Deliverable D2 & D3
Anders Betalen voor Mobiliteit
MoT - The Netherlands

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Executive Summary

The Ministerie von Verkeer en Waterstaat, The Netherlands have appointed Q-Free for taken on assignment within the scope of phase 2 of the market consultation in the “Anders Betalen voor Mobiliteit” project.

This document comprises the two deliverables [1]:

- D2: Analysis of possibilities to integrate OBUs with existing in-car systems
- D3: Formulation of favourable and realistic integration scenarios

of research topic [2] 6: Integration with in-car platforms

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2 TERMS AND DEFINITIONS

ABvM	Anders Betalen voor Mobiliteit
ANPR	Automatic Number Plate Recognition
C2C-CC	Car2Car Communications Consortium
CALM	Continuous communications Air interface for Long and Medium range
	Work title of set of standards from ISO TC204 WG16
CEN	Commission Européen de Normalisation
COMeSafety	Communications for eSafety
CVIS	Cooperative Vehicle - Infrastructure Systems
DSRC	Dedicated Short Range Communications
	Work title of CEN TC278 WG9, sometimes (mis)used in other contexts
EFC	Electronic Fee Collection
	Term used for all types of road charging, being a tax or a fee.
ETSI	European Telecommunications Standards Institute
FOAM	Framework for Open Application Management
GSM	Groupe Spéciale Mobile
GST	Global Systems for Telematics; an Integrated Project in the 6 framework programme
IETF	Internet Engineering Task Force
in-car platform	Term used in the title of this work activity [2]. Synonym to OBE.
in-car system	Term used in the title of deliverable D2 [1]. Synonym to OBE.
IR	Infra Red
	Communication Technology as standardised at ISO TC204 WG16
ISO	International Standards Organisation
ITS	Intelligent Transport System(s)
	Work Title of ISO TC204
LPN	License Plate Number
HMI	Man Machine Interface.
	Set of display, keyboard, audio output, voice recognition functionality available to a human to interact with a digital system. Here part of the OBE.
MoT	Ministry of Traffic
OBE	On Board Equipment
	Part of an ITS implementation being installed inside a vehicle

OBU	On Board Unit This term is wide-spread used for a battery-powered devices performing EFC, mainly based on DSRC, and normally installed at the windscreen of a vehicle. More generic it indicates the part of an ITS implementation being installed inside a vehicle. Synonym to the generic meaning are OBE, in-car platform and in-car system. Dedicated to this project it means the EFC part of an OBE.
OEM	Original Equipment Manufacturer; in this context Vehicle Manufacturers
POMA	Positioning, Maps and Location referencing
SWG	Sub Working Group e.g. at ISO
TC	Technical Committee e.g. at ISO or CEN
WAVE	Wireless Access in Vehicular Environments
WG	Working Group e.g. at ISO or CEN
WLAN	Wireless Local Area Network

3 INTRODUCTION

This document is derived from work assignment ‘integration with in car systems’, ref [1]. In order to address this issue properly with a limited number of pages and combine this concern with enhanced readability, the following document structure has been adopted:

- Section 1 contains references, applicable to this assignment
- Section 2 includes abbreviations
- Section 3, is this introduction
- Section 4, provides a summary of identified requirements, relevant for this work assignment
- Section 5, provides an overall definition of the term OBU as this document is not prescribing any specific OBU for the ABvM.

For the integration scenarios the user should read:

- Section 6, provides an overview of existing in car systems and products.
- Section 7, includes the integration scenarios for ABvM.

For further details that contain supporting information for integration scenarios, the user may read:

- Section 8, which provides details on requirements analysis
- Section 9, which details on existing in car systems
- Section 10, including developments in in-vehicle sensors
- Section 11, yields details on the development in standardisation and technology, and finally
- Section 12, contains useful links to various websites

4 IDENTIFIED APPLICABLE REQUIREMENTS

A full analysis of the applicable requirements for the OBU and its integration with the vehicles is performed in section 8. An extract of the various requirements are summarised in the tables below.

