

The letters 'RCI' are rendered in a large, 3D, metallic blue font with a rainbow-colored gradient. They are positioned on a perspective view of a road that stretches into the distance under a cloudy sky. The road has white dashed lines and a solid white line on the right side. The background shows green fields and a blue sky with scattered clouds.

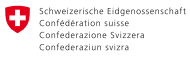
RCI

Road Charging Interoperability November 2008

Demonstrates real interoperable road charging services in Europe

27 principal road charging stakeholders in Europe defined, implemented, demonstrated and recommend one standard architecture which is considered indispensable by European Toll Service Providers, Toll Chargers and Equipment Manufacturers for offering a European 'one box, one contract, one invoice' road charging service to the end-user.

Key results, lessons learned and recommendations on how a validated open architecture can provide the missing technical framework for operation of what is to become the European Electronic Interoperable Toll Service.



Zoll Douane Dogana Customs



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EXECUTIVE SUMMARY

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 by the CEN and ISO standardization committees and the ASECAP tolling operators' and Member States' Stockholm Group role model (CESARE III).

The RCI architecture, presented to the EC in February 2007, represents the 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 intends to contribute to the further work on the EETS specification (and eventually standardization) to help avoid future deployment of road charging systems that will delay or block the introduction of interoperability.

The RCI architecture defines what technical interfaces must be implemented in interoperable road charging solutions to support the exchange of information between the different actors. It will be these interfaces through which one actor will receive or send information, will monitor or even enforce another actor.

It will be these interfaces that are crucial for the implementation of the procedural and contractual agreements made between the actors to ensure interoperability, with the objective being to establish and keep common trust in the system and operation thereof.

Critical for the contribution that RCI can make to advancing interoperability of road charging services in Europe, is how as technical reference it is in support of the procedural and contractual framework that European stakeholders, more specifically the Member States and operators, are defining in the context of the EETS. This document defines the technical interfaces and specifications that at a very minimum are required for establishing:

- Support for the EETS organisational and contractual model (CESARE III)
- Appropriate market conditions (economies of scale, innovation, competition)
- Trust between Toll Chargers (Member States) and EETS Providers.

The following key conclusions can be drawn:

The RCI project demonstrated that operational interoperability of road charging services in Europe can be realized on the basis of clear agreements between the different stakeholders.

This includes the role model defining 'who is responsible for what and what are the contractual relations', and the technical architecture defining 'how and what information is being exchanged'. These two models should go hand-in-hand and RCI so far is the only technical reference that has the support of 26 leading private-sector stakeholders with proven validity and the RCI architecture proved a suitable basis for this, showing:

- Support for the EETS (CESARE) role and contractual model
- Basis for required conditions for competitive mass market
- Enabling the establishment of trust between Toll Chargers (Member States) and EETS Providers.

With respect to the first bullet the following results have been achieved:

- The RCI prototypes demonstrated functional operation and interoperability of different prototypes in six existing toll schemes.
- In France, RCI demonstrated that for DSRC-based road charging, a technical implementation of interoperable road charging can be used up to the procedural and contractual level.
- Validation results showing that processes can be technically implemented on RCI architecture and consistent with roles and responsibilities as defined by Member States and operators in CESARE.

With respect to the second bullet the following results have been achieved:

- Stimulating innovation and cost reductions: Both ‘thin’ and ‘intelligent’ solutions are being explicitly supported (Front-End concept) allowing European industry to invest in cost-effective optimised implementations without further constraints.
- Open, stable and competitive market: Proven starting point for CEN278 WG1 standardization of stable and pan-European open specifications, creating conditions for a competitive Europe.
- Catalyst for new business: The RCI architecture provides a sound basis for development into a support framework for Value Added Services, and also provides expertise on how this model could be built into ongoing Member State procurement programs.
- Economies of scale: Industry can bring to market systems that work with today’s tolling systems, but which, with the RCI Toll Context Data and architecture definitions, are capable of supporting future systems as well.

With respect to point 3, the following results have been achieved:

- Trust can only be achieved if the Toll Charger can verify the appropriate operation of the EETS as provided and operated by the EETS Provider and if the EETS Provider can rely on the appropriate infrastructure as operated by a Toll Charger (or Member State). The RCI architecture includes one clear interface allowing the Toll Charger to perform compliance monitoring.
- Trust also requires that the Toll Charger can have confidence that the correct charge data with sufficient performance is generated and provided to him.

This requires service monitoring and certification, for which RCI results provide:

- Clear indications and recommendations in a Special Interest Group’s report on Service Certification and the Type Approval deliverables.
- A clear service interface between the EETS Provider and the Toll Charger in support for this service monitoring process.

On the basis of the RCI conclusions and lessons learned, the following recommendations are being made:

- Continue and finalise the standardization of the interfaces (CEN) and the work on the contractual aspects (CESARE IV).
- Define the technical EETS architecture and the interfaces, which are necessary for interoperability as elements in the EETS definition.
- The responsibility of the EETS Provider for the EETS Front-End including the OBE must be stated very clearly in the EETS architecture.
- Initialise/coordinate activity envisaging the tools needed for performance monitoring that can help establishing trust, beyond CE 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 finalised. This roadmap should clearly state how the private-sector can take its responsibility in the context of Member State action, European coordination and EC involvement.

All reports that are referenced in this document can be downloaded from the RCI public website at www.ertico.com/rci

1 RCI OBJECTIVES AND WORK CARRIED OUT

1.1 CONTRACTUAL CONTEXT, POLITICAL SETTING

For a long time, the European Commission has identified interoperable road charging as one of its objectives. The Directive on the interoperability of electronic road toll systems in the Community (2004/52/EC) imposes the provisioning of the interoperable Electronic Toll Service (EETS):

- A Toll Charger shall adapt its toll system(s) such that the technical and procedural EETS interoperability requirements are met
- A Member State shall take all provisions necessary so that all users can subscribe to the EETS in their country.

Following this Directive in 2004, the European Commission was seeking to establish an open framework for road charging (taxing or tolling) systems in Europe, which enables interoperability at the technical, procedural and contractual level and the EC initialized a process of projects and expert groups which would contribute to the formulation of, and consensus on, a definition of the European Electronic Tolling Service (EETS).

It was considered crucial to validate the early building blocks for what was meant to become the EETS in existing tolling markets to:

1. Validate and improve the technical building blocks with respect to the objectives of the EETS
2. Contribute to a better and common understanding of how interoperability technically can be achieved
3. Identify and validate if and how interoperability could be technically realized in existing tolling markets while safeguarding existing investments.

The RCI project was therefore being considered as one important element in the EC-coordinated process (see figure 1), as a project that demonstrates the major building blocks that are being defined in the context of the definition process of Directive 2004/52/EC and its follow-up Decision in six of the principal existing markets of electronic systems in Europe.

1.2 RCI OBJECTIVES

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, Italian, Spanish 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).

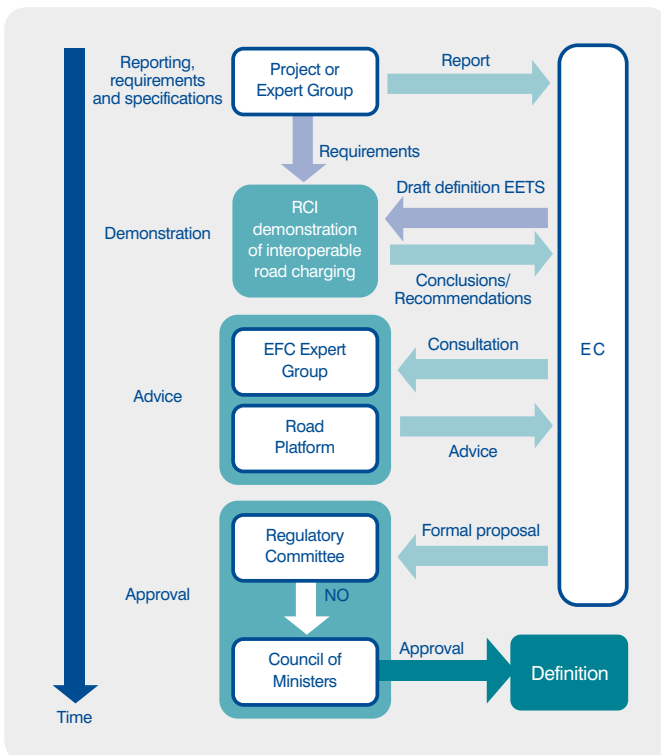


Figure 1: RCI demonstration project

In 2004 very different understandings of how interoperability could be achieved in Europe, and what the impact of it would be on the existing tolling markets existed.



- One box, one contract and minimum number of invoices for the end-user who seamlessly can cross borders
- Economies of scale and cost reductions for manufacturers of road charging systems
- Open competitive market for the provisioning of road charging services and synergies with ITS deployment

- Local ETC, often ANPR - Enabled
- Existing DSRC - Based
- Existing GNSS - Enabled
- Targeted new procurements possibly for GNSS enabled

Based on source material provided by ASECAP, edited by RCI consortium. RCI does not take any responsibility for the accuracy and completeness of the picture.

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 missing at this moment. RCI therefore defined a high-level architecture for interoperability that is based upon work by the CEN and ISO standardization committees, the ASECAP tolling operators' and Member States' Stockholm Group role model (CESARE III). It is this RCI architecture that has been implemented and used for demonstration of road charging interoperability at the technical (and related procedural) level, based on the key existing and planned road charging deployments in Europe (ASFINAG, LSVA, TELEPASS, TIS-PL, TOLL COLLECT and VIA-T).

1.3 RCI PROJECT ACTIVITIES OVERVIEW

1.3.1 RCI High-level architecture

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.

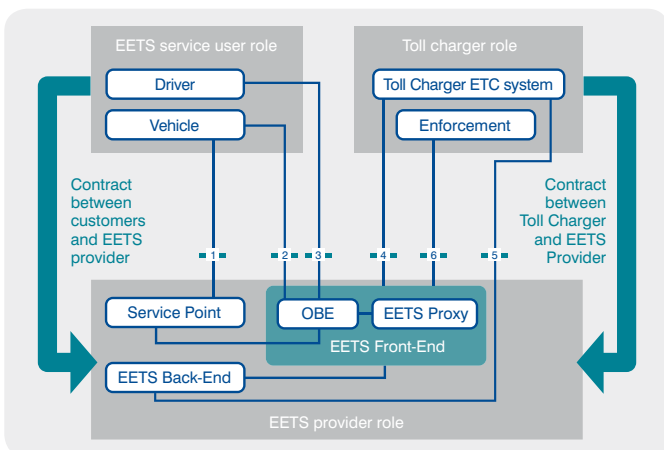


Figure 2: RCI High-level Architecture for interoperable road charging

The RCI High-level architecture will be described in detail in chapter three of this document.

