A DEMONSTRATION OF INTEROPERABLE ELECTRONIC FEE COLLECTION SYSTEMS IN THE EUROPEAN MOTORWAYS – THE CASE STUDY OF GREECE

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Abstract

This contribution to the "WCTR'04", will explain the main features of the European Project PISTA, "Pilot of Interoperable System for Tolling Applications", focusing upon the case of the 3 major Greek Transport Service Providers. This Demonstration Project consists of carrying out a series of pilot tests of interoperable Electronic Fee Collection (IOEFC) Systems, throughout a corridor belonging to several European motorway networks (Spain, France, Italy, Greece, Denmark and Sweden). The IOEFC system technology as defined in PISTA is based on Dedicated Short Range Communications (DSRC), which is still considered as the "state of the art" technology that can be implemented with enough security and financial feasibility. The project, belonging to the broad area of Transport Telematics, also incorporates the study of a number of relevant aspects related to Electronic Fee Collection such as cross-border enforcement, taxation and management procedures.

Keywords: Electronic fee collection (EFC); Dedicated short range communications (DSRC); Monolithic on board units (OBUs); Post-payment; Dedicated mono-lane EFC systems; Vehicle classification systems; Vehicle enforcement systems
Topic Area: B2 Telecommunications and Advanced Information Systems

1. Introduction

PISTA, the acronym of "Pilot on Interoperable Systems for Tolling Applications", is an Electronic Fee Collection validation project based on interoperability concepts developed in former European Projects, mainly, CARDME, MOVE-IT, A1 and especially CESARE, under real traffic conditions. The expected duration of PISTA is 30 months, starting in January 2002 and finishing in early summer 2004. The Project is partially supported by the European Commission, who has granted a total subsidy of 2.4 million EUR of a cost budget that exceeds 6.5 million Euros.

PISTA is conceived in a multinational environment that takes into account existing EFC systems implemented in several European countries. The PISTA Consortium was originally formed by 16 Toll Motorway Operators of six different European countries (Spain, France, Italy, Greece, Denmark and Sweden) and the Aristotle University of Thessaloniki, Greece. During the time scale of the Project, five additional Toll Operators of Spain, Greece and Portugal have also joined the Consortium. The overall objectives of the project are:

- Definition of a payment method compliant to the European DSRC standards (CEN TC278) and to interoperability concepts defined in other European projects but not yet operational at international level
- Definition of an open-market EFC system as opposed to a proprietary system
- Study and Recommendations to provide a migration path for existing systems
- Demonstration of an actual implementation of an interoperable EFC system in several countries under real traffic conditions
- Validation of a common service management model
- Identification of emerging interoperability issues

PISTA Project will be the platform to demonstrate a true Interoperable EFC system for tolling throughout a main highway network in Europe. The IOEFC system technology as defined in PISTA will be based on DSRC, which is still the "state of the art" of the technology that can be implemented with enough security and financial feasibility.

The Project also involves the study of a number of relevant aspects related to EFC, like enforcement, taxation and management procedures, which may be also applied to emerging tolling technologies that are expected to be ready for implementation in the future decades.

2. Basic concepts of EFC interoperability

What is generally called EFC (Electronic Fee collection) is a system that allows toll or road pricing transactions without the need to stop the vehicles. To this extent, the vehicles must be provided with an OBE (On Board Equipment) in order to perform the toll transaction in toll lanes equipped with the required RSE (Road side Equipment).

The current EFC technology as defined in the European standards is based in Road Traffic and Transport Telematics (RTTT) using Dedicated Short-range Communications (DSRC) between OBE devices installed in vehicles and an RSE beacon placed on the top of the toll lane, at about 5.5m height. The microwave range of frequencies for EFC has been established in the European standards at 5.8Ghz.

The IOEFC is a standard EFC system, which allows the users to carry out toll transactions with the same OBE in a regional-wide, national-wide or cross-border network of toll motorways. The EFC interoperability would then be established at three different levels:

a) **Technical interoperability**: EFC systems need to have common technical features. In that sense, a number of standards must be prepared, approved and used for the definition of a common set of technical specifications for both OBEs and RSEs. These specifications will have to be followed in full detail by all the equipment manufacturers and system integrators. Technical interoperability also requires the definition and adoption of a **common Transaction Model**, which defines the way the OBE information is organized into the device or interchanged between OBE and RSE (EFC attributes and data elements). The failure of implementing a common transaction model may obstruct the interoperability even between equipment fully compliant to the European standards.