Derived from the EFC directive [4]:

Table 1: EFC Directive Requirements

The part of the implementation of the ABvM system being installed inside a car	
Req 1)	shall contain, as core technologies, at least one and only technologies out of the following list: a) DSRC according to the set of CEN [6, 7, 8, 9, 10] and ETSI [15, 16, 17] standards, b) DSRC according to the Italian Telepass standard [11, 12, 13, 14], c) Navigation system GPS or GALILEO, d) GSM-GPRS cellular network communications,[1]
Req 2)	in addition may contain further communication technologies,
Req 3)	in addition may support other applications than EFC,
Req 4)	may be connected to the odometer,
Req 5)	in addition may be connected to other vehicle sensors,
Req 6)	may be integrated together with the new digital tachograph [5].

[1] The German TollCollect system for HGVs is not considered as it uses SMS instead of GPRS.

In addition derived from MoT's requirements [3]:

Table 2: MoT Requirements

The part of the implementation of the ABvM system being installed inside a car		
Req 7)	shall contain a means to estimate the distance travelled inside The Netherlands	
	a)	continuous distance monitoring using e.g. positioning satellites, odometer
	b)	spot-wise position monitoring and distance calculation using e.g. DSRC
Req 8)	shall have access to real time	
	a)	continuous time from positioning satellites
	b)	on-board quartz real-time clock and spot-wise alignment with global time, or spot-wise global time
Req 9)	shall contain a means to determine its position	
	a)	continuous using e.g. positioning satellites
		i) additional optional on-board support by means of gyro, odometer, … to improve accuracy
	b)	spot-wise using e.g. DSRC
Req 10)	shall contain a means to calculate the tariff	
	a)	on-board tariff-tables – to be dated up regularly
	b)	off-board tariff-tables – real-time link for access
Req 11)	shall allow for future modifications of parameters for road user charging	
	a)	functionality for remote software update
Req 12)	shall minimise the risk for a loss of income	
	a)	all core components under direct control of the road operators
Req 13)	shall comply with European and National laws and regulations on privacy of data	
	a)	there shall be no systematic means to record a track of vehicles
Req 15)	The actual costs for driving (road charge) shall be visible in the vehicle.	

5 DEFINITION OF OBU

Following the title of deliverable D2 [1], the term OBU seems to be used in the following sense:

> The complete set of hardware and software components that constitute the part of the ABvM EFC system which is installed inside a vehicle.
>
> The OBU
>
> - may either be implemented in a single box,
> - or as a distributed system with several boxes,
>
> and
>
> - may either be implemented as a stand-alone application,
> - or together with other functionality,
>
> and
>
> - may be connected to in-vehicle sensors.

The design of the OBU is covered by other work assignments of the Dutch Mobility project, ABvM, such that a detailed definition of the OBU is out of scope of this document.

In the remainder of this document, certain assumptions apply for the various realisation options of ABvM compliant OBU. Unless explicitly stated otherwise, these assumptions are made by the authors of this document.

6 EXISTING IN-CAR SYSTEMS - SUMMARY

6.1 General

The information provided in this chapter does not claim to be complete, but reports the major projects, activities and technologies and systems relevant for the project ABvM.

The existing in-car systems are summarised in the table below, whereas detailed information supporting this summary is included in chapter 9.

System/Products	Scope	Current capabilities	Potential to support ABvM
LSVA Terminal (CH)	HGV tolling terminal used in Switzerland. Tolling is based on the distance travelled.	A retrofit device specially intended for HGV. Requires installation using skilled personnel. Compatible with DSRC. Does not support autonomous positioning of the vehicle.	Terminal in its current form may support distance based charging for HGV. Less optimal for personal cars due to potential lack of social acceptance.
GNSS/CN Tollcollect Terminal (D)	HGV tolling terminal used in Germany. Tolling is based on the route/distance travelled.	A retrofit device specially intended for HGV. Requires installation using skilled personnel. DSRC interface not activated and hence it is not proven to be compatible with DSRC.	Specifications and de-facto implementation features are not public.
DSRC-OBU (N, S, DK, F, E I, PT)	Monolithic device supporting central account functionality across Europe (used both for HGV, personal cars and motorcycles). De-facto DSRC implementations include Autopass, PISTA, OMISS and TIS	A retrofit device, but does not require installation using skilled personnel. Does not include autonomous positioning of the vehicle. No support for dynamic charging tables.	Due to moderate costs, it could be used as first generation OBU and/or as a sub-module of the OBU. However, it is unclear whether interoperability will be important for the Netherlands and how the system deployment would actually be done.
Digital Tachograph	Measures the distance travelled as well as speed profiles	Does not include payment functionality.	May be used as input sensor to the OBU. See also comment for Infotainment Telematics Platforms
Infotainment Telematics Platforms	Infotainment (predominantly route guidance)	Does not include payment functionality	Will require redesign of functionality and hardware where most stakeholders in the automotive industry cooperate. This seems unrealistic unless massive investments are done. EC is currently funding CVIS/CALM and RCI as leading initiatives.

