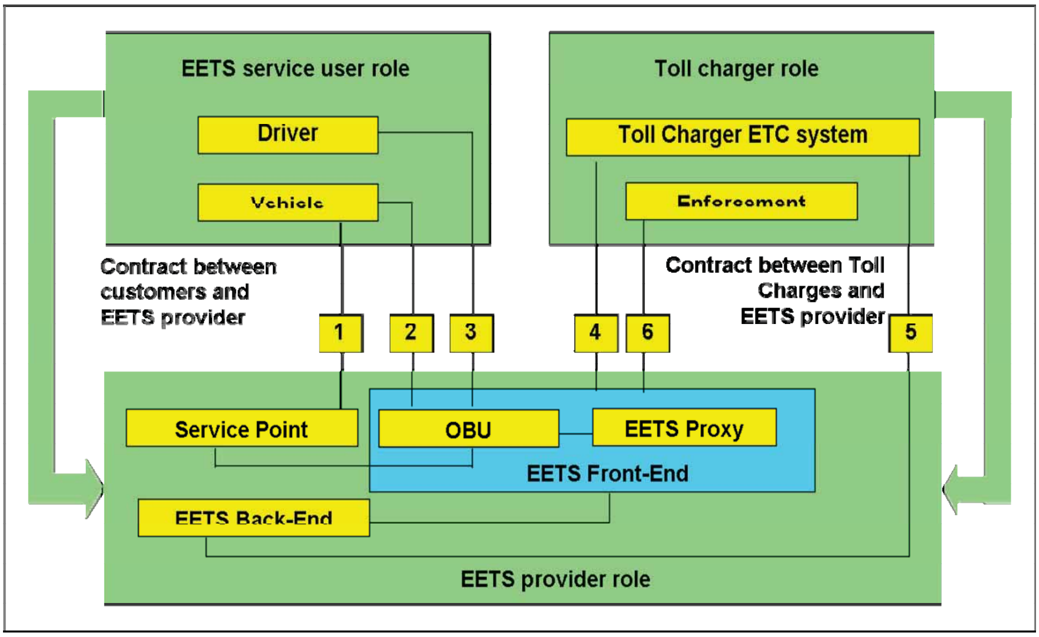

Fig. 1. RCI Project architecture [4]

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 supports beacons is considered the responsibility of the Toll Chargers. Interface 5 enables the

[2] 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).

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 report stresses that RCI technical architecture should include the interfaces 4, 5 and 6, and be 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. The following interfaces should meet standards:

- Interface 4
  - Charging data according to ISO 12855, based on data Definition of ISO 17575-1, DSRC Charging – EN 15509; Localization Support – CEN TC278 WG1, SG6, PT 22/23.
- Interface 5
  - Payment Data – ISO 12855,
  - Security, Blacklists, Enforcement – ISO 12855,
  - Toll Context Data – ISO 12855 based on data Definition of ISO 17575-3.
- Interface 6
  - Enforcement for DSRC systems – EN 15509,
  - Enforcement for GPS/GSM systems – ISO 12813.

Interface 3 (HMI – Human Machine Interface) is required, but interfaces 1 and 2 are not applicable to CESARE role model and not critical for interoperability (how ever European consensus on high-level security requirements is needed).

4. The European Commission decision 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.

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.

5. National Automatic Toll Collect System Pilot Project

The Motor Transport Institute has created the structure of The National Automatic Toll Collection System for Poland (NATCS) in cooperation with FELA Management AG and AUTOGUARD SA. System consists of The National Automatic Toll Collection Centre (NATCC), on-board units (OBU) and control subsystem (Fig. 2).

The National Automatic Toll Collection Center (NATCC) based on telematic system approved all functions performed for the National Automatic Toll Collection System (NATCS). The NATCC elements are as follows:

1. Redundancy servers.
2. Applications and system software.
3. Data bases.
4. Interfaces:
   - between NATCC and OBU,
   - between NATCC and control gates,
   - between NATCC and external systems (bank systems, Internet charge operators, Central Evidence Systems of Drivers and Vehicles).
5. User interface – www Internet service, Call Center, SMS gate, automatic telephone service.
6. Data transmission nets (WAN, LAN).