b) **Service/Product interoperability**: The common service has to be defined as a whole in all the regions and countries involved in the perimeter of the interoperable EFC service. A common set of codes and signs has to be established (logos, trademarks) in order to introduce the IOEFC service to the market as a commercial "product". Marketing techniques have to be used for this purpose. The toll road users must perceive the unity and scope of the common EFC service. The more the knowledge of the "product" features and conditions, the safer and more effective its usage will be.

c) **Business/Contractual interoperability**: To ensure the operations related to the common EFC service, an organization has to be established. This organization must act as a service performance monitor and must provide support to several key activities, such as the transaction information interchange, clearing and invoicing. The EFC organization is to be materialized by means of several agreements between the different "actors" of the EFC service: Toll road operators or Transport Service Providers (TSPs), Issuers of the OBEs, Authorities, Users, etc.

Some different models of contractual EFC interoperability can be found around Europe, depending on the "actors" involved. In some cases the EFC service is "proprietary", that is, there is a unique Service Provider, generally the biggest toll operator in the country; this EFC Service Provider "sells" the service to the rest of toll operators (if any) in the country; this is the case of "Telepass" service in Italy. In France, the system named TIS is a fully distributed "multi-node" service, in which each TSP (acting also as "issuer" of the OBEs in his "hinterland") implements its own transaction management system and there is merely a multiple bilateral data and funds interchange; finally the Spanish model tends to become a collaboration of management aspects related to the IOEFC system.

These interoperability levels are sequential. In order to achieve Product interoperability, the first step is to achieve Technical interoperability; finally, to reach Business interoperability, it is previously required to achieve Product interoperability. These three interoperability levels are depicted in Figure 1.

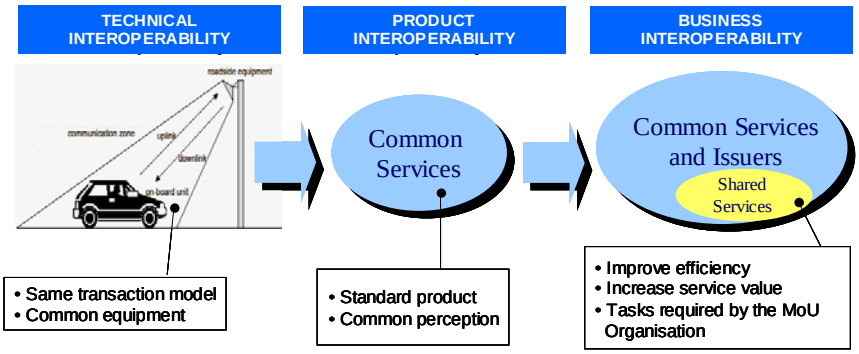

Figure1. Interoperability Levels

3. PISTA definition of the IOEFC service

3.1 Technical interoperability

Technical interoperability requires a common Transaction Model and compatible equipment according to System Specifications:

- System Specifications define the technical characteristics of the EFC equipment (OBE and RSE) for IOEFC between different suppliers.
- The Transaction Model defines the communication protocol. Without a common transaction model the communication between the OBE and the RSE is not possible.

3.1.1 How to achieve the Technical Interoperability

With the aim to achieve Technical Interoperability, PISTA Project carried out the following activities:

- Identification of the applicable standards
- Definition of the Transaction Model
- Definition of the Security Scheme
- Identification of the operational requirements for the EFC equipment

- Definition of System Specifications
- Pre-qualification of equipment under real traffic conditions
- Elaboration of a migration plan for existing EFC systems

3.1.2 EFC Equipment Pre-qualification Tests

From March to May 2003, PISTA has carried out interoperability tests in a Toll Plaza near Madrid. Seven European EFC equipment manufacturers (Combitech, Thales, CS-Route, Sainco-Tráfico, Q-Free, Kapsch and Fela) participated in the test providing OBE (on-board equipment) and RSE (road-side equipment) compliant to CEN TC-278 pre-standards. During the test each combination of OBE-RSE was tested in a real lane with two types of vehicles under two different speeds. Test results show the transaction result and the transaction duration for security levels 1 (Data certification) and 2 (OBE authentication) as well as the communication zone. Table 1 summarizes the transaction results for each OBE-RSE pair.

