Expert Group 5 on GNSS technologies for EFC

Open issues to enable the widespread introduction of GNSS-based EFC services in Europe

Final report

Version 1.0

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1 Introduction

The Directive 2004/52 of the European Parliament and the Council restricts the implementation of new Electronic Fee Collection Systems in the EU to some specific technologies to enable the interoperability among these systems. On the other hand this directive leaves the definition of details of local EFC implementations to the member states. These apparently contradictory definitions require a detailed description of the boundaries of an acceptable variety on both sides – the vehicle units roaming through Europe and the operators defining details of their set-ups.

Currently a lot of different activities are resulting in the partial definition of these limits:

- Various experts and standardisation groups are working on details of the definition of the European Electronic Toll Service (EETS) based on GNSS/CN technology
- Well advanced is the technical specification ISO 17575 defining the overall architecture and concentrating on the data exchange between an OBU and the back office
- A first (in details partly incomplete) draft of an implementation of ISO 17575 defining the minimum features to achieve interoperability among a variety of EETS operators is defined in the “MISTER” (Minimum Interoperability Specification for Tolling on European Roads)
- Other standards on short, medium and long range communication are ready or well advanced
- New standardisation items and projects are defined and work on them will start soon

But it is not completely clear whether all items needed for a widespread introduction in Europe are covered.

This report is the output of a series of workshops held by experts from different EU member states looking for the available definitions and environments to find out what is missing to make consistent and complete the framework for the implementation of new EFC systems according to the EU directive enabling European-wide interoperability among these EFC systems.

In order to enhance the understanding of the unclear items covered in this document it is necessary to have a common understanding of the current definition of the European Electronic Toll Service (EETS)which is briefly summarised in the following.

1.1 Summary of existing definition of the EETS

In order to allow a wide range of variety in the definition of local EFC systems and still be able to handle all of this in a single OBU there are limits defined on what parameters and algorithms by which road fees may be determined.

The EETS will support fee collection according to:

- distance travelled on dedicated roads (Germany)
- distance travelled in defined areas (Switzerland)

Fig. 1: OBU gathering traveled distance

Fig. 2: usage within defined areas

- usage within defined areas (London Congestion Charging)
- events crossing an area border (Oslo, Trondheim)
- time staying in an area (e.g. parking garages)
- point-based charging (Austria, Norway and many others using DSRC beacons)
- all tariffs may depend on time of day
- all tariffs may depend on day of week
- all tariffs may depend on special days of the year
- all tariffs may depend on vehicle classes

With these elements an operator may define its tariff model and involved roads and/or areas. It is allowed to combine all these elements even overlapping. Each of them may be operated by a different service provider. If at special locations more than one charge object is defined (e.g. a dedicated road in an area) then priority parameters describing the charge objects are used to define which one has to be paid, or even both.

Fig. 3 shows a quite complex example. Here sector D is assumed to cover the boundaries of a country, Inside this sector there are several EFC contexts defined. One is a distance based area pricing scheme where the EFC domain is coincident with the sector – that means the area is covering the whole country (Switzerland or UK would be an example). Inside this area several arterial roads are defined which represents an overlapping distance based highway charging system. Attributes in the data define whether or not the area scheme in the background has to be paid in addition.

There is another smaller area defined which may represent an urban area where cordon pricing shall be applied (of course it is possible that this is just a more expensive distance based tariff). And to demonstrate the flexibility of the current definition of the EETS there is another EFC context as an inner area defined where a time depending tariff may be applied.

All these tariffs may depend on vehicle classes and on defined time slots during the day, the week and the year.