The RCI architecture, presented to the EC in February 2007, represents 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.

More information on the RCI architecture can be found in chapters 3 and 4 of this document and in deliverables D3.2, D3.3 and D3.4 on the RCI website.

1.3.2 RCI prototypes

In the RCI consortium two different supplier groups (F.E.Q. and T2ASK) were responsible for the implementation of an interoperable prototype.



Figure 3: RCI operational truck with F.E.Q. OBU on the top and T2ASK OBU on the bottom right

More information on the RCI prototypes can be found at the RCI website in reports D4.1.

The final and ultimate task within the project is the demonstration phase (also called the Operational Testing): two trucks, each equipped with one interoperable OBE that seamlessly, and without user intervention, adapts functional behaviour when crossing borders, according to the rules that apply for the German (Toll Collect), Swiss (LSVA), French (TIS-PL), Spanish (VIA-T), Italian (TELEPASS) and Austrian (ASFINAG) tolling schemes.

The RCI Operational Testing has been prepared and in total there have been 3 different stages of testing and demonstrations starting mid 2007:

- The Factory Acceptance Testing (FAT)
- System Acceptance Testing (SAT)
- Operational Testing (OT).

More information on the RCI testing and validation plan can be found in D7.1 at the RCI website.

The launch of the RCI trucks was a new European milestone. The functional validation of the RCI prototypes based on an open technical architecture will help European stakeholders, including industry, operators, service providers and public authorities, and the EC in advancing the definition of a European Electronic Tolling Service (EETS).



Figure 4: RCI vehicles used in Site Acceptance Tests in Switzerland

In France, agreements were made between French Toll Operators (acting as Toll Chargers) and the RCI project (facilitated by RCI partners Cofiroute and ASF) that made it possible, for the duration of the demonstrations, to:

1. Ensure that the RCI prototypes were being recognised and accepted by all French Toll Chargers; these Toll Chargers then could
2. send invoices to the RCI Toll Service Providers, who then could
3. invoice the service-users (owners of the two RCI trucks).

The RCI demonstration therefore clearly shows how RCI is demonstrating the technical implementation in support of a European contractual (role) model that operators and Member States agreed in the CESARE III project.

1.3.3 RCI factory acceptance testing illustrated

FACTORY ACCEPTANCE TESTING F.E.Q PROTOTYPE

LAB Setup for DSRC, OBU behavior and tolling SW

29.11.2007



F.E.Q prototype, implemented by FELA, ELEM, Q-Free, is being tested under LAB conditions according to the test specification for OBU MMI functionality, DSRC (CEN+UNI), GPS and real time access to backend via GSM connectivity.

OBU, fully installed in Test vehicle

29.11.2007



All EU test sites have been setup as virtual contexts in the area of Torino. During the test trip, context changes and behavior of OBU could be observed in real time in the vehicle.

FACTORY ACCEPTANCE TESTING T²ASK PROTOTYPE

LAB Setup for DSRC (EN 15509 and LSVA)

1.11.2007



Development and tests with EN 15509 and LSVA are performed in Vienna with a Kapsch beacon.

FAT Team

21.11.2007



Members of the T²ASK development team got together in Vienna to get things working. Later on all relevant WP leaders have been invited to witness FAT in Reading (UK). A comprehensive test script was used and exemplary tests were executed to demonstrate results.

1.3.4 System acceptance testing

FRENCH ROAD NETWORK

4 - 6.12.07



The first step of the SAT in TIS-PL environment was a verification of the attributes, their personalization, the security mechanism and some set of commands in laboratory. For this purpose; COFIROUTE used a table beacon and simulation software like TEPTIS and SIMUTIS. It took 3 days to check the compliance of both prototypes.

11 - 13.12.07



The second step was to verify the behavior of the prototype in toll lanes. These tests have been done to compare the response time and the communication area with already certified transponders.

SPANISH ROAD NETWORK

January 2008



Acesa

January 2008



Autopistas del Sol

January 2008



Autopista del Atlántico

January 2008



Display of transactions performed (Acesa)

SWISS ROAD NETWORK

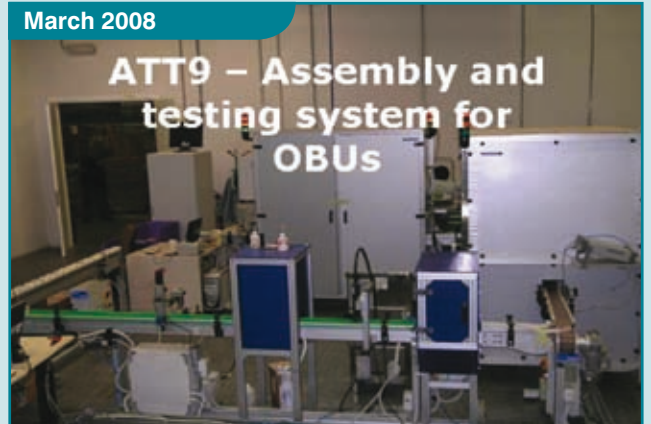
17.01.08 - 22.02.08



At the LSVA test site on the former military airport of Interlaken the behaviour of the DSRC tags was tested on conformity with the LSVA transaction and to exclude unexpected behaviour in the real system. The tests had to be repeated several times.

ITALIAN ROAD NETWORK

March 2008



March 2008



GERMAN ROAD NETWORK



Both prototypes were installed in a Toll Collect test vehicle together with a set of reference OBUs of the German Toll Collection System and a separate GPS Data Logger for tracking of the route



The System Acceptance Test has been performed on a part of the real German motorway network around the western motorway ring of Berlin.

AUSTRIAN ROAD NETWORK

22.02.2008



OBE installed in vehicle



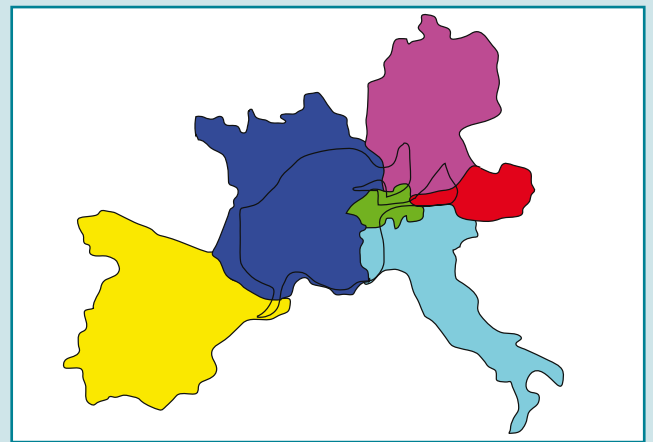
OBE installed in vehicle

23.2.2008



The transaction performance was tested under dynamic conditions by driving several times (8x) through a MLFF tolling station at a speed of 80 km/h. It could be shown that all DSRC transactions were fully performed – no broken or missing transactions occurred. The enforcement system could match all transactions to the corresponding data of the detection system – no transaction was mismatched or unmatched.

1.3.5 Operational testing by RCI truck start of the 5000km journey



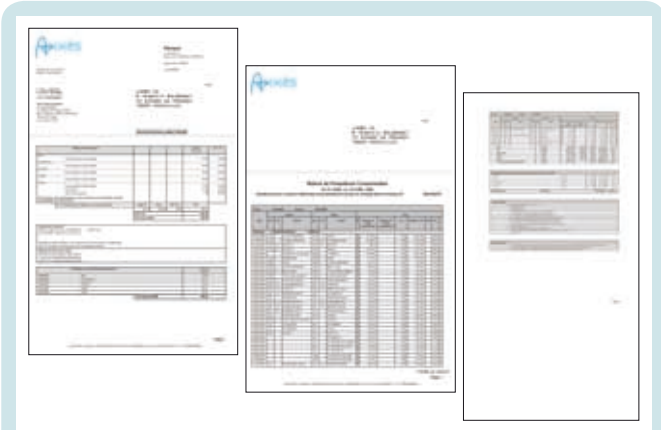
The Road Charging Interoperability (RCI) project finalized the FAT and SAT in preparation of a 5000-km long, first of its kind, tour of two trucks demonstrating true interoperable road charging while seamlessly crossing six different European countries.



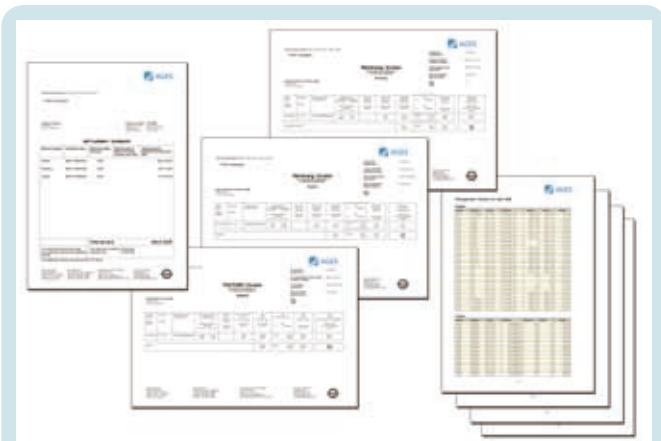
Preparation of Trucks Tour at Les Eprunes in France. Each prototype is being tested once more and then installed in a truck.



The F.E.Q OBE generated EN15509-compliant transactions for TIS PL on the ASF network. T²ASK OBE crosses the border with Germany, adapts its behaviour and starts sending positioning data to the T²ASK proxy that identifies road sections as defined by the Toll Collect scheme. Later that day, it leaves Germany and enters Switzerland. The T²ASK proxy finalises the exchange of all charge data generated in Germany with Toll Collect and starts measuring the distance travelled in Switzerland as required by the LSVA scheme. Finally it came back to France generating a EN 15509-compliant transaction. 3 toll environments and border crossings in one day.



Invoice addressed to the truck owner using the truck with F.E.Q prototype



Invoice addressed to the truck owner using the truck with T²ASK prototype

1.3.6 RCI type approval and certification

There is a consensus on the conclusion that Certification of Conformity and Interoperability of ETC systems (1) contributes to the acceptance of equipment and services of EETS Providers by Toll Chargers, (2) builds confidence by Toll Chargers in an EETS Provider who is extending its business with supplementary services and (3) minimizes the need for elaborate bilateral agreements of an EETS Provider with all individual Toll Chargers.