6.2 System and Product Assessment

Handling of a complex OBUs such as LSVA, TollCollect and Digital Tachograph require an authorised service station. The equipment needs considerable space, and thus this equipment is generally only applicable in large commercial vehicles. Even in commercial vehicles, installation space may be a serious problem, e.g. HGVs at 3,5 t.

Widespread usage of complex OBUs, especially usage in passenger cars, as a pre-requisite requires the availability of the hardware in a vehicle, already at time of sales of the vehicle. Thus the automobile industry has to co-operate with road operators in order to achieve the goal of an integrated ITS platform supporting road tolling.

Feasibility of using complex OBUs in motorcycles is doubtful. Even in the long run it is likely that motorcycles will have a reduced capability compared to other vehicles.

Most of the existing in-car systems are after-sales systems. The ones currently being at-factory -installed by automobile industry are infotainment / navigation / car service systems, and not useable for road tolling/charging.

The As processing power, functionality and data capacity for in-vehicle infrastructure tend to increase, the product synergy and co-existence between infotainment applications and a trusted payment application for road user charging, is technically viable within the next five to six years. However such scenario assumes long term agreements between governmental authorities and the automotive industry (the full range of car manufacturers and service stations) does not existent today. It will require a new process for technical standardisation and operational MoUs. Should an ABvM system based on complex OBU be implemented within the 5 to 7 years time horizon, end users will have to retrofit equipment that includes required functionality such as trusted payment application functionality. As opposed to commercial vehicles, there is a trend that private cars are without any standardised (DIN) radio slot and rather equipped with a fully integrated radio/infotainment/communication module, customised for the dashboard. Finally, taking into account that agreement between governmental authorities and the automotive industry properly may take several years to arrange, before the full range of infotainment products for various types and brands of vehicles are adjusted to road pricing. Therefore it seems apparent that this is in a time conflict with the expected earliest realisation time of the ABvM (2012-2013).

Unless local stakeholders intend to invest massively into development of ABvM compliant OBU (see for example the ‘In Vehicle Computer’ scenario in chapter 7.4), this seems to favour the CALM scenario where the car manufacturers themselves bring fully integrated in-car equipment to the market, with product guarantees, functionally capable of meeting ABvM requirements. CALM will be backwards compatible with DSRC systems, enabling a graceful migration from DSRC based technology to an advanced in vehicle platform.

7 IMPLEMENTATION AND INTEGRATION SCENARIOS

7.1 Basic Considerations

The activities in standardisation, research projects, industrial developments and initiatives discussed in later section of this document merge from several stand-alone boxes with redundant functionality towards an electronics in-vehicle platform providing communications, localisation, computation power, data storage, data security, audio-visual MMI for applications in the ITS sector, makes use of in-vehicle sensors.

However automobile industry is in a position to request quasi full control on ITS equipment being installed in a vehicle and the following consequences can be derived from this situation:

- Installation of ITS equipment that needs connections to the vehicle systems, e.g. car battery, sensors, …, is only possible if either
  - done by the automobile manufacturer at time of manufacturing the vehicle, or
  - as an after-sales equipment being required by law or regulation, e.g. such as the Swiss LSVA tax OBU or the German LSVA EFC OBU.
  - after-sales equipment requiring connection to existing in vehicle systems requires professional service stations
- Installation of after-sales equipment without connections to the vehicle is limited by legal requirements, e.g. such as the allowed size of the windscreen being shadowed by equipment.
- Installation of after-sales equipment without connections to the vehicle outside the passenger cabin is unfortunate or impossible due to the constructive constraints in a vehicle.
- Installation of DSRC OBUs at a windscreen is already supported by some automobile manufacturers by means of dedicated windscreens, i.e. metallised windscreens with a "slot" for the DSRC antenna.

EU directive pre-scribes the use of either GSM/GPS/Gallileo and/or DSRC based systems.