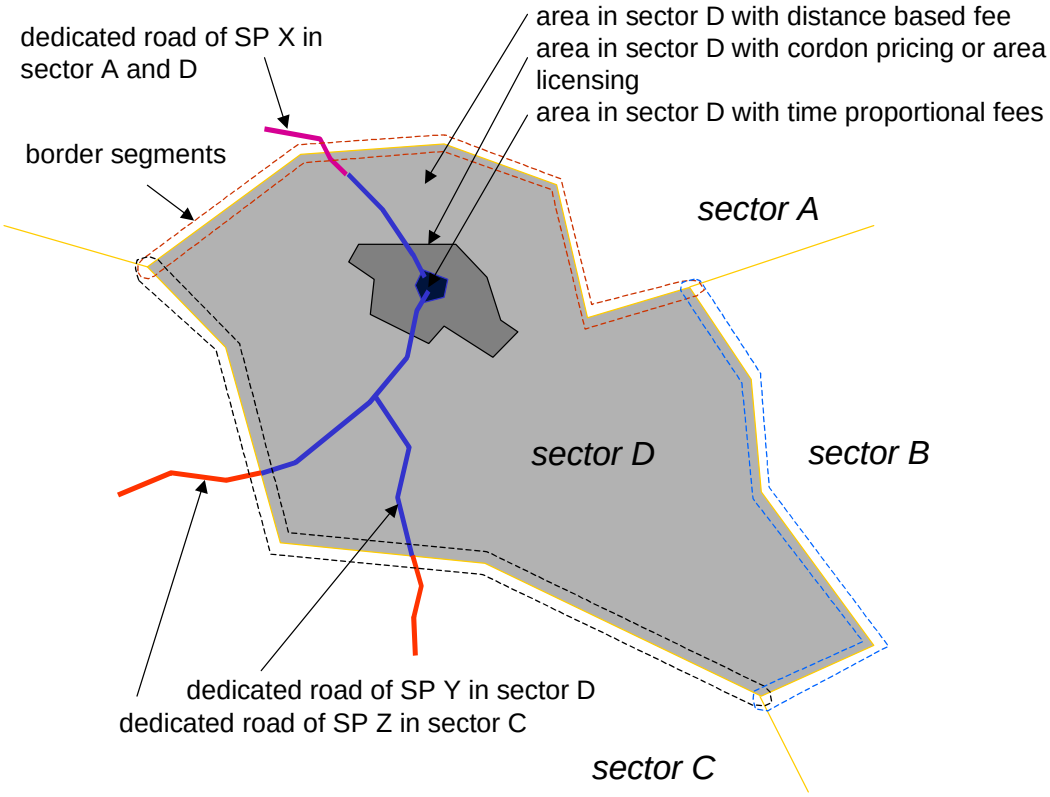

Fig. 3: example of a complex EFC context

In order to operate according to the different anticipated implementations of all the EETS compatible EFC systems in Europe the OBU must be able to adapt its functionality accordingly. Details of this are described in the following clause.

Passing the border between different EFC domains

Fig. 4 indicates the process and the sequence of functional steps when an OBU passes the border between different EFC domains.

The general concept is that different EFC contexts are handled in the OBU each with its own instance of an application software. This software is reduced to a sequence of calls of very powerful support functions. When approaching the border to a new EFC context the software module required for this context will be activated. During the transition from one to an adjacent EFC context both application software modules will be active at the same time. So an EETS OBU can operate several EFC applications in parallel. This is also required when EFC contexts are overlapping.

The context itself is defined in a set of data modules. If any of the data or software modules are not available in the OBU or its validity period has expired the OBU is able to download these modules from a service provider.