However, discussions in this context have revealed that there is a need to clarify fundamental certification issues. There are different views and understandings on what needs to be certified, and how this should be done. The EC, Member States and to some extent the CESARE IV consortium seem not to include the complete scope of the certification. It has not yet been recognized that the EETS is primarily a service and not a piece of equipment. There is a need to focus on how the services can be certified. Without this, business in the scope of the EETS may prove difficult to set up.

RCI has identified this shortcoming and has established the Special Interest Group (SIG) Service Certification which:

1. Identified and formulated clearly the scope of the challenge (what is the object of certification and why?).
2. Showed what interfaces need to be assessed and certified.
3. Figured out types of Key Performance Indicators (KPIs) and measurement methods which should then be elaborated/ approved at EU level.
4. Referred to EFC services which are crucial for interoperability and are potential candidates for third party inspections.
5. Provided recommendations towards the involved stakeholders: Toll Chargers, ETS Providers, Member States/ Notified Bodies and the EC helping to advance this topic.

More information can be found in the report of the RCI Special Interest Group Service Certification on the RCI website.

The RCI partners recommend that relevant stakeholders (Member States, EC, EETS Providers), establish, at the European level, the appropriate conditions for taking action towards harmonised Key Performance Indicators, tools and measurement methods that are a prerequisite for offering the EETS service. This means that the organisation, financing and European coordination is needed to work on the following:

1. Developing criteria and procedures for conformity assessment of Toll Chargers' Toll Context definition. This work could be started when first drafts of the related European standards are available.
2. Developing criteria and procedures for assessing Toll Chargers' Road Side Equipment.
3. Developing criteria and procedures for verifying conformity of the EETS Providers' Toll Context implementation with the Toll Chargers' Toll Context definition.
4. Defining a set of Key Performance Indicators (KPI), including measuring methods and monitoring procedures to be established and harmonized by the ETS Providers and Toll Chargers.
5. Elaborating on inspection criteria and procedures for those services deemed crucial for interoperability.
6. Review of the applicability of Decision 768/2008/EC (referred to in the Draft Decision to EU Directive 2004/52/EC) with regard to services certification and proposed possible adaptations.

2 RCI NOTION OF INTEROPERABILITY

Interoperable road charging solutions in line with the Directive 2004/52/EC, mean for the EU citizen that he can make use on a voluntary basis and anywhere in Europe of a European Electronic Toll Service using one on-board equipment (OBE), based on one contract and resulting in one invoice (or at least a minimum number of invoices).

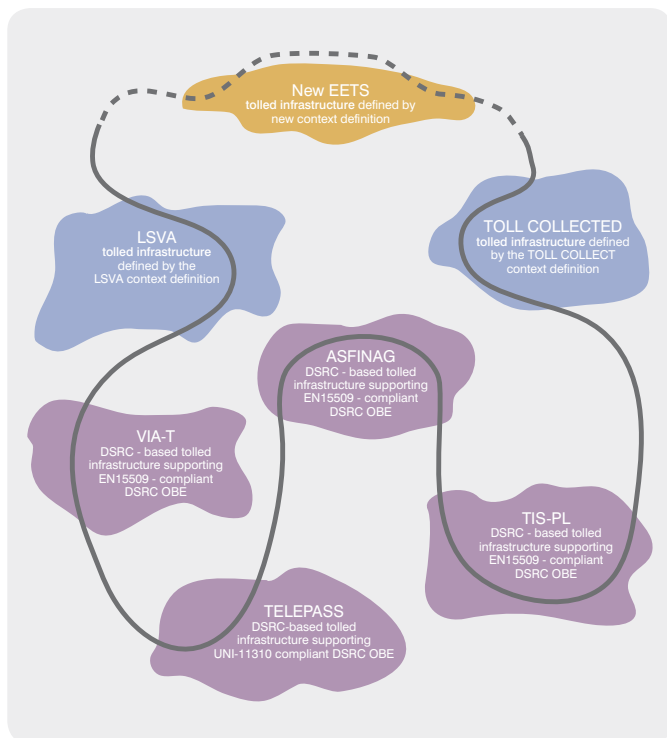


Figure 5: RCI concept for interoperable road charging shows how one service-user can travel from one tolled infrastructure to another, seamlessly and without any user intervention and both including DSRC -based infrastructure and GNSS enabled tolled infrastructure.

In the remainder of this document, specifications of functionality and interfaces that such a service needs, are called EETS specifications referring to the envisaged technical specification of this future European Electronic Tolling Service. The term interoperable solution then means that the implementation is compliant to this EETS specification. The RCI specification is meant to contribute to the further work on the EETS specification and eventually standardization.

2.1 DIFFERENT TYPES OF TOLLED INFRASTRUCTURE

The assembled grouping of all objects that are subject to tolling or taxing is called the tolled infrastructure. Interoperability means that one EETS OBE works for different tolled infrastructures.

In the RCI architecture two charging principles for a tolled infrastructure are supported:

- DSRC-based tolled infrastructure:** Charging data is generated in a real-time DSRC communication between the OBE and roadside microwave beacons. The data is further processed by the toll charger. The OBE serves as a data storage device, and allows reading data from it and writing data to it via the DSRC air link. The same set of data in the OBE serves the need of all DSRC- based tolled infrastructures.
- GNSS enabled tolled infrastructure:** Data enabling GNSS tolling is generated in the OBE autonomously and the GNSS charge data is forwarded via the central system of the EETS Provider to the Toll Charger periodically. The level of data processing within the OBE is dependant on the implementation that the EETS Provider is using. It is the responsibility of the EETS Provider to implement the relevant processes in order to produce the GNSS charge data described by the Toll Charger. GNSS, DSRC and mileage counters (odometer or tachograph) are the main technologies available for generating GNSS charging data. The Toll Charger receives the GNSS charge data through a back-office interface and can use DSRC for enforcement and localisation support.

It is mentioned that within this concept, two or more tolled infrastructures could overlap. It is also noted that the DSRC-based tolled infrastructure could be deployed anywhere, including inside the domain of GNSS-enabled tolled infrastructure.

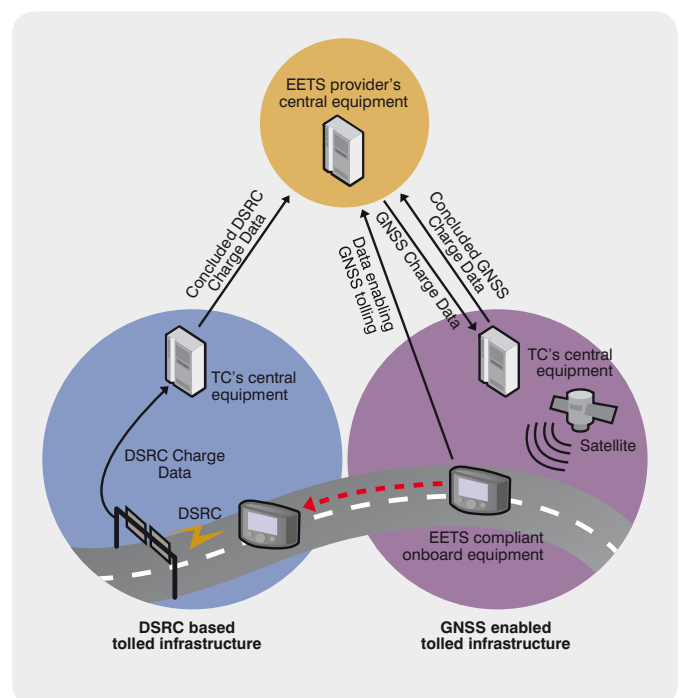


Figure 6: Charging principle for DSRC-based and GNSS enabled tolled infrastructure

2.2 TOLL CHARGERS' FREEDOM: TOLL CONTEXT DATA

Within the interoperability concept, those imposing and receiving the tolls or taxes should be free to define the charging in their tolled infrastructure, even in case where this local system is to be EETS compliant. This freedom in defining the charging for tolled infrastructure cannot be without limits in order to ensure that an existing base of operational EETS OBEs could operate correctly for tolled infrastructure that did not exist when these OBEs were being manufactured. This freedom should however be sufficient to avoid constraining toll chargers and/or Member States in defining new charging policies for tolled infrastructure.

The RCI architecture supports such freedom to toll chargers while ensuring feasibility for the implementation and potential for "horizontalisation" of the market of road charging solutions towards the EETS Provider and its suppliers.

For DSRC-based tolled infrastructure, the required freedom for toll chargers is defined within the specifications of the EN15509 standard and is realised through implementation at the roadside and central equipment of the Toll Charger.

For GNSS-enabled tolled infrastructure this toll charger's freedom is reached through an agreed specification of the "Toll Context Data" (TCD)¹.

¹It is being noted that the RCI project elaborates the Toll Context Data interface only to the extent needed for the interoperability during the generation and exchange of the charge data; information with respect to configuration data such as vehicle classes and/or tariff information etc., are out of scope of the RCI TCD but might be further elaborated in standardization activity under CEN278. For this reason the RCI TCD applies to GNSS-enabled road charging solutions and not to DSRC-enabled systems.

TCD is transferred from the Toll Charger to the EETS provider to inform the EETS provider about the tolled infrastructure on the following:

1. Communication of the charging data: When the EETS Provider needs to send charging data to the Toll Charger and what data elements should be included (e.g. if a certain list of charge records must be communicated or counter values).
2. Generation of the charging data: The triggers and actions that are relevant for the generation of records with charging data and for the handling of counters, in other words the core functionality of that specific road charging service (e.g. if the entry to a zone or the attachment of a trailer requires recording).

This TCD specification therefore exactly describes how any Toll Charger can define how he wishes to toll his infrastructure. It does however not define how the EETS Provider needs to implement the corresponding procedures; instead maximum flexibility to development and industrialisation is given in a fashion that the EETS provider can ensure that its existing stock of Front-Ends will behave appropriately in any tolled infrastructure without the immediate need for replacement of software or hardware.