7.2 Short Term View

In a short term (0 to 7 years), DSRC based systems seem most apparent available candidates, where the OBU can be easily installed in all kinds of vehicles as after-sales equipment. The main reasons for this are:

1. There is no agreed specification for a system combining all EFC technologies mentioned in the EU directive on EFC [4].
2. The Expert Team working on a suitable interpretation of the EU directive on EFC [4] has not finished its work.
3. The RCI project just started.
4. The TollCollect Specification is not publicly available
5. The TollCollect System seems to not fully comply with the EU directive on EFC [4].
6. APNR systems still are in the phase of being technically optimised, taken into account that licence plate and letter formats, licence plate conditions vary from country to country and sensitive to tamper attempts and weather/light conditions. Note that London as the largest user of APNR-only is now considering to introduce other technologies.
7. APNR systems are not standardised.
8. APNR systems used for payment might not be accepted by the population due to problems with privacy of data.
9. APNR systems are not covered by the EU directive on EFC [4].
10. DSRC is the agreed de-juro and de-facto standard for EFC in Europe.
11. DSRC is fully covered by the EU directive on EFC [4].

12. DSRC based EFC is fully standardised. Even test standards / draft test standards are available.
13. DSRC is capable to support all requirements of this project.
14. DSRC OBUs from different operators basically are technically compatible, such that EFC interoperability is mostly a juridical matter.

7.3 Long Term View

In a long term approach, automobile industry will definitively deliver all vehicles with a build-in ITS platform as currently being standardised at ISO TC 204 WG16 CALM and as being tested in the EU research project CVIS. Integration of DSRC into the CALM / CVIS system will improve functionality, performance and reliability of DSRC. The DSRC technology will continue to live at least for enforcement purposes since it has the capability to pin-point positions down to +/- 20cm, and it is likely that this will be as anform a very important integral part of the microwave medium CALM-M5.

Once the GALILEO system will have been launched new trials for GNSS/CN based area tolling systems will be conducted. As a result, standards on GNSS/CN EFC systems will be finalised and agreed in Europe. At this time CALM / CVIS platforms will already exist in vehicles, and, by means of CVIS-FOAM/POMA, these platforms can easily take GALILEO-based GNSS/CN area tolling on board.

It is assumed that this long term goal will be completely achieved about 10 years from now, see also section 7.4.3

As a default scenario, private investments or public investments (or a combination thereof) in the Netherlands is assumed to be financially capable to fund the development of OBU meeting relevant requirements. Furthermore they are assumed to be able to operate such a system according to time requirements at the discretion of the Dutch Ministry of Transport. As previously indicated, this requires tight interactions with automotive industry, services providers and EC (with respect to legislation).

7.4 Integration Scenarios

For ABvM, the following implementation scenarios are further analysed

- In vehicle computer, customised for ABvM to secure full compliance of all requirements
- DSRC stand alone OBU
- CALM / CVIS

The reason why implementation scenarios are considered in comparison with the In Vehicle computer approach is summarised as follows:

- The DSRC stand-alone OBUs can be used for a long time, and will last throughout the vehicle lifetime until new vehicles are introduce who support the CALM / CVIS platform.
- The DSRC stand-alone OBUs will be needed indefinitely for a sub-set or road users, e.g. motorcycles and specialised vehicles, where geometrical constraints, cost or other reasons would prevent installation of a CALM / CVIS platform.
- The digital tachograph, payment application(s) can be an integral part of the CALM / CVIS platform.

7.4.1 In vehicle computer

The vision that Intelligent Telematics Platforms may combine infotainment with payment applications is the most viable implementation scenario for the In Vehicle Computer.

The reason for this is assumed to be the combination of user requiring product aesthetics and related public acceptance, road user safety and guarantees given by the auto manufacturers. It is further assumed that the ABvM can be enforced for all vehicles such that the In Vehicle Computers can be timely installed in a number of 8 million before year 2012-2013. A complex and heavy device cannot be placed anywhere else than in the radio slot if to be mounted onto the dashboard. A mounting anywhere else may create problems related to integration with In Vehicle sensors, LCD screen, standardised mounting instructions, accessibility of the computer for maintenance and aesthetic requirements from the public.