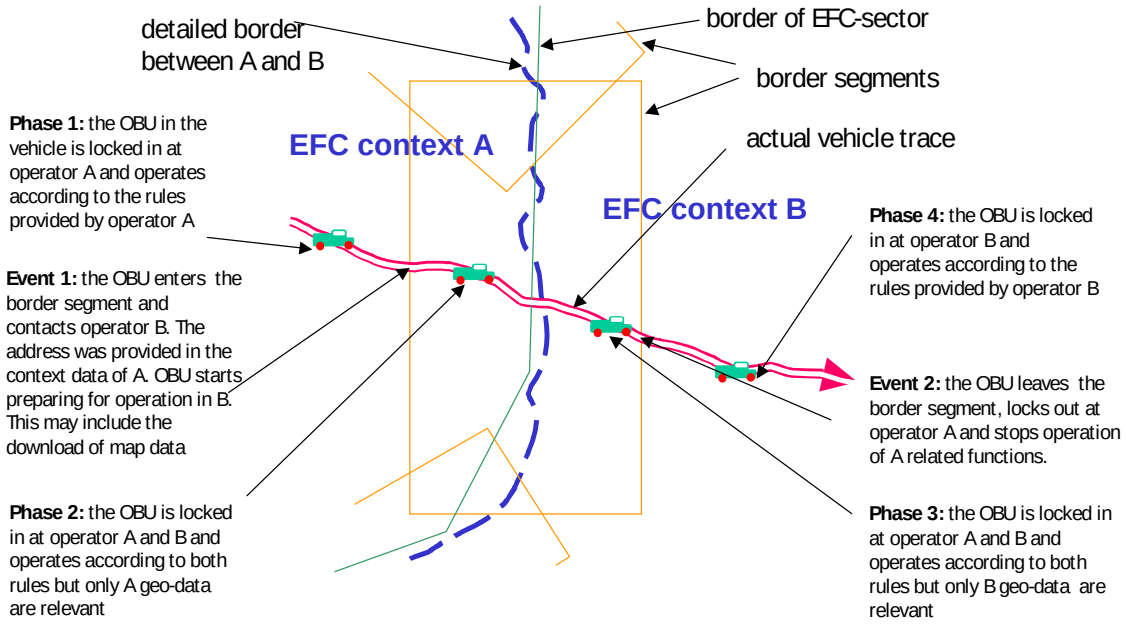

Fig. 4: Sequence of passing from one EFC domain into another

To ensure that each service provider can handle each EETS OBU in its context it is required that each combination must achieve some kind of a type approval in advance. With that a positive authentication will enable mutual acceptance.

The EETS definition is described in the document MISTER which is still incomplete and a draft. The MISTER document references some other documents such as beacon based payment protocols as well as communication and authentication standards. However the most detailed referenced draft specification is the ISO PDTS 17575, which defines in general the set-up of GNS/CN based EFC systems and allows a much higher flexibility than it is anticipated to be needed in Europe.

1.2 Documents specifying EETS details

ISO PDTS 17575:

- defines the application interface for long range communication anticipated to be needed for the process of interoperable autonomous EFC in a most comprehensive way
- supports all known and realistic tariff models
- allows complete flexibility for contractual relationships between service providers
- real implementations according to the “enabling specification” ISO 17575 might not use all the features and options defined
- WG5 members are incorporating comments sent by national delegates on final draft

ISO 17575 is necessary for interoperability, but not sufficient. Therefore DG TREN arranged for the initial drafting of MISTER as the technical basis for the EETS

MISTER:

- uses ISO 17575 and limits its options to the minimum needed for an implementation in Europe.
- specifies a vehicle platform which allows the secure implementation of that subset of the ISO specification
- includes beacon based EFC systems by referencing relevant DSRC documents
- allows a variety of EFC definitions with independent operators while still enabling interoperability

2 Methodology

Having in view the general architecture described in chapter 1.1 and seeing what is needed for an operational implementation it is obvious that not all what is needed to be defined is already available. So new work items must be defined to close that gap leaving enough flexibility for a sufficient variety of individual implementations.

With that in mind the members of the Expert Group 5 identified a list of anticipated open issues:

1. User requirements
2. Positioning sensor aiding devices
3. Digital maps
4. Standards and interoperability
5. GNSS related issues
6. Pan-European maintenance concept
7. Enforcement interoperability
8. Safety services
9. Security
10. GPRS roaming

In the following sections each of these issues is discussed in detail with some derived recommendations.

3 User requirements

Hypothesis:

If the EETS OBU has to support all the features of current EFC systems *and* ideas for the future then it might be too expensive

Situation today:

Charging systems in existing and planned EFC systems use a wide range of charging rules, input parameters and charge objects -Error rates need to be minimised in order to promote operability and public acceptability, but there is not full consensus on what are acceptable maximum error rates

Some user information may be required from OBE HMI but there is no consensus on minimum requirements

There are two contradictory requirements: keeping a high level of data privacy and keeping the capability of providing evidence in disputes

Conclusion:

Most anticipated charge system requirements can be accommodated in anticipated GNSS/CN OBE, but there need to be defined limits of charge system definitions

the geographic parameters defining a charge system must be limited by the realistic location performance of the OBU

There is a trade-off between OBE cost and functionality

Recommendation:

1. The Commission should arrange for more detailed investigation of charge system definition limits

2. The Commission shall arrange for more detailed investigation of minimum HMI requirements for a EETS OBU

Examples:

- a new expert group may closely work together with the RCI team proposing the minimum HMI requirements
- lane based tariffs might be excluded in the list of usable tariff models
- congestion charging with on-line adaptation of the tariff to the actual traffic density might be excluded
- acoustic speech outputs or inputs might be excluded
- external indications like the external visible lights in Switzerland might be excluded
- the smallest road length charged independently might be set to 100m
- route dependent charging might be excluded
- the list of events immediately triggering clearing might not include local requirements like entering a harbour