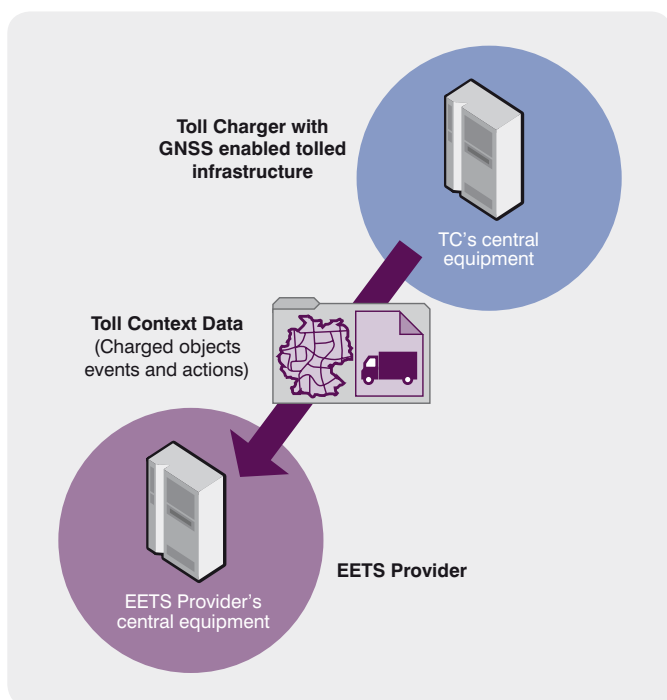


Figure 7: Toll Context Data

2.3 TOLL CHARGERS' TRUST IN EETS PROVIDERS AND VICE VERSA

Trust and confidence between Toll Chargers and EETS Providers is critical for successful operation of the EETS. RCI experience shows that certification of the equipment is not sufficient. Instead, continuous certification of the quality and monitoring of the quality by the Toll Charger/EETS Provider or independent 3rd party of the service as operated by the EETS Provider as well as of the service operated by the Toll Charger is a fundamental process in operation of the EETS at the European level.

Trust can only be achieved if the Toll Charger can verify the appropriate operation of the EETS as provided and operated by the EETS Provider and if the EETS Provider can rely on the appropriate infrastructure as operated by a Toll Charger (or Member State). This requires first of all that the Toll Charger can perform compliance monitoring. RCI included the required interface for this in its architecture, providing full support to this essential Toll Charger's process. Trust also requires that the Toll Charger can have confidence that the correct charge data is generated and provided to him. This requires Service performance Level monitoring and the EETS needs to incorporate a clear service interface between the EETS Provider and the Toll Charger in support for this process including a European agreement on what the Key Performance Indicators are and how these can be measured¹. The work in the RCI work package on Type approval and certification and in the Special Interest Group on Service Certification showed that the interfaces defined by the RCI architecture enable service monitoring, however European agreement on Key Performance Indicators, performance levels and measurement methods are needed.

¹ Example 1 monitoring EETS Provider's service: How to measure the accuracy of the detection of charge objects by the EETS Provider and what is the European performance level that must be met. If different for all Toll Chargers, (1) industry cannot guarantee its products meet the requirements in the market of tomorrow, (2) EETS Providers will have difficulty understanding/negotiating/accepting all service level agreements and (3) Toll Chargers will have difficulty applying monitoring on the service of EETS Providers that are not operating frequently on their tolled infrastructure.

Example 2 monitoring Toll Charger's service: the accuracy of how the TDL-based charge records are being created depends on the accuracy of the definition of the charge objects and on the availability and the performance of location support beacons. The accuracy of the definition of charge objects is expected to fall under responsibility of the Toll Charger but is (1) an important design- and cost-driver for manufacturing performing solutions as well as for (2) EETS Providers in identifying the need to install additional location support

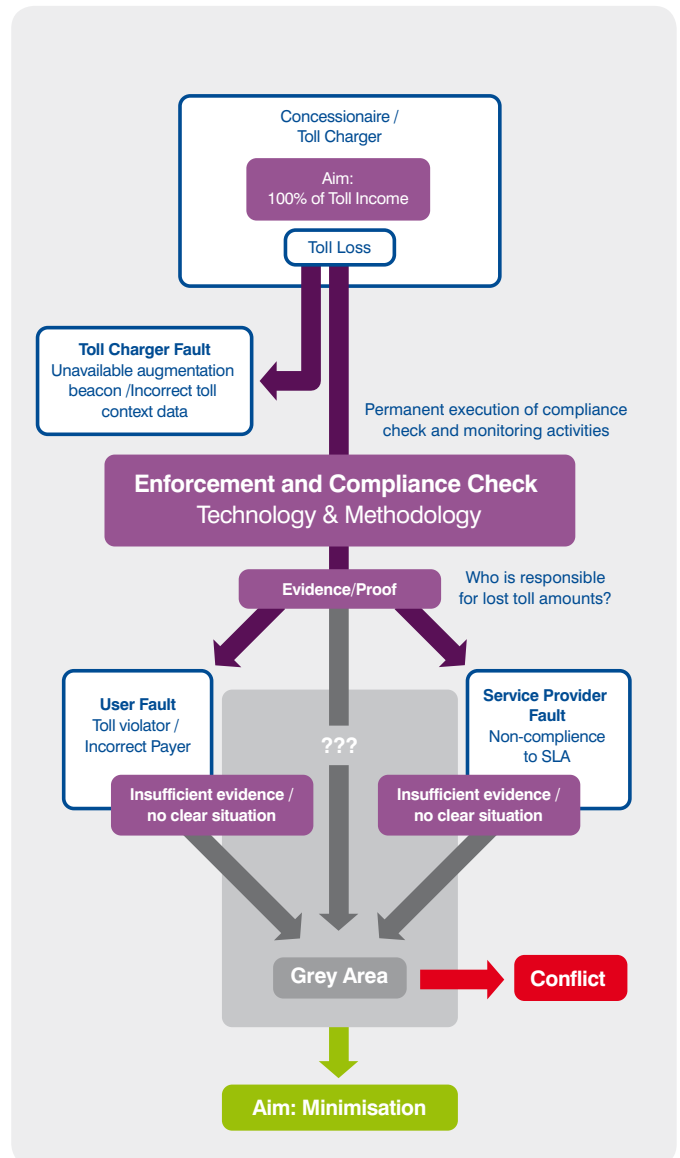


Figure 8: Trust relationship between Toll Chargers and EETS Providers is based on the RCI enforcement interface and Service performance level monitoring

2.4 EETS PROVIDER IMPLEMENTATION OPTIONS: FRONT-END

As mentioned, the TCD does not specify how the EETS Provider needs to implement the procedures imposed by this data. The EETS Provider is allowed to optimise their implementation independently of the local characteristics of different tolled infrastructures. They have several alternatives on how to implement the Front-End including the following:

- Distribution and allocation of processing across a proxy in the central equipment of the EETS provider and the OBE installed in the vehicles.
- How sensor-data is used to determine “in reality” when events are being triggered.
- How the charge objects are being represented and stored in the memory of the OBE and/or proxy in the central equipment of the EETS provider.

The RCI architecture includes the two main approaches currently discussed:

- A. Thin client approach:** The OBE sends most of its sensor data to a Proxy as part of the central equipment of the EETS provider. The Proxy processes this data in order to prepare the GNSS charge data and then forwards it to the Toll Charger.
- B. Intelligent client approach:** The OBE processes itself the sensor data, prepares the GNSS charge data, and stores them temporarily in its memory before they are forwarded to the Toll Charger via the central Proxy of the EETS Provider.

Both approaches include a back-office interface towards the Toll Charger for the exchange of the GNSS charging data and this interface should be specified by the EETS standard for interoperability. To include both approaches in the RCI architecture, the term “RCI Front-End” is used to refer to the OBE in conjunction with a Proxy. It is emphasized that the Front-End is a logical concept and not a physical component. In the context of the EETS, the use of an OBE is unavoidable; the use of a proxy for processing data however is optional. The Proxy is always required for the forwarding of the GNSS charge data to the Toll Charger¹. In case of the Intelligent Client approach the Proxy is only used as a communication server to exchange data between the central equipment and the OBE. This concept also allows approaches where the processing of the data is spread to OBE and Proxy.

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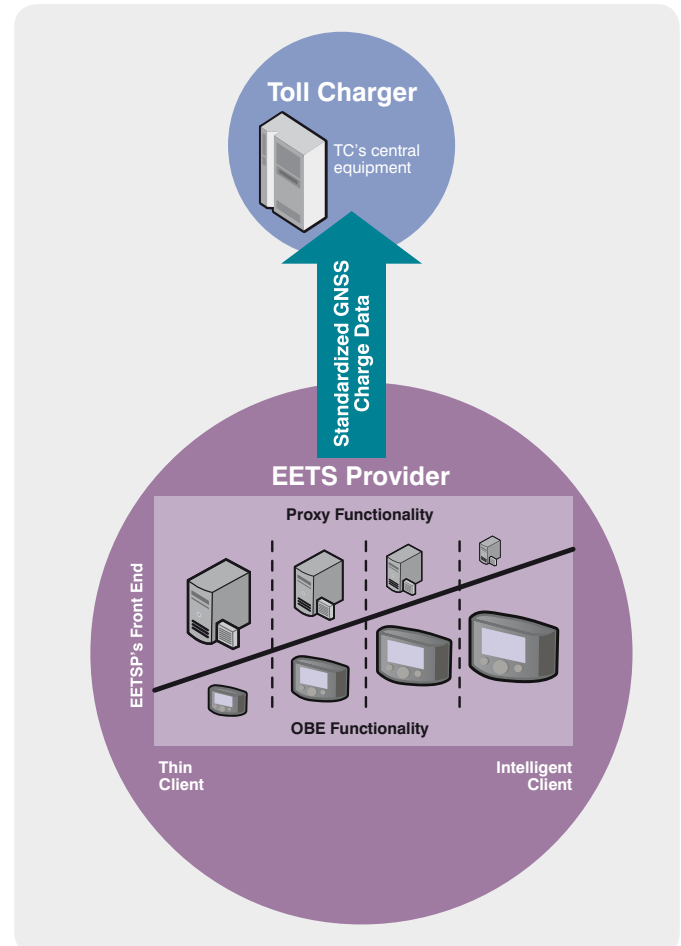


Figure 9: Preparation and forwarding of the GNSS charge data

Choosing which approach to follow for commercial implementations of the Front-End relies on a decision made by the manufacturers and the needs of the EETS providers. Competition in an open market will be the best guarantee for further research and development by industries for more functionality and flexibility and lower prices; surely this support for different approaches is a better guarantee for the success of the EETS than imposing one approach far before industry has had a chance to optimise and industrialise its solutions.

The RCI architecture, as such, keeps maximum freedom both at the implementation side by the EETS Providers as at the functional side at the Toll Chargers.

¹ A Toll Charger and a EETS Provider can still commonly agree that the OBE sends the data directly to the Toll Charger. Nevertheless this is not recommended by RCI as mandatory option for the EETS (to be offered by EETS Providers or to be requested by Toll Chargers).