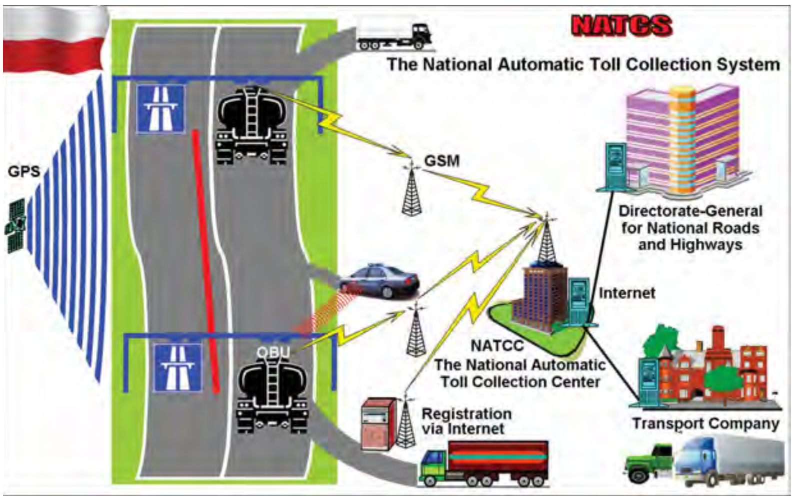

Fig. 2. The structure of the National Automatic Toll Collection System (NATCS)

OBU (Fig. 3) is installed in vehicles windscreens and realized the following functions:

1. Vehicles data storage.
2. Digital map nodes and points storage.
3. Toll charges calculation based on introduced data (admissible mass, No of axles, emission class, distance, tariff model).
4. Analyze data coming from module and sensors (GPS, GSM, DSRC).
5. Optical and sound signalization of OBU working parameters (for instance distance, fees).
6. Safety data transmission to system and communication with control gates (stationary and mobile).
7. Remote data actualization and parameters exchange.
8. Data security based on cryptographic module.
9. Additional DSRC module to spread services and interoperability.

The system is based on an innovative combination of mobile telecommunications technology (GSM) and GPS, the satellite-based Global Positioning System. 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 kilometres 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 NATCS 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.

Charge counting will start after highway entrance gate and finished after highway exit gate. Data on vehicle position will be additionally approved by GPS system and delivered to NATCC by GSM net. The toll amount is based on the truck's emission category and number of axles, as well as on the length of the toll route.

For truck drivers, automatic log-on requires the least amount of effort: He is not required to book the route himself. All key data is already stored in the On-Board Unit. The prerequisite for participating in automatic log-on is registration of the transport company and the trucks with General Directorate-General for National Roads and Highways (DGNRH) and toll payment to DGNHR. After registration, the company receives a vehicle card for each truck. This card contains the most important vehicle information. With this vehicle card, the user can schedule an appointment with an authorized Toll Collect Service Partner to have an On-Board Unit installed.

The simplest way to pay the truck toll is to register the company and vehicles with DGNHR. A registered user can have an On-Board Unit installed and participate in automatic log-on and use all possible means paying the toll (credit account, credit card or fuel card, cash payment). Immediately after registering the company, it will receive a personal user number and a master PIN number for security. After vehicle registration, Toll Collect Service Partner will send the transport company a vehicle card for each truck, containing the most important information about the vehicle.

Toll enforcement and the punishment of violations are the responsibility of the Road Transport Inspection (RTI). RTI with the technology needed for an effective enforcement system so that RTI can enforce correct booking of the toll, thereby ensuring that all toll payers are treated equally. With the aid of this system, RTI can determine if a vehicle has an obligation to pay toll and if it has met this obligation fully, partially, or not at all.

The control system distinguishes between automatic enforcement through control gates, enforcement by mobile teams and patrol teams. This combination guarantees comprehensive, continuous enforcement of the requirement to pay toll and allows the control system to be constantly adjusted to meet prevailing circumstances.

Automatic control subsystem consists of permanently installed enforcement control gates are used to ensure toll requirements are met without interrupting traffic flow (Fig. 3).

Fig. 3. Tripon EU OBU

RTI employees engage in portable (mobile) enforcement on parking lots in the vicinity of the control gates. Mobile inspections are carried out by RTI officers at selected parking lots near the control gates. The control mobile teams receive wireless data on vehicles that may have not properly paid the toll. This occurs seconds after the truck passes under the control gates. The team then pulls the truck over for a detailed inspection.

6. Conclusions

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. Decision to be the most important improvement for drivers since the abolition of border controls, stating that "the European Electronic Toll Service will enable road users to easily pay tolls throughout the whole European Union 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.

With regard to future expansion and development, the satellite-based toll collection system will be a better solution, especially with regard to flexibility when it comes to extending toll collection to every road category, every category of vehicle and, what's more, in terms of cost efficiency in implementation and operation.

The NATCS pilot project meet requirements of Directive 2004/52/EC and European Commission decision of 6 October 2009. OBU is equipped with GPS, GSM and DSRC (5.8 GHz, IR) module to be interoperable with different type of EETS in member states. Equipment is designed in such a manner that its interoperability constituents utilize open standards and OBU is equipped with HMI, which indicates to the user that the OBU is functioning properly, and an interface for declaring variable toll parameters as well as for indicating the settings of those parameters.

Acknowledgement

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