Table 1: Pre-qualification test results

RSE Model	**OBE Model**						
	Kapsch	**Combitech**	**Thales**	**Sainco**	**Q-Free**	**CS-Route**	**Fela**
Kapsch	YES	YES	YES	YES	N/A*	N/A*	YES
Combite	YES	YES	YES	YES	N/A*	N/A*	YES
Thales	YES	YES	YES	YES	YES	N/A*	YES
Sainco	YES	YES	YES	YES	YES	N/A*	YES
Q-Free	YES	YES	YES	YES	YES	YES	YES
CS-	YES	YES	YES	YES	YES	YES	YES

* N/A means "Not Available" that is the OBE was not available for this test.

It is important to observe that this is the first time that a real interoperable multi-vendor EFC equipment test has been demonstrated in Europe. These seven EFC equipment manufacturers have also committed themselves to participate in the PISTA Pilot Tests that will take place in 24 Pilot Sites implemented in seven different European countries (Spain, France, Italy, Greece, Denmark, Sweden and Portugal).

3.2 Product interoperability

3.2.1 How to achieve Product Interoperability

In order to ensure Product Interoperability PISTA has defined the main characteristics of the EFC Common Services (i.e. objectives, requirements, scope and providers), as well as a detailed definition of all the services provided in the PISTA interoperable EFC system.

3.3 Business /contractual interoperability

Business Interoperability has two aspects:

- A set of three levels of contracts, which allows a user, equipped with only one OBE, be capable of paying to separate/independent TSPs.
- An Organization that supports the IOEFC System

3.3.1 How to achieve Business/ Contractual Interoperability

The interoperability requires at least a contract between the user and the issuer of the payment means and it also requires a common agreement between TSPs and Issuers.

PISTA has defined three contracts dealing with the common EFC System, aiming to achieve full Contractual Interoperability:

- **Clauses of the MoU Signatory TSPs** constitute the basis to create the EFC System and to implement the common MoU Organization.
- **Clauses of the MoU Adherent Issuers** allow the adhesion of Issuers to the EFC system.
- **Issuer/User Contract clauses** guarantee the proper use of the OBE and allows the payment of the tolls by the User.

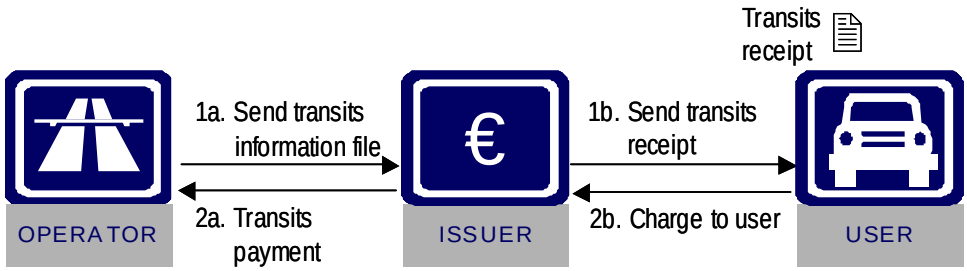

Figure2. Payment Method

3.3.2 How to implement an MoU Organization

One of the key elements to implement an interoperable EFC System is to constitute some kind of Organization, which is in charge of assuring the maintenance of the common elements and promoting the adoption of the common EFC System by the greater possible number of TSPs and Issuers. PISTA proposed the type of organization to be implemented at European level in order to give full support to the common EFC System. Main characteristics of this proposal are the following:

- **Coexistence**: PISTA assumes the coexistence of the European MoU Organization with the current National EFC Organizations.
- **Decentralization**: The system is decentralized at the level of each TSP and Issuer, for the functions necessary for the operation of the system.
- **Bilateral agreements:** Commercial agreements between TSPs and Issuers are based on bilateral agreements.

4. PISTA demonstration of the IOEFC system

Having finished the first phase of the project, PISTA is carrying out the implementation of the Pilot Sites. A total of 24 Pilot Sites is being implemented in seven European countries. During the Validation Phase around 5000 OBEs will be distributed to real users and volunteers, including One-concession area users, Multi-concession national users, Multi-concession international users, under real traffic conditions. A complete EFC service (compensation, invoicing, etc.) will be implemented and offered to the users. The Pilot Sites evaluation will cover Technical IOEFC performance and Contractual IOEFC performance (quantitative analysis) and user acceptance (qualitative analysis through questionnaires). The results will be publicly available by June 2004.

The exploitation aspects are fundamental in the different documents being prepared in PISTA. The definitions and concepts studied in PISTA are being used for the implementation of several national new EFC Systems and the participants expect these results to be relevant for the achievement of future cross-border EFC interoperability between countries.