3 RCI ARCHITECTURE

The RCI technical architecture has been built upon the role model definition of CESARE III.

RCI applies this organisational model, which includes the four main actors as roles: Interoperability Manager, Toll Charger, EETS Provider and Service User.

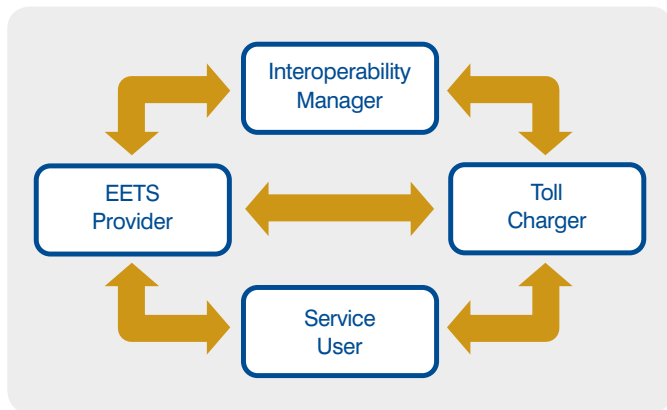


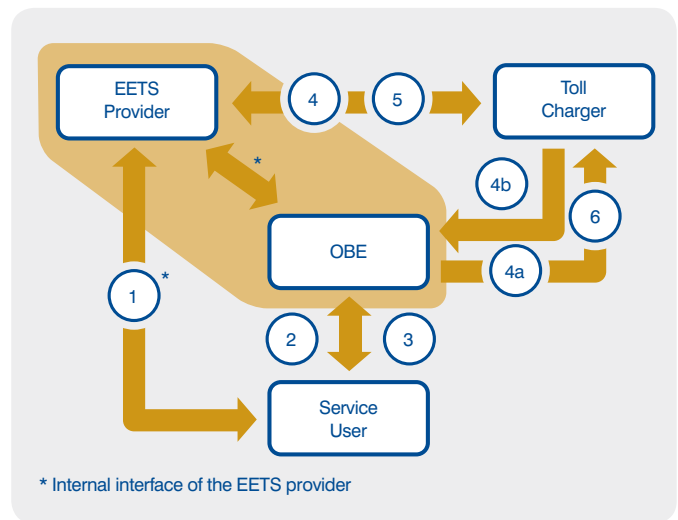
Figure 10: CESARE role model

The Interoperability Manager is not involved in the operation for the interoperable road charging service and therefore outside the scope of RCI. From this model the RCI architecture has been defined.

The RCI architecture defines what technical interfaces must be implemented in interoperable road charging solutions to support the exchange of information between the different actors. It will be these interfaces through which one actor will receive or send information, will monitor or even enforce another actor. It will therefore be these interfaces that are crucial for the implementation of the procedural and contractual agreements made between the actors to ensure interoperability, with the objective to establish and keep common trust in the system and operation thereof.

The GNSS based charging process for the part that is within the scope of RCI, consists of three functions: the GNSS charging process, the GNSS charge data transmission and the compliance monitoring and enforcement.

It is proposed that the CESARE III role model and the RCI technical architecture become starting points, possibly followed by extensions and/or modifications.



Interface 4*

- 4 - Charging Data
- ISO 12855 based on Data Definition of ISO17575-1
- 4a - Charging Data
- EN15509 (DSRC-Charging)
- 4b - Localization Support
- CEN TC278 WG1 SG6
- PT 22/23

Interface 5

- Payment Data
- ISO 12855 (in progress)
- Security, Blacklists, Enforcement
- ISO 12855 (in progress)
- Toll Context Data
- ISO 12855 based on Data Definition of ISO 17575-3

Interface 6

- Enforcement
- EN15509 (DSRC-Systems)
- ISO 12813 (in progress) for GNSS-Systems

Interface 3

- Minimum HMI interaction

Interface 1, 2

- Not applicable to CESARE role model and not critical for interoperability (how ever European consensus on high-level security requirements is needed).

The GNSS charging process is the collection and processing of the charging data that according to RCI is carried out by the OBE, possibly with the help of a proxy. Whether to choose this option is left open to industry; RCI states that the GNSS charging process takes place in the Front-End. It is noted that physically the proxy is likely to be part of the back-end, logically however it is dealing with charge data (optionally to generate the GNSS charge data, but at least to forward the GNSS charge data to the Toll Charger). The interface between the OBE and the proxy is the responsibility of the EETS Provider and the EETS does not require standardization of this 'internal' interface. The GNSS charge data transmission to the Toll Charger for the determination and/or verification of the fee will make use of an external interface 4, which should be standardised.

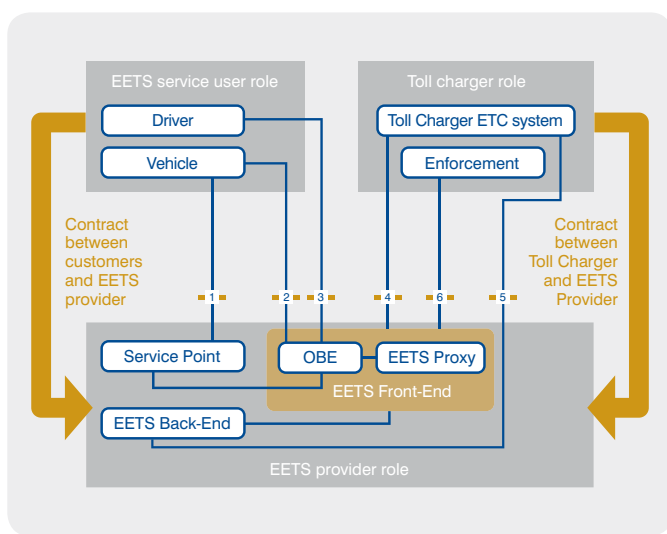


Figure 11: RCI architecture and interfaces

Enforcement of GNSS-enabled OBE takes place on the basis of the transmission of the OBE status and parameter declaration data, related to the road usage to be enforced, from the OBE to the enforcement equipment of the Toll Charger, possibly in combination with information that is being sent from the EETS Provider's proxy to the enforcing Toll Charger (see later in open questions interface 6). Compliance monitoring and enforcement therefore makes use of an 'external' interface 6, which needs to be standardised.

In the DSRC charging process the charging data is generated in a transaction between the OBE and the road side equipment, and is immediately available at the Toll Charger. No extra data have to be transmitted for enforcement, as all relevant data are included in the charging transaction. The DSRC charging process therefore is making use of external interface 4.

In order to operate on GNSS-enabled tolled infrastructure, the EETS Front-End should be operational and provided with the up to date Toll Context Data. As mentioned and explained in chapter 2.2, this TCD is being defined by the Toll Charger and published to the EETS Provider in a standardised manner and making use of 'external' interface 5, which needs to be standardised.

Interoperability also requires subscription by a Service User to an EETS Provider, an installed OBE in the vehicle provided with contractual data, vehicle data and the appropriate software. It is the user's responsibility to only use a tolled infrastructure if the OBE informs him that the status is OK. Via the human-machine interface (HMI) the Service User is informed on the status of the OBE and via this interface he can change those settings and declarations that are under his control. The HMI interface is interface 3.

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 EETS Provider and the Service User.

We can also see that only two contracts are necessary:

1. Between the Toll Charger and the EETS Provider
2. Between the Service User and the EETS Provider.

These contracts will have to contain the roles and responsibilities aligned to technical specifications and characteristics of the interfaces.

4 RCI INTERFACES

This chapter enumerates and explains assumptions and open questions that need to be considered in the context of further development of the EETS when ensuring consistency between the technical and contractual frameworks.

4.1 INTERFACE 1: Service Interface

Interface 1 provides an in-vehicle access point for the servicing and maintenance of road charging OBE.

In-line manufacturing by Original Equipment Manufacturers of this service interface that allows access to the road charging OBE could improve the access to the OBE that service engineers have and potentially reduce the cost of the manufacturing of the OBE. However, the standardization of vehicle-provided access points for the servicing and maintenance of road charging OBE is not considered critical for interoperability and therefore outside the scope of RCI.

4.2 INTERFACE 2: Vehicle Integration Interface

Interface 2 defines how the OBE 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, it can require the placement of the OBE/DSRC component at a particular place (in the case of a metallised windscreen) to allow for proper DSRC performance as well as a connection to the vehicle tachograph/odometer, the vehicle power-supply/ignition or other in-vehicle systems and sensors.

Especially from a toll assurance point of view, it might be necessary to use redundant sensor information (e.g. Tachograph and GNSS or trailer declared by driver and trailer sensor/CAN-Bus information, etc.) to provide the correct base information for later Charge Data calculation. The most reliable way to provide such information is via a standardized (secured) interface, whereas this logical OBE/Vehicle interface can consist of different physical ones.

Additionally, 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/CN/DSRC etc.

Last but not least the standardization of interface 2 has great advantages for reduction of installation time and costs for initial OBE fitment or in case of replacement. As a conclusion, the standardization of the vehicle integration interface is not considered critical for interoperability. Nevertheless, certain high-level requirements must be formulated on a common European level (e.g. regarding which vehicle sensors must be connected and regarding possibilities for the user to deinstall and/or reinstall the OBE).

4.3 INTERFACE 3: Human Machine Interface

Interface 3 provides access to the OBE for human interaction. A very important function of this interface is to enable the road charging application to indicate to the Service User if the OBE is operational and correctly functioning and to allow the Service User to declare variable vehicle data (e.g. trailer information).

Standardization of the HMI interface could comprise two elements that are essentially different:

1. Specification of what messages/information the OBE (at the minimum): (a) is supposed to be capable of providing to the Service User (e.g. OBE states and event information) and (b) should allow the Service User to provide to the OBE (e.g. variable vehicle data).
2. Specification of how these messages/information should be expressed (visual text, coloured LEDs, speech, keyboard, buttons, etc.).

The use of certain functionality in a toll domain has to be included in the Toll Context Data issued by the Toll Charger of that toll domain. It is obvious that the Toll Context Data can not require giving messages to the end user that are not included in a European reference for minimum HMI support for providing messages to the end user¹;

As an example for the first bullet, the minimum European support for displaying messages to the end user could be:

a) Normal Operation [Mandatory]:

Every thing is o.k. I am working properly in all contexts.

b) Malfunction [Mandatory]:

OBE does not operate in those contexts to which the malfunction indication applies. (e.g. if the CEN DSRC functionality is broken.) The Service User has to behave according to the rules which apply in this context under the situation of malfunctioning equipment.

c) Problem Indication [Optional]:

There is a malfunction that influences the full functionality of the OBE, but for the operation in the current context the available functionalities are still sufficient.