Therefore the in vehicle computer, is assumed to fit all vehicle types' radio slot and include:

- General purpose processing unit (with a capable operating system running all the below functions including the trusted road user charging application at the users convenience to the availability for the service operators)
- Data storage (DVD-ROM, HDD, RAM) to support the infotainment and payment applications
- Secure module for payment application's cryptographic operations and data (for example a SIM module)
- Back up battery to ensure safe and secure operation of the payment application
- GSM/UMTS modem
- DSRC modem (interoperability with minimum France, Austria, Switzerland is assumed necessary as well as providing a general purpose enforcement channel)
- GPS receiver
- Digital Tachograph and speedometer interface
- Analogue/Digital Radio
- CD-DVD ROM drive
- MP3 player
- LCD
- Combi-Antenna for GSM/UMTS/GPS/Radio/DSRC, for example 'shark-fin' type. GSM/UMTS antenna can be connected to other modems/mobile phones.
- 12V/24V/48V Power supply
- Cables and Adaptors to external Combi-Antenna for all foreseeable vehicle types and brands
- Front ends / Finishing for all foreseeable vehicle types and brands

The remainder of this section analyses the feasibility of this scenario.

<u>Public acceptance</u>

As indicated above, an In Vehicle Computer with equal or less functionality than the current infotainment platforms will most likely lead to public disapproval. The implementation of installation centre for retrofit must be widespread and efficient from the start-up day of the system. Most new cars now come with infotainment systems that take the place of the car radio slot. This means that there is either no slot available, or that the In Vehicle Computer must replace the pre-installed infotainment system with all that implies for interfacing and visual aesthetics.

<u>Automotive industry's acceptance</u>

In parallel to the development of the in vehicle computer, navigation systems become more integrated with the vehicle and more advanced, rendering this scenario old-fashioned even before it is introduced to the market. It is therefore of outmost importance that stakeholders seek coordination with vehicle manufacturers and infotainment devices along the process. There have been major changes in the market (Ford, DaimlerChrysler etc) leading to some standardisation of components. This also may be challenging due to their conflicting commercial interests.

Cost drivers

- Development and qualification comprising development of the product adaptations for different types of vehicles or brands are costly processes. Additionally, qualification activities will include certification of the payment application as well as automotive certification.
- Manufacturing of minimum 8 million modules for the Dutch market, including adaptors to various vehicle types/brands..
- Distribution of adequate numbers of devices to auto service stations. In addition personnel shall be trained to inform the public, execute installation, periodically inspect, test and repair units
- Installation, being mainly a question of mobilising sufficient number of service stations for different vehicle brands
- Maintenance and Operation.

Implementation Time

Based on experience from similar infrastructure projects, product design conforming to automotive standards and mass production for the full set of 8 mill Dutch vehicles has it's time line. The implementation time is estimated to be at least:

- Procurement process, requirements synthesis and contract agreements, 1 year.
- Design, 1 year
- Development, 1 year
- Product and production qualification, 1 years
- Production, 1 year
- Distribution and installation, 1-2 years

Hence implementation time is estimated to be 6-7 years, from start of procurement until completion of installation of 8 million devices. It is assumed that there is a road side infrastructure for charging, using GSM network with sufficient capacity/cost level that makes this scenario feasible.

Automotive Standards for production and approval

As the In Vehicle Unit is to be a retrofit device and minimum to connected to power supply of the vehicle a mandatory and rigorous automotive standard quality regime conform standard ISO16949 applies. This imposes a time consuming product and production certification process. Minimum one year must be assumed and to run on various versions and variants of the units (alpha, beta, production series). Also note that connection to in-vehicle data buses for tagograph and other sensors will void manufacturer guarantees and may have safety impacts since it may influence traction control/braking systems in the vehicle.

Legal issues/ Product guarantees

It is assumed that Dutch vehicles shall be interoperable with other neighbouring countries. This necessitates the need for a DSRC modem. Also the issues concerning guarantees and for retrofit devices inside vehicles and vehicles themselves, being refitted, should attain attention for legislative bodies along the implementation phase. Otherwise, this might delay the implementation.

7.4.2 Monolithic OBU

The monolithic OBU is a device that may be fitted by the user to the front windscreen and is self powered. Most systems in Europe are based on the DSRC standard and this enables interoperability between different ETC systems.

The monolithic OBU would comprise

- DSRC module with capacity to support ETC applications (Cardme based, IAP, PISTA or combinations thereof)
- Memory for data and transaction log
- Self powered battery for minimum 5 years operation
- Optional Display. Currently infeasible with self powered battery. The ability of meeting drivers' safety of reading information from a device mounted on the windscreen is questionable.
- Optional GPS receiver. Currently infeasible with self powered battery. It is expected that GPS will become cheaper and with low current consumption. The main reason for this drive is the inclusion of GPS receiver into mobile phones. On this background DSRC module with GPS receiver is not ruled out as an implementation option after 2012.