4 Positioning Sensor Aiding devices

Hypothesis:

If the quality of the location performance of an OBU is not specified equally for all European EFC systems interoperability may remain a vision

Situation today:

OBUs are optimised to reach the accuracy requirements of their own operators with the minimum costs independent of other existing or future requirements of other EFC operators

Operators are still defining new systems according to their own goals independent of capabilities of existing OBUs already in operation

MISTER contains a first definition of the location performance requirements for the EETS

Germany uses local augmentation by beacons

Conclusion:

If the EETS does not limit the required measurement quality then technical interoperability will be not possible

If the local operator requires higher accuracy than the definition of EETS then the operator may use local augmentation beacons

Recommendation:

3. The Commission should arrange for the validation and/or refinement of the position accuracy requirements contained in the first draft of the MISTER

4. Member States should investigate on the legal constrains on the toll concessions if a fee directly depends on measurements taken from GNSS

Examples:

- OBU suppliers shall confirm that the error distribution defined in MISTER can be met. This may result in a more abstract definition to allow new ideas of sensor combinations to overcome gaps in the availability of GNSS.
- what are the required service level agreements (SLAs) if Galileo is used. This should result from direct negotiations between the GALILEO concessionaire and the EFC operators using satellite technologies.

5 Digital maps

Hypothesis:

-Digital maps available today may not fulfil immediately all the EETS functional and performance requirements

Situation today:

European map databases available today are specifically designed for vehicle navigation, LBS and GIS systems

Map providers alone cannot collect and provide definitive charging data because of responsibility issues between map suppliers and EFC operators

Map accuracy is suitable for navigation systems but needs to be validated for EETS

There is no road map certification process available today

Maps used in OBUs have an expire date set by the Service Provider and are updated on request of the OBU

The communication cost for map updates are paid by the contract operator of the OBU

Digital maps are split into tiles of a size of 10 to 50 kBytes using GSM-B26 to download them

Conclusions:

EFC operators using satellite tolling are solely responsible for defining charging data

Charging data can be added to map databases but legal liability issues will need to be solved and EFC operators

EFC operators are responsible for checking if map data available from suppliers are suitable (in terms of accuracy and completeness) to support their charging policies

Recommendations:

5. Future generations of the EETS should benefit from certified European digital maps with charging attributes. For the first generation of EETS maps the EFC operators shall work directly together with the map manufacturers

6. The EFC operators will have the responsibility to investigate that quality levels to be achieved by maps used in future EETS solutions cope with their requirements.

7. The Commission should investigate if a certification process for maps to be used in EETS is achievable and required. If such a process is required, the modalities should be specified. However, it appears that interoperability between the products available on the market is not feasible at the time horizon of the launch of the EETS in 2009. Therefore, it remains a question of full responsibility of EFC operators using satellite tolling to investigate which product fits best to their requirements.

8. Digital maps used for the purpose of EFC will be downloaded before entering in the tolled zone. This downloading shall use the GPRS facility of the onboard unit. EFC operators will have the responsibility to ensure that the proper downloading has been successfully achieved. Clients are not deemed to be liable for this operation. The cost for the communication has to be included in the cost of levying the fees.

9. CESARE III should investigate whether the cost is to be paid by the visitor – either directly or via his contract operator .

6 Standards and interoperability

Hypothesis:

Standards and specifications may not be sufficient for manufacturers to produce OBUs or for operators to define their new EFC systems

Situation today:

ISO 17575 provides a framework for interoperable EFC systems and roaming mechanisms

MISTER is intended to provide the basic technical specification for the EETS

MISTER is partially drafted but is incomplete

A new standardisation work item on data exchange between EFC operators has been approved

Proposal for new work item on test procedures and conformance testing based on ISO 17575

Conclusions:

ISO 17575 and MISTER are suitable for providing the basis of the technical definition of the EETS

The MISTER needs to be completed in a number of areas

There is scope for closer contact between the different bodies with an interest in standardisation

Recommendations:

10. The MISTER should form the complete basis of the technical definition of the EETS, and should be completed in cooperation with RCI

11. The Commission should support the proposed standardisation NWI on conformance testing thru the Mandate 338 provided by DG Enterprise to the European Standardization bodies.