It is therefore concluded that a European reference for the minimum HMI support (first bullet) is required. The way this information is displayed (second bullet) does not require standardization.

As a conclusion, the standardization of the Human Machine Interface of the OBE itself is not considered critical for interoperability.

¹ EETS Provider and Toll Charger can commonly agree to offer further functionalities. These additional functionalities must not discriminate EETS users.

Nevertheless, certain high-level requirements must be formulated on a common European level (e.g. regarding which vehicle data must be possible to be entered via the HMI interface, like axles, weights etc. and what messages display should be supported by the HMI). These aspects can be specified through interface 5 as part of the Toll Context Data publishing standard.

4.3.1 Assumptions with respect to the procedural/contractual framework

It is assumed that before deployment of interoperable road charging at a European level, a standard or agreement is available that specifies (and limits) the functionality of the HMI (RCI recommends the use of the Toll Context Data publishing standard).

The Service User has to declare changes of vehicle properties at the OBE for toll domains where such a declaration is foreseen. The variation in information that the service user is expected to configure through the HMI (e.g. vehicle classes) as well as the messages sent to the service user by the OBE through the HMI, needs to be limited and defined exhaustively through a standard or European agreement.

This standard should also, without any ambiguity or contradiction, specify if the OBE can or cannot be switched off and should or should not always remain in communication with the EETS Provider proxy. Since the OBE can be in operational mode for two or more different toll contexts simultaneously, these features should be harmonised at a European level.

RCI considers the Toll Context Data a suitable concept for standardization of this functional HMI capability.

It is assumed that the meaning of specific HMI indications such as a red light, green light, flashing display, etc. is currently not being standardised and decided upon by the EETS Provider and/or manufacturer of the equipment.

It is expected that the EETS Provider will ensure that an OBE will show uniform and consistent HMI behaviour across the different EETS-compliant tolled infrastructures in Europe.

More specifically, it is expected that an HMI indicating that the OBE is not operational in one country will use the identical HMI message for indicating this in another country. However the OBE of brand x can use a flashing LED while the OBE of brand y could use a red LED.

It is assumed that it will become part of a standard that the OBE must be capable of indicating the tariff to the service user, however, it is noted that this feature would be a potential cost-driver and potentially in conflict with the allocation of the responsibility for determining the tariff.

Interface 3 shows that only information present in the OBE can directly be visualised to the service user. The indication of tariff (or other text messages related to an event) to the service user inside the vehicle therefore has significant consequences on the design of the EETS Front-End.

The Toll Charger can decide which functionalities shall be used for its toll domain in which manner by its Toll Context Data, but the requested functionalities can not exceed the commonly agreed minimum functionalities which an EETS OBE is offering.

It is furthermore noted that the Toll Charger does not have access to the OBE for sending information that is provided to the Service User through the HMI. Including the functional requirement that tariff information can be given to the service user through the HMI furthermore suggests that the EETS Provider has a legal basis for providing this information which would be contradictory with the contractual framework as set out by CESARE and the EETS. The CESARE role model allocates the responsibility for the tariff definition as well as for the approval of the calculation to the Toll Charger.

4.4 INTERFACE 4: Charge Data Exchange / Toll Declaration

This interface 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 localisation support via (augmentation) support beacons but only if the operation of location support beacons is considered the responsibility of the Toll Chargers (see assumptions).

The illustration below clearly shows a fictive example, from the perspective of a French national Toll Charger, on how European interoperable road charging involves each Toll charger receiving charging data from several different brands of Front-Ends.

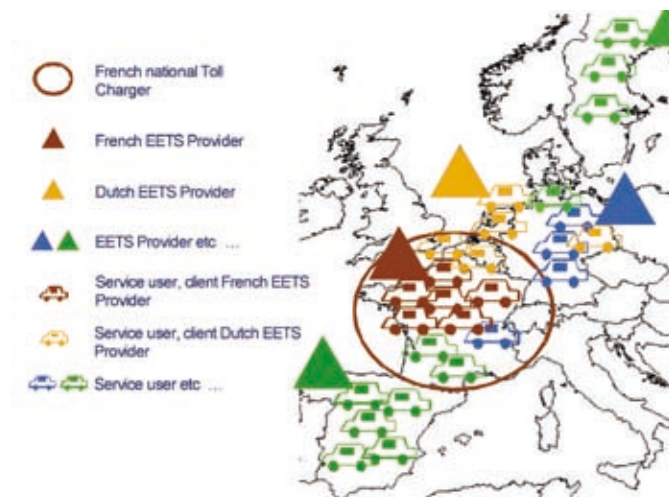


Figure 12: Each Toll Charger receiving charge data from multiple and different EETS Providers

It is clear that the manner through which a Front-End sends its data to a Toll Charger must be standardised. It is also clear that if a Toll Charger operates a network of location support (augmentation) beacons, this interface for the exchange of location support data between the beacon and the OBE requires standardization.

It is noted that the situation for GNSS-enabled road charging is fundamentally different to the one for DSRC-based solutions.

For GNSS-enabled road charging system the data enabling GNSS tolling as generated by the OBE will first be sent to the EETS Providers and (possibly after some processing) be forwarded to the Toll Charger. The interface in this case that requires standardization is interface 4 between the EETS Provider's Front-End and the Toll Charger's central equipment. For DSRC-based road charging it will be the OBE that directly communicates with the Toll Charger. This communication takes place between the OBE and the RSE beacons and does not require wireless cellular communication.

For DSRC-enabled road charging, interface 4 is therefore standardised by EN 15509.

4.4.1 Assumptions with respect to the procedural/contractual framework

It is assumed that the EETS Provider is responsible for the communication of the charge data (also called use data) to the Toll Charger in case of GNSS-enabled road charging.

The RCI architecture puts the interface between the OBE and the proxy fully under the responsibility of the EETS Provider and assumes that this is consistent with the CESARE role model. The EETS Provider is expected to own the communication contract and control all software and behaviour of the OBE and proxy.

It is assumed that the interface for sending charge data in the case of GNSS-enabled road charging from the EETS Provider to the Toll Charger does not make use of wireless communication technologies; the Toll Charger therefore is not expected to operate gateways that connect to one or more mobile telecommunication networks (for reasons see directly above).

For GNSS-enabled road charging it depends on the implementation choice of the Front-End if the EETS Provider needs a proxy or not to ensure that the OBE-generated data is meeting the Toll Charger's requirements. In the case that the OBE is generating data that requires further processing by the EETS Provider, the EETS Provider will receive the OBE-generated data in his proxy, have it processed and then send it to the Toll Charger over the most reliable and cheapest communication channel that he has access to (in general a fixed and wired connection). In the case that the OBE generates exactly those charge data records that the Toll Charger requires, no further processing by the EETS Provider is needed. Even in this case, the EETS Provider will need to know this charge data and never allow the OBE sending this data directly to the Toll Charger without having a copy.

The EETS Provider therefore will first receive the data from the OBE, make a copy and then forward the data over the most reliable and cheapest communication channel that he has access to (in general a fixed and wired connection) to the Toll Charger.

It is assumed that the EETS Provider has the responsibility to generate and communicate charging data (also called use data) to the Toll Charger compliant to the Toll Context Data as specified, and is provided according to a European standard by the Toll Charger to the EETS Provider.

The RCI architecture is based on the assumption that a European standard for this exists and that this standard is being used by each Toll Charger to specify the required functional behaviour on his tolled infrastructure, the events and conditions that lead to charge object identification and the format for communicating these charge data records. RCI calls that standard the Toll Context Data standard which is interface 5.

It is assumed that for DSRC road charging, the Toll Charger has the responsibility to operate roadside equipment to collect charging data in transactions between any OBE that is EN 15509 or UNI-compliant and his RSE equipment.

The RCI architecture is based on the assumption that the interface between the EETS Provider (Front-End) and the Toll Charger is standardised and allows the manufacturer to have his OBE equipment certified for use in any EETS-compliant tolling scheme.

It is assumed that the Toll Chargers and EETS Providers will agree on an appropriate interface for the communication of DSRC-enabled charge data (also called use data) from the Toll Charger to the EETS Provider.

RCI architecture includes all interfaces needed to generate the charge data, have it delivered to the Toll Charger, allowing the Toll Charger to apply compliance monitoring and enforcement. The clearing and data streams for justification between the back-offices of the EETS Provider and the Toll Charger are beyond the scope of RCI.

It is assumed that the Toll Charger does not have the right/possibility to exchange information with the Front-End except when using the standards for interface 4 or interface 6.

The EETS Provider is completely responsible for the correct operation of the Front-End. As a result, access to the Front-End will be controlled by the EETS Provider and the Toll Charger cannot directly access the Front-End unless making use of interface 6 for enforcement or interface 4 for DSRC-enabled solutions and/or GNSS location support data.

This raises the following additional issue: in a GNSS environment the EETS Provider has the responsibility to indicate to the OBE if it is blacklisted or grey listed. If the OBE is not informed of this, there is no possibility of informing the Service User of any black- or grey-listing; consequently, the Service User cannot be held responsible for stopping the use of tolled infrastructure being subject to EETS when he is not allowed (i.e. the EETS Provider still guarantees the payment to the Toll Charger).

It is assumed that the Toll Charger can not communicate black/grey listing to the OBE (for reasons see directly above).

It is assumed that this interface allows localisation support beacons that are operated by the Toll Charger to send data to the OBE.

The Toll Charger or the EETS Provider has the responsibility to operate roadside equipment supporting the identification of tolled road links in the EETS Front-End (so-called localisation beacons) at locations with an expected or measured insufficient success rate of the EETS Front-End with respect to the correct link identification, taking into account required service levels by the Toll Charger.

If the EETS Provider would be responsible for operation of location support beacons, each EETS Provider would need to install a complete network of such beacons for one and the same tolled infrastructure. This would be an extremely expensive solution and not scalable into a European level.

RCI recommends that the responsibility for installing and operating augmentation beacons should be allocated to the Toll Charger on the basis of harmonised Key Performance Indicators and corresponding measurement methods. Access to augmentation beacons should be provided on a non-discriminatory basis to all EETS Providers by the Toll Charger. However, there should be no mandatory requirement for an EETS Provider to use augmentation beacons even if a Toll Charger provides them: as long as the EETS Provider's equipment successfully identifies charge objects with the accuracy required by the Toll Charger, it does not matter how he achieves this.

It is assumed, there will be a European agreement on harmonised Key Performance Indicators and corresponding measurement methods enabling deployment of the EETS (for reasons see directly above).