Public acceptance

The monolithic OBU is a retrofit device intended for mail distribution and for self installation. Experience from Scandinavia proves this to be acceptable for the public.

Compliance to requirements

A monolithic OBU without GPS will not meet the requirement of providing feedback to the user which charge that apply from time to time in a nationwide area covering charging zone.

Implementation time

The Netherlands does not have any DSRC road side infrastructure (including enforcement) and it is assumed to be economical and time-wise infeasible to introduce beacons with sufficient density to cover the extensive Dutch road network. On the other hand DSRC road side toll rings could be erected around clusters of congested areas as a possible start. It is assumed that traffic planners have analysed such clusters to be vital for controlling congestion. Recent results from Stockholm prove that congestion could be reduced by as much as 25 per cent during rush hours, see the web-site of the Stockholm Congestion Charging trials. Should such an approach be chosen, several vendors could provide the required DSRC road side infrastructure (including enforcement) and battery powered OBU today.

Cost factors

Today a standard monolithic OBU is sold in the range of 18 to 30 Euro, depending on vendor, functionality and volume. An 8 million volume would potentially decrease the price further. A multilane free flow road side infrastructure with video enforcement, excluding gantry and civil works, power and wide area network would be in the range of 60-80000 Euro pr lane, depending on performance level, vendor and quantities orderred.

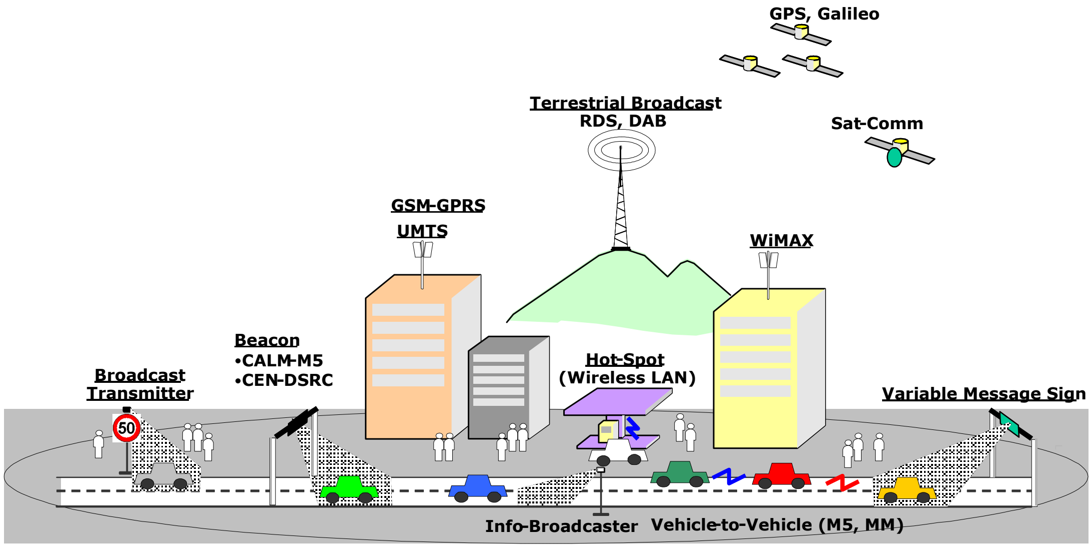
Migration to CALM / CVIS

As CALM contains DSRC as one of the default communication channel, CALM / CVIS would be able to communicate with DSRC roadside network. CVIS/CALM enables new functionality such as infotainment and safety. Should extra functionality be needed, road side must be upgraded.

Migration to In Vehicle computer

Should the In Vehicle computer support DSRC, similar migration effects apply as for CALM/CVIS.

7.4.3 CALM / CVIS router



The next generation of devices is in the middle of intense standardisation and research activity as documented in later chapters. The authors of this document are centrally involved in the standardisation and R&D activities, and therefore well placed to have opinions on the status and future possibilities.
In particular the Vehicle manufacturers (OEMs) are very active in this work, and there is little doubt that future vehicles will be equipped with new systems that has multiple radio interfaces and flexible software with loadable applications. All of course is transparent to users.
The open questions are mostly:

- When will it arrive,
- How many cars will include these functions, and
- What will be the minimum functionality level?