In **Spain**, the toll operators signed a Memorandum of Understanding. According to this document, the Spanish TSPs have agreed to create a national interoperable EFC system,

called “Via-T”. The organization that gives support to this EFC service has been set up as a permanent Committee of ASETA, the Spanish Association of Toll operators. A second agreement has been established between the Spanish TSPs and the three companies that manage the most important Bank-related payment means services: SERVIRED, 4B and EURO-6000. These companies represent the majority of Spanish financial institutions capable of acting as issuers of credit cards and other payment means. With this agreement, the payment means companies carry out the inter-Bank data and fund interchanges and the Banks provide the OBEs to the users, linking these devices directly with their own bank accounts. It is important to remark that most of the deliverable documents generated in PISTA have been used as the reference for “Via-T” EFC system. “Via-T” has been launched in early 2003 in the North-West and the North-East of Spain with success and it is now being extended in the area of Madrid.

PISTA project is also promoting the interoperability between different countries. ASF (Autoroute du Sud de la France) in **France** and the Spanish Toll Operator ACESA will carry out an interoperable test with real users at the cross-border. The Spanish toll operators and BRISA (**Portugal**) as well as other Portuguese toll operators (Lusoponte, Auto-Estradas do Atlântico and AENOR) will perform IOEFC tests with the Spanish “Via-T” system. The objective of these two initiatives is to link different national EFC systems by means of bilateral agreements that lead to a “cluster” of IOEFC systems. In all cases, the documents being prepared in PISTA are expected to be useful to establish the conditions of cross-border interoperability.

5. The case study of Greece

In **Greece**, PISTA results are being used by all three local TSPs with the aim to implement a Greek IOEFC system fully based on CEN TC-278 standards. Currently TEO SA, Attiki Odos and Egnatia Odos are involved. At the present time Greek TSPs act as Issuers as well.

TEO SA, manages the PATHE national motorway which is the backbone of the country’s transportation system expanding from Patras in the West Peloponnesus to the East borders with Turkey. TEO SA is also the Site Manager of the Greek pilots and currently operates in pilot mode 4 legacy EFC lanes in 2 toll stations on PATHE (Elefsina & Korinthos toll stations). A number of motorways is at present under construction around the PATHE motorway and a lot of EFC lanes are expected to be installed in the near future.

The technology used initially was based on TELEPASS, the Italian Motorway EFC System, which is not compliant to CEN TC278. Originally, it was decided that Telepass lanes would be migrated to PISTA, through the use of bimodal OBUs which are developed by Autostrade per Italia. These bimodal OBUs were supposed to be capable of communicating with both CEN TC-278 based RSEs, as well as with Telepass RSEs. However, in the course of this project TEO SA proceeded with the installation of new CEN TC278 EFC lanes in Elefsina and Isthmos, close to Athens. The new system, with the commercial name TEOPASS, having already passed the internal tests and the Predefined Extreme Condition tests prescribed by PISTA, is currently operating having reached 6.000 users during the second month of operation. TEO SA apart from seeking the increase of this figure also investigates the possibility of expanding TEOPASS on the PATHE corridor.

Egnatia Odos, a 680 Km highway in North part of Greece currently under construction, is investigating through this project the future use of EFC in their network.

Two EFC lanes, fully PISTA compatible, at Malgara toll station are about to be implemented.

Attiki Odos, the 65 Km Athens ring road, currently operates 42 EFC lanes which are already CEN TC278 compatible. Having Road Side Equipment, already CEN compatible from day one, merely software modifications in the backoffice systems were necessary in order to achieve PISTA compatibility. During the pilot, two EFC lanes are supposed to be migrated to PISTA.