4.4.2 Open Question

What are the minimum privacy requirements?

European guidance is required to ensure privacy for the service user concerning what data may and what data may not be communicated between the EETS Provider and the Toll Charger. RCI identifies the risk that different Member States could apply different requirements or increase requirements over time as such disturbing the market of possibly hundreds of thousands or even millions of in-vehicle systems.

Note that this issue also applies to the proprietary interface between the OBE and the Proxy. Perhaps not all data present in the OBE may be communicated with the proxy because of privacy constraints. European agreement on this will drive industry's design decisions with respect to thin or thick clients.

4.5 INTERFACE 5: Toll Context Data Publishing

This interface 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). This definition is being called Toll Context Data (TCD)¹. The EETS Provider has the obligation that the behaviour of its Front-End is compliant to this Toll Charger's definition. Figure 12 shows that deployment of the EETS requires that the way any Toll Charger can define his TCD must be standardised and describes clearly and exhaustively all variety that the Toll Charger has when defining his TCD. The TCD cannot include functionalities which exceed the minimum functionalities which the EETS Front-End has to offer.

(Interface 5 also hosts the back-office transactions/clearing between the Toll Charger and the TSP as well as the communication of invalidated OBEs which is outside the scope of RCI)

4.5.1 Assumptions with respect to the procedural/contractual framework

It is assumed that each Toll Charger will define the Toll Context Data for his tolled infrastructure in compliance with a European standard.

The RCI architecture is based on the principle that within the interoperability concept, those imposing and receiving the tolls or taxes should be free to define the charging in their tolled infrastructure, even in the case that this local system is to be EETS compliant. This freedom in defining the charging for tolled infrastructure cannot be without limits in order to ensure that an existing base of operational OBEs could operate correctly for tolled infrastructure that did not exist when these OBEs were being manufactured. This freedom should however be sufficient not to constrain Toll Chargers and/or Member States in defining new charging policies for tolled infrastructure.

The RCI architecture supports such freedom to Toll Chargers while ensuring feasibility for the implementation and potential for "horizontalisation" of the market of road charging solutions towards the EETS Provider and its suppliers.

¹ It is being noted that the RCI project elaborates the Toll Context Data interface only to the extent needed for the interoperability during the generation and exchange of the charge data; information with respect to configuration data such as vehicle classes and/or tariff information, etc., are out of scope of the RCI TCD but might be further elaborated in standardization activity under CEN278. For this reason the RCI TCD applies to GNSS-enabled road charging solutions and not to DSRC-enabled systems.

For GNSS-enabled tolled infrastructure the Toll Chargers' freedom is reached through an agreed specification of the "Toll Context Data". Toll context data is transferred from the Toll Charger to the EETS provider, to inform the EETS provider about the tolled infrastructure on the following:

- 1. Generation of the charging data:** the triggers and actions that are relevant for the generation of records of charging data and for the handling of counters (e.g. if the entry to a zone or the attachment of a trailer requires recording).
- 2. Communication of the charging data:** when a specific Front-End of the EETS Provider needs to send charging data to the Toll Charger and what data elements should be included (e.g. if a certain list of charge records must be communicated or counter values).

This Toll Context Data specification therefore exactly describes how any Toll Charger can define how he wishes to toll his infrastructure. The EETS Providers have to implement the toll context updates at the EETS Front-End of their EETS subscribers. They have to guarantee that the Toll Context Data is up-to-date when the corresponding vehicles are using the tolled road network of the context, such that the correct charge data and enforcement data is generated. The TCD therefore does not define how the EETS Provider needs to implement the definitions; instead maximum flexibility to development and industrialisation is given in a fashion that the EETS provider can ensure that its existing stock of Front-Ends will behave appropriately in any tolled infrastructure without the immediate need for the replacement of software or hardware.

RCI concluded that a European standard for this TCD must become available and that each Toll Charger should publish this TCD in a manner so that any EETS Provider has easy access and is being informed on any changes.

It is assumed that there are rules for the maximum frequency through which a Toll Charger can change the TCD in relation with the requirements of the EETS Providers as well as for the minimum delay for the EETS Provider to have the new or updated TCD implemented in the Front-End.

RCI interface 5 shows that the processing of location data into charge data can be done either in the OBE or in the proxy. New charge objects that are part of the TCD therefore need to be known by the OBE or the proxy. European agreement on this will drive industry's design decisions with respect to thin or thick clients as well as mechanisms through which the Front-End's software can be updated.

It is assumed that the format and exchange of Toll Context Data shall not be object of bilateral agreements between EETS Provider and Toll Charger but need to be subject to one European standard.

Lacking a European standard for this Toll Context Data and methods for certification could potentially block new EETS Providers from entering a market if there is no suitable European version available for each Toll Charger Toll Context Data.

Furthermore a lack of a standard for the Toll Context Data would result in the situation that an existing Front-End cannot be guaranteed to support new EETS schemes. As such, it would block a European market development and decrease chances for economies of scale and related cost reductions.

It is assumed that there is support and acceptance at the European level for the fact that the functionality of any new EETS-compliant tolling scheme should only be defined using the standardised TCD (and is as such constrained by a European standard).

It is assumed – this needs validation when a standard would be drafted – that all functionality needed (from business or from policy perspective) is supported by the standardised European TCD. RCI showed how Toll Collect and LSVA could be translated into such a TCD.

4.5.2 Open Question

Who is responsible for the provision of geographic coordinates in a standardised geodetic model for all charge objects in the GNSS-enabled road charging scheme?

The Toll Charger has the responsibility to define all charge objects as part of this TCD, but it needs to be clarified at what level of detail the charge objects have to be defined. If the Toll Charger is responsible for the provision of geographic coordinates in a standardised geodetic model, there could be a risk of lack of legal clarity in the event that the final performance by the Front-End is not sufficient – is this because of the Front-End itself or because of the inaccurate definition of the charge objects used? If this is the EETS Provider then each EETS Provider will have to generate or buy a good implementation of these charge objects for each tolled infrastructure. This is a potential market killer. If this is being done on the basis of bilateral agreements between the Toll Charger and the EETS Provider this is a risk for free market entry and fair market. The issue is the distinction between the task of the Toll Charger to identify charge objects uniquely and that of the EETS Provider to ensure that charge objects are correctly recognised.

4.6 INTERFACE 6: Enforcement

This interface enables the Toll Charger to carry out enforcement and compliance checking transactions with the OBE.

4.6.1 Open Question

Is compliance monitoring and enforcement being carried out through interrogation of the OBE only or through a combination of interrogation of the OBE and the proxy?

For GNSS-enabled road charging it needs to be clarified if there is the obligation for the EETS Provider to enable the Toll Charger to communicate all enforcement data directly with the OBE, or that the Toll Charger is allowed to retrieve specific data from the EETS Provider's proxy?

The RCI interface number 6 can drive design choices of the industry for thin or intelligent clients, so this interface needs to be clarified urgently. RCI experience shows that off-board processing of location data into charge data results in a 'thin' OBE that cannot fully meet existing enforcement requirements by Toll Collect and Swiss Customs; these systems would require some modification in order to accept thin OBE. It should be clarified if and how Europe can define the Toll Charger enforcement requirements to maximise industrial freedom for optimisation and to ensure Toll Charger interests and assets to be elaborated. PT22 of TC278 is currently working on that issue.

4.7 ASSUMPTIONS PROPRIETARY INTERFACES

It is being assumed that the EETS Provider has the responsibility to indicate to the OBE if it is blacklisted or grey listed.

If the OBE is not informed on this, there is no possibility to inform the Service User on this hand in GNSS-enabled tolled infrastructure, and as a consequence, the Service User cannot be held responsible for not stopping the use of the tolled infrastructure being subject to EETS when not allowed.

It is being assumed that the EETS Provider has the sole capability for remote data and software update of the OBE (which could be done through a proprietary interface).

Any update (also based on additional or updated TCD by Toll Chargers) and any contact to the OBE is the responsibility of the EETS Provider. The Toll Charger is in no circumstance responsible for the OBE of the EETS Provider.

4.8 GENERIC ASSUMPTIONS AND OPEN QUESTIONS

It is assumed that a European standard will exist that defines the Key Performance Indicators and measurement methods that will provide the cornerstone for establishing trust and confidence between the Toll Chargers and EETS Providers.

Critical for successful operation of the EETS is trust and confidence between Toll Chargers and EETS Providers. RCI experience shows that certification of the equipment is not sufficient. Instead, continuous certification and monitoring of the quality by the Toll Charger of the service as operated by the EETS Provider, and vice versa, is a fundamental process in operation of the EETS at the European level. At this moment CESARE is identifying what these contractual and procedural obligations for both roles comprise and how decisions in this domain can be taken; however, the operation thereof and any decision-making process requires cost-effective methods that can be proposed including a harmonized set of Key Performance Indicators as well as on the methods for measuring these¹.

¹ Example 1 monitoring EETS Provider's service: How to measure the accuracy of the detection of charge objects by the EETS Provider and what is the European performance level that must be met. If different for all Toll Chargers, (1) industry cannot guarantee its products meet the requirements in the market of tomorrow, (2) EETS Providers will have difficulty understanding/negotiating/accepting all service level agreements and (3) Toll Chargers will have difficulty applying monitoring on the service of EETS Providers that are not operating frequently on their tolled infrastructure.

RCI assumes that before GNSS-enabled interoperable road charging can be deployed, the contractual and procedural frameworks covering this aspect are in place as well as harmonization and clear specification of the KPI and measurement methods at the European level.

4.8.1 Open Question

Should existing or future Toll Chargers' performance requirements limit EETS Providers' freedom regarding his Front-End design?

RCI found that in current toll charging systems different performance requirements already exist – especially in the GNSS enabled systems and alike ones – which greatly reduce industrial freedom on optimisation of its design, and which are potential cost drivers. Since EETS-compliant equipment has to meet such requirements, even if only imposed by one Toll Charger, the validity of a business case for offering the EETS as a service will depend, among others, on the success to agree on European performance requirements at a European level. In this context it is noted that Toll Chargers have a fundamental interest in assuring their toll revenues in cases of EETS, as well as not facing a serious unequal treatment regarding performance acceptance between EETS and their "Home-Users".

Example 2, monitoring Toll Charger's service: the accuracy of how the TDL-based charge records are being created depends on the accuracy of the definition of the charge objects and on the availability and the performance of location support beacons. The accuracy of the definition of charge objects is expected to fall under responsibility of the Toll Charger but is (1) an important design- and cost-driver for manufacturing performing solutions as well as for (2) EETS Providers in identifying the need to install additional location support.