To answer these questions, we have to look at the driving motivations for the OEMs.

1. Accidents are taking more than 40000 lives in Europe every year, and it is a political goal to reduce this by 50% within 2010. The OEMs have a large responsibility in this reduction, but a lot of what they can do with autonomous (vehicle-internal) systems like seatbelts, airbags, ABS, stability control and other passive means is already done. The investments in such measures are reaching a situation of diminishing returns, and therefore more pro-active means must be used. The most promising one is to use the WAVE/CALM M5 vehicle to vehicle communication system. There are around 50 safety applications using this technology like warning following vehicles of emergency braking, warning about slippery roads and so on. In total these measures will have the potential to reduce accidents dramatically when a certain saturation of devices in cars is reached.
2. More and more car buyers are starting to question why Internet and infotainment as they are used to enjoy everywhere else is not available in a car. Even airplanes now offer Internet access, but no car manufacturer today can offer a connected car with passenger access to Internet. The group of buyers willing to pay the extra cost has been too small so far, but projections show that this is changing rapidly, and the OEMs with their 3-5 years development time know they have to do something now.
3. The current Telematics platforms in vehicles are struggling from the same problem as analysed in the first section on in-vehicle computers. Stand-alone dedicated computers may be cost efficient and quick to install, but they are just not flexible enough to do what will be needed over the 10+ years of vehicle lifetime. Therefore most OEMs are radically changing their approach to such proprietary, non-interoperable computers

and communication subsystems. Another point to this is that the cost of separate proprietary ITS systems in vehicles is rising, and OEMs are extremely sensitive to ways to cut costs and/or find ways to get an acceptance for higher costs in vehicles.

It is difficult to answer the questions raised above with any degree of certainty since they involve commercial strategies that are secret by definition, but there are some indications coming out of discussions with OEM representatives:

When will it arrive?

Final decisions seem to be going on now. Some OEMs want to see more testing take place before committing, but this testing is going on in C2C-CC and VII at this moment. It is therefore reasonable that all new models started from now on will include this technology as an option. With a three-five year lead time it would mean that volume deployment will start in the 2010-2012 timeframe.

How many cars will have this equipment?

This depends more on pricing strategy and the user take-up. In the US, it is likely that all cars sold after 2012 must have this equipment (see later chapters). In Europe this depends on the discussion between authorities and OEMs and if there will be some form of mandating or not. The public awareness and well documented request for safer cars (NCAP Stars) alone is likely to drive this technology the same way as air bags, ABS, stability control and so on, meaning close to 100% saturation within one model generation (5 -7 years).With an average European turnover of 15% of cars per year, it is easy to plot the saturation level in the coming years.

What will be the (minimum) functionality level?

If we only look at the needs of safety alone, then there are three air interfaces that are absolutely needed: CALM M5 for vehicle-vehicle collision avoidance (plus DSRC because of interference mitigation, see later chapters), GSM/UMTS for emergency calls over long distances, and (multiple)GPS/Galileo for accurate positioning. It is likely that the OEMs will put more that the minimum safety functions in to answer bullet 2) and 3) above. In fact a lot of the user acceptance for increased costs will have to come from the infotainment extra functions.

Technically speaking

The available interfaces in the future will very likely be of two types:
a) Ubiquitous radio interfaces that are totally user and application transparent in a similar way as Internet connections are today. The only noticeable differentiations will be usage cost and available data rate.
b) A secure application interface that allows new applications to be loaded into vehicles. This is being researched in the GST project today, and it does include secure payment functions there the charging parameters can be changed dynamically. It would suit the ABvM requirements fully as far as it is possible to see today.

The actual box configuration and in-vehicle architecture is likely to remain proprietary since there is no absolute requirement to open up. This means that we will probably see different combination of functions where one OEM goes with a “radio modem” that is inserted in a navigation computer, while another will install a full mobile router with Ethernet connections. And of course functions, perceived quality, HMI and so on will still be used to differentiate between the different car brands and models.
This is of less importance for the end users – the important thing is the ability to load the needed (Java) applications and get access to internet when needed.

8 DETAILED ANALYSIS OF REQUIREMENTS

8.1 MoT

The requirements for the research project "Anders