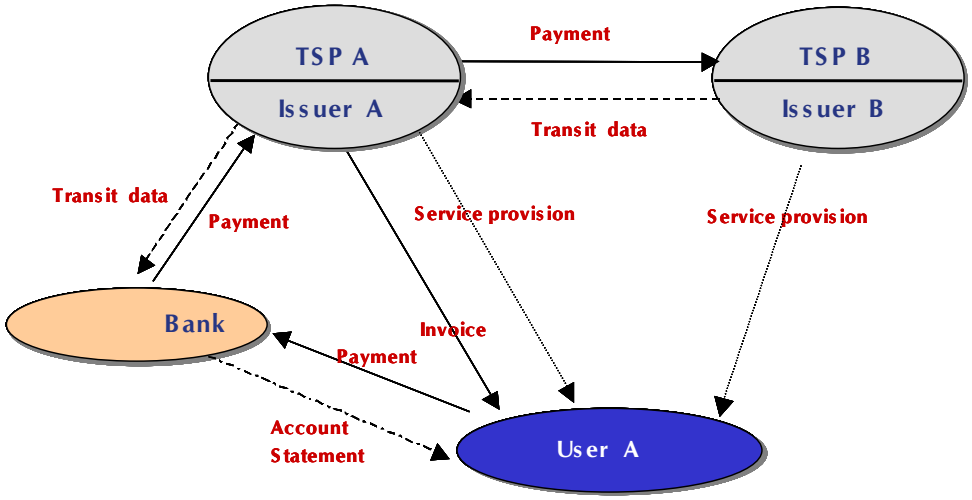

Figure 3. The Greek IOEFC Case

A Greek Technical Committee has been launched with a rigid objective, which is to prepare a model MoU to path the way for full scale deployment of IOEFC service across Greece. Moreover, the initial Greek MoU that will cover the PISTA pilot period is already prepared and agreed by the TSPs. Moreover, Aristotle University is responsible for the integration of back-offices (Greek Cluster) during the PISTA pilot period (black and white list exchange, security key distribution issues, etc.).

During the 3-month validation phase of the Greek Pilot Sites, which is expected to end by mid 2004, at least 15.000 EFC transactions per Site are expected. Launching the pilot, a complete EFC service (compensation, invoicing, etc.) will be implemented and offered to a closed group of internal users and volunteers. However the PISTA lanes at first will not be open to the wide public.

European interoperability will be demonstrated through the OBE exchange with European TSP peers. Multi-Concession International User transactions will be simulated by internal users bearing exchanged tags, in order to have a substantial sample size to proceed with quantitative analysis of system performance. By the time of the presentation, the Pilot Sites evaluation and validation analysis results that take account of the Technical and Contractual IOEFC performance (quantitative analysis), as well as user acceptance (qualitative analysis) will be publicly available.

The future Greek MoU that will enforce IOEFC at national level is still under development but certainly based upon PISTA pilot results. Greek TSPs anticipate that the final “long-run” MoU will be more binding than the PISTA’s proposed “Signatory TSPs MoU”.

6. Conclusions

PISTA is the validation of a common EFC system already defined in previous projects. Once the validation phase is completed, the technical definition of the system will become a rigid technical specification through the introduction of necessary amendments identified during the tests. The experiences will demonstrate:

- Technical Interoperability aspects.
- Migration paths on the evolution of the current toll systems to IOEFC systems compliant with the related national specifications, preserving old investments.
- European MoU Organization aspects that give support towards European IOEFC.

From the most optimistic view, once PISTA is over, IOEFC at international level will be no longer a theoretical concept but a reality to be improved by successive experiences all over Europe. The implementation of free-flow tolling schemes in Europe, like the experiences already implemented in Canada and Australia and under development in other countries, requires a complete review of the European legal framework and the harmonization of several operative aspects, mainly in terms of tolling enforcement.

Focusing in the case study of Greece, all Greek Highway Authorities, along with the Hellenic Ministry of Environment, Physical Planning and Public Works, recognize PISTA not only as a prerequisite towards standardization and harmonization with the EC directives, but also an ideal opportunity for national interoperability.

The development and implementation of free-flow tolling systems based on emerging technologies (GNSS, mobile communications) is almost a reality in some European countries, but the extension of this concept to the rest of the continent will require tests and efforts in a maturity process that will take some years. The Participants of PISTA Project are also active in this field and some of the results of the Project are already taking into account this expected evolution in the world of tolling.

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Glossary

Word /Acronym	Explanation
OBE	On Board Equipment. This is the equipment placed into the vehicle. It is also known as “OBU”, “TAG” or “Transponder”
RSE	Road Side Equipment. This is the fixed equipment that is connected to the Toll lane controller (Antenna, EFC concentrator, beacon, etc)
OBU	On Board Unit. It is equivalent to OBE
DSRC	Dedicated Short Range Communications
IOEFC	Interoperable Electronic Fee Collection
PISTA	Pilot on Interoperable Systems for Tolling Applications
CEN	Comité Européen de Normalisation , European Standards Committee
ASECAP	Association Européenne des Chemins à Péage, European Association of Toll Operators
MoU	Memorandum of Understanding
GNSS	Global Navigation Satellite System
TSP	Transport Service Provider (here, equivalent to Toll Operator)