12. The DSRC based EFC onboard unit should contain a commonly accepted EFC-application.

Examples:

- allocate resources to complete and maintain MISTER
- encourage closer cooperation between the different bodies with an interest in standardisation
- CARDME or the results of the project MEDIA may be the EETS compatible EFC application definition

7 GNSS related issues

Hypothesis:

Given suitable commercial conditions, the EETS will use Galileo and EGNOS under defined SLAs

Situation today:

EGNOS and Galileo have potential advantages for EETS:

Integrity can be used to decrease the liability risk on GPS

Improved accuracy and availability

guaranteed services

The use of Full EGNOS commercial service readiness is planned for Q3 2005, receivers having the same price as a 'normal' GPS receiver

The price of a combined GPS/EGNOS/Galileo receiver is to be expected almost the same as a GPS receiver which cost about 10-20 Euro at 10^5 pieces.

GPS services are not guaranteed

The choice of Galileo and EGNOS Concessionaire will be made in 2005, so a future SLA is not yet defined

Conclusion:

The equipment cost is not an issue for upgrading to EGNOS & Galileo

the SLA provides a means to guarantee the location performance of an OBU

If the cost of the SLA is too high, there is a risk that EGNOS & Galileo will not be used

Recommendations:

13. EFC operators should seek early clarification with the Galileo Concessionaire, with the support of the EU Commission, on plans for an EFC service level agreement (SLA)

14. The EETS OBU specification (MISTER) should include a guaranteed minimum location performance.

15. In order to gain experience with guaranteed services, RCI and similar projects should use EGNOS

8 Pan-European maintenance concept

Hypothesis:

If OBU maintenance strategies do not support pan-European use the customer acceptance may not be sufficient

Situation today:

Today there is an urgent need to repair a defective OBU only inside the EFC domain it is belonging too and there the density of repair shops is sufficient

Today the OBUs are not installed by the vehicle manufacturers, so there is no process defined in the vehicle manufacturers' service station network to handle spare parts or how to exchange defect OBUs

Conclusion:

In an interoperable EFC world there will be OBUs from local operators/manufacturers which do not have a pan-European service network.

As long as the OBU interface to the vehicle is not standardised, the cost to handle the service in an independent service network will be quite expensive and the quality may not be assured.

The vehicle user may require a possibility to repair a broken OBU wherever it is required to use it.

In order to be able to exchange the OBU and using a different brand or type, the configuration and the security means must be able to be transferred by the service station without using a proprietary process.

Recommendations:

16. The need for a pan-European OBU maintenance and/or exchange service shall be investigated in cooperation with CESARE III

17. As long as OBUs are not installed by the vehicle manufacturer it is necessary to define one or more electrical and mechanical interfaces between OBU and the vehicle

18. Complete the detail in MISTER to enable an OBU exchange with a common process in the service stations

19. The maintenance concept has to be harmonised with the results of the Expert Group 6

9 Enforcement interoperability

Hypothesis:

If local enforcement procedures cannot be applied to foreign vehicles and/or OBUs than interoperability is not achievable

Situation today:

Procedural and institutional enforcement issues investigated by VERA2

Aspects of enforcement also covered by Expert Group 3

Technically, enforcement depends on capturing visual images of violating vehicles and/or the capability to stop violating vehicles

Short range communication (IR) is used in Germany to read out the last transaction and log-file entries

Conclusion:

The only requirement to achieve technical interoperability if no barriers are used is to standardise the enforcement process and its associated communication link. This is essential to achieve full EFC interoperability and is covered partly by CEN 14906

Short range communication should be the only enforcement communication in order to reduce complexity

There is a need for coordination between activities dealing with enforcement issues which is partly covered by the EETS related activities of the Commission.

MISTER does not yet contain all the necessary parameters to define the short-range communication requirements

Recommendations:

20. MISTER should be completed with the necessary short-range communication parameters

21. An Expert Group should be launched in order to specify the functional requirements for the enforcement process in open toll systems (with no barriers), and the technologies involved.

10 Safety Services

Hypothesis:

If a minimum of safety services are not defined from the very beginning than the chance of a widespread introduction may be lost

Situation today:

OBUs for autonomous EFC services include sensors and some HMI features to handle some (safety related) services.

The EETS will provide a large deployment of onboard units in trucks and long distance coaches. This provides a large opportunity to deploy rapidly new services related to Road Safety, Traveller Information and Fleet Management.