5 RCI VALIDATION CONCLUSIONS AND RECOMMENDATIONS

Operational interoperability of road charging services in Europe cannot be realized without clear agreements between the different stakeholders on (1) the role model defining 'who is responsible for what' and (2) the technical architecture defining 'how/what information is being exchanged'.

The role model defines the responsibilities and rights that exist for each of the three roles involved in the operation of interoperable tolling: the Toll Charger, the ETS Provider role and the Service User role.

Following a common European view on the role model, it can be derived who in the service chain of European interoperable road charging has the obligation to generate, process, store or make available an information stream. Information that flows from one stakeholder to another needs to be formatted in a manner that it is understood, the functionality used to generate the information needs to meet minimum performance requirements and the information needs to be complete. A common agreement on these aspects should be expressed by a technical architecture showing the interfaces (what information is being exchanged, between who and in which format), showing the functional blocks (how the information is being generated).

5.1 CONCLUSIONS

The RCI technical architecture has been validated on many aspects and it is concluded that the RCI architecture is suitable for the basis of the EETS definition:

1) Completeness: the interfaces 4, 5 and 6 are necessary and sufficient to provide the levels of interoperability required for the EETS

- a) DSRC interfaces validated: RCI validated the new standard EN 15509 (and EG11 for DSRC Telepass UNI) in a way that existing DSRC-enabled tolling schemes can operate in an interoperable European service context; the RCI architecture was validated in France up to the operational level with RCI prototypes installed in two trucks, and with real invoices being generated.
- b) The GNSS interfaces have been precisely defined and it has been validated that these interfaces can establish interoperability. On all interfaces that RCI defined as crucial for interoperability of GNSS-enabled road charging, CEN TC 278 WG1 initialized related work items.
- c) One of these interfaces includes what RCI calls the Toll Context Data (TCD) definition. RCI validated this TCD and its suitability to be used throughout Europe for establishing interoperable GNSS-enabled road charging services. The Toll Context Data is currently being defined by EN 12855¹ and must be used by Toll Chargers in order to provide interoperable tolling.
- d) RCI developed specifications on the basis of existing implementations for LSVA and Toll Collect. Although full European specifications for a number of interfaces are not yet available, nevertheless the project took account of anticipated requirements from several other potential systems, such as those being developed in Sweden, France, the Netherlands, Slovakia and Slovenia. For a complete basis for the EETS the following needs to be addressed:
 - i) The LSVA specification needs to be translated into a common European definition. The RCI translation exercise (SIG document on the translation of proprietary specifications into RCI TCD, downloadable at the RCI website) shows the feasibility of bringing forward a number of decisions/agreements to be made at the European level with the involvement of the Swiss authorities: among these issues are the modeling of events, the definition of the charge objects, and enforcement based on declared characteristics and on states of the OBE.
 - ii) The Toll Collect specification needs to be translated into a common European definition. The RCI translation exercise (see reference above) shows the feasibility of bringing forward a number of decisions/agreements to be made at the European level with the involvement of the German authorities: among them are the interface for augmentation system (also called location support beacons), the enforcement interface, and performance parameters such as the 1/3rd of section length detection interval (these issues are discussed further in section 4).
- e) It is noted that there is currently no complete set of performance specifications to define exactly how an EETS front-end must perform. RCI WP6 has addressed this issue (SIG document on Service Certification and deliverable D6.1 both downloadable at the RCI website) and has defined what further work is required, including the achievement of a common understanding on service level requirements and European framework of Key Performance Indicators and measurement methods.
- f) It is also noted that European validated clarifications are required on procedural and contractual aspects that drive the finalization of technical specifications: The RCI architecture defines what technical interfaces must be implemented in interoperable road charging solutions to support the exchange of information between the different actors. It will be these interfaces through which each actor will receive or send information, will monitor or even enforce another actor. It will therefore be these interfaces that are crucial for the implementation of the procedural and contractual agreements made between the actors to

¹ EN12855 is also defining aspects which apply to GNSS enabled as well as to DSRC based tolled infrastructures.

ensure interoperability, with the objective of establishing and maintaining common trust in the system and its operation. For finalizing technical specifications therefore, clear agreements at the procedural and contractual level that will further drive the technical definition are to be made, such as:

- i) Who defines charge objects' coordinates?
- ii) Who is responsible for augmentation systems?
- iii) Who has access to OBE from outside?
- iv) What are the European privacy requirements?
- g) The RCI architecture is compatible with CESARE recommendations, and supports the business model behind them.

2) European acceptability

- a) The RCI architecture is acceptable to Toll Chargers and potential EETS providers. It has taken into account the results of CESARE III and the EC Expert Groups and has liaised with CESARE IV group.
- b) The availability of EETS OBE independently of an EETS Service Provider may be a long term objective, but is under the current market conditions not feasible. The RCI partners contend that the EETS architecture should not provide this feature, which could compromise EETS performance. The RCI architecture is based on the availability of the EETS service from different service providers who conform to EETS specifications but who retain complete control over the equipment they provide; these service providers can decide to act as telematics service aggregators, offering (3rd party) Value Added Services, as long as the Toll Charger can verify the correct operation of the road charging service. It is noted that the best guarantee for convergence of different OBE solutions is the formalization and use of European interoperability standards. Under mass market conditions, such as exist for mobile phone suppliers, the convergence might reach a stage that one EETS Provider can work with OBE of different brands.
- c) Access to the tolling platform by third party Value Added Service providers shall not be restricted but must be under EETS Provider's control. The RCI architecture is predicated on full control of the tolling Front-End by the EETS provider. The assignment of OBU resources to different software applications must also be under the EETS Provider's control. The EETS Provider has the obligation continuously to meet the service levels required by Toll Chargers. He may choose to do this within the OBE if there is sufficient capacity and he is confident in continuing to meet service level requirements, by using a separate device interfaced to the tolling OBE, by using back-end processing, or with a combination of these possibilities. Issues of data privacy must be taken into account. Given these requirements, there is no constraint on the availability of Value Added Services (VAS) from competing providers.

3) Socio-economic aspects (support for policy needs and meeting business requirements)

- a) The RCI architecture provides a basis for providing Value Added Services, and a basis for providing economies of scale and reduction of costs.
- b) There is scope for further cost reduction through further standardization – for example interfaces 1, 2 and 3.
- c) The RCI concept of the Front-End is crucial to maintaining freedom for suppliers and stimulating for innovation and cost optimisations.
- d) Economies of scale – industry can bring on to the market systems that work with today's tolling systems but which, with the RCI TCD and architecture definitions, are capable of supporting future systems as well.
- e) The RCI architecture, and any compliant equipment, is suitable not only for the EETS but in addition would be suitable as the standard equipment for any (EETS-compliant) regional or national implementation. Specifically, any country considering the introduction of a GNSS-enabled national road charging scheme would be able to require all users to have EETS equipment.
- f) The work on the Toll Context Data has taken account not only of existing schemes but all foreseeable future schemes.
- g) Discussions with Transport for London have covered the possibility of RCI-compliant equipment being used in an ANPR (Automatic Number Plate Recognition) system such as the London congestion charge, and confirmed that it would be suitable.
- h) RCI recognizes that several Member States may in the near future introduce new road charging systems, or make extensions or modifications to existing ones to take account of opportunities offered by up to date technology. The RCI prototypes and the RCI architecture take account of possible future road charging systems and requirements. The work on the Toll Context Data has taken account not only of existing schemes but also of all realistically foreseeable future charging policies.
- i) By defining the recommended EETS technical architecture, the RCI project has also contributed to the potential technical convergence of future tolling systems: such systems will be required to accept EETS units and therefore will benefit from being as compliant as possible with EETS definitions. The existence of minimum interoperability specifications will contribute to the emergence of an increased market for OBE, whilst allowing for a diversity of specific implementations; this is analogous to the GSM world where suppliers are able to develop their own mobile phones with different feature sets, whilst retaining complete interoperability throughout Europe.

j) The RCI architecture defines the Front-End to be provided by an EETS provider and does not specify the location of charging processing capability, leaving EETS providers free to select their own optimum in the range between thin and intelligent client on-board equipment. Both approaches were successfully demonstrated and validated within RCI although no detailed cost analysis has been carried out.

4) Openness, availability, legal or IPR blockage

- a) 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. In order to provide fully interoperable equipment it will be necessary for suppliers to have access to specifications of existing systems, including Toll Collect, LSVA and Telepass.
- b) No detailed analysis of IPR issues has been carried out within the project. However, the work on interfaces has been conducted in close liaison with CEN TC 278 WG1, which has an ongoing task to monitor relevant IPR activity. There are many hundreds of patents which are relevant to electronic fee collection, but WG1 has sought to obtain assurances from holders of patents relevant to the standards it has developed that access to any IPR represented by the patents would not be withheld.
- c) It is believed that it would not be necessary to infringe any existing patent in order to develop equipment suitable for use within the RCI technical architecture, but this statement is not guaranteed.
- d) There could be some problems with GNSS-related patents. In general this should be solved in a way that any (national) system that comes with a tender should require that specific IPR used by a successful bidder must be openly available and free of charge for competitors that want to produce interoperable equipment. If this cannot be established, and licenses must be paid for all the different (existing) system implementations then an interoperable OBU will never be possible for a reasonable price.
- e) Interoperable Tolling is a European and Nationwide public issue.
- f) Patents are mainly used to protect markets against competitors. Patents could therefore basically be a threat to interoperability. An obligation to give a license to competitors once a contract is given to a main contractor would not help if the license fee were prohibitive. However, the assurances already sought and received within CEN TC 278 should help to ensure that this does not happen.

- g) The above applies specifically to tolling specific patents, like scheme principles, specific tolling algorithms for detecting tolling events and security which mainly affects the Front-End. For back-end all necessary interfaces must be openly available.
- h) Patents may be a benefit to win a local tender, but after that interoperable access for others must be guaranteed. Any interoperable solution must assure minimum accuracy and performance levels.

5.2 RECOMMENDATIONS

RCI makes recommendations to:

- Continue and finalise the standardization of the interfaces (CEN) and the work on the contractual aspects (CESARE IV), take into consideration the open issues as elaborated in this Compendium (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.
- The responsibility of the EETS Provider for the EETS Front-End (including the OBE) must be stated very clearly in the EETS architecture.
- Initialise/coordinate activity envisaging the tools needed for performance monitoring that can help establishing trust, beyond CE 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 finalised. 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.

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SIXTH FRAMEWORK PROGRAMME