The Directive 2004/52 includes in its preamble clause 8 the expectation that the European EFC service shall open the door for new safety and information services

However, in the definition of existing EFC systems there are no services of any kind included.

Then, the European Court had forbidden to use the EFC OBUs for telematic services until detailed preconditions are met to guaranty open competition (EFC module availability and CAN bus interface)

Conclusion:

If the general conditions to implement services are not changed any service including safety and information services will not be implemented

Recommendations:

22. The Commission shall arrange for investigation for the conditions for the deployment of a minimum set of safety services the EETS OBU should support in order to facilitate the deployment of ITS services using the opportunity of the EETS deployment in vehicles.

23. The Commission should strongly recommend the inclusion in the EETS OBU of at least those safety functions which do not significantly increase OBU cost. Further studies should be launched on this issue. MISTER should already start to include the required elements.

24. Within these studies, the Commission should investigate institutional mechanisms for establishing and operating the minimum set of safety services

Examples:

- automatic emergency calling with caller location
- management of dangerous goods
- inter vehicle hazard warning (using IR)

11 Security

Hypothesis:

Cooperation between EFC operators may be accepted only if the security level allows processes among non-trusted partners

Situation today:

Today all existing EFC services uses their own proprietary security means.

None of them are practical to be used in a cooperation among “non-trusted” operators

It is anticipated that a “European Trust Centre” will not be accepted because the risk allocation together with the commercial responsibility may not be solvable

Conclusion:

A peer to peer security architecture using asymmetric keys may be the only solution

The definitions in MISTER set out a practical concept but not enough detail for an implementation

Recommendations:

25. The Commission should arrange for levels of trust between EFC operators to be defined (e.g. allocated to CESARE III)

26. The Commission should arrange for the investigation of the achievable security level of the EETS defined in MISTER by an independent IT security audit organisation.

12 GPRS Roaming

Hypothesis:

The setup of GSM/GPRS may not efficiently support the special communication needs for EFC in a roaming scenario

Situation today:

Today almost all GSM networks provide GPRS

Layer 3 is based on IP version 4 which is very limited in the amount of available addresses

To save address space GSM provider normally don't offer global IP addresses which prevents mobile terminated "calls"

Mobile terminated GPRS transactions require a permanent PDP context which may result in unacceptable high cost

Layer 4 is not standardised. Some provider use UDP which is not fully error corrected, some use proprietary definitions, some use TCP which performs badly while moving

Conclusion:

The whole communication stack currently is not optimised for mobile mass application

There is no common agreed procedure for mobile terminated transactions which are needed for maintenance and services

due to the variety in different implementations of upper layers roaming is currently possible only inside closed groups of providers

B26 and SMS are in principal sufficient for EETS

Recommendations:

27. As long as the full GPRS communication stack is not harmonised the EETS shall allow also bearer 26 and SMS as a backup means

28. The EU should obtain that the ISO CALM standard in its GSM G2,5 media will include the layer management to handle the special roaming requirements fitting to the existing networks in Europe. This may be a specific requirement covered by Mandate 338

29. ETSI shall be mandated to harmonise the European GPRS "flavours"

30. The EU and the Regulatory Committee should later on work on the possible migration from GSM GPRS to UMTS, when this technology is sufficiently deployed.

13 Summary of recommendations

The commission should arrange for a more detailed investigation addressed to

13.1 MISTER:

completion of MISTER including precise accuracy requirements of the sensors [2,14,18,20, 26]

definition of attributes and non functional requirements on digital maps usable for EETS [5]

how OBUs can be certified [16]

using MISTER in RCI to qualify the usability [10,15]

13.2 Operators Point of View:

limits in charge system [1]

minimum HMI requirements [2]

defining details on how GNSS shall be used [4]

the security architecture sketched in MISTER [25,26]

plan to organise a pan-European maintenance scheme for EETS OBUs [16,19]

13.3 Standards:

setting up a NWI on conformance testing [11]

defining a NWI in standardising the interface of retrofit OBUs to vehicles [17]

which DSRC transaction will be compatible with the EETS [12]

defining the enforcement communication to include foreign vehicles into local enforcement procedures [21]

setting up a NWI in standardising the GSM media in the layers 3 to 7 in the CALM environment [28,29]

13.4 Commission/Galileo Concessionaire:

Helping to define a SLA with the upcoming Galileo concessionaire [13]

which safety services shall be mandatory implemented in EETS OBUs [22,23,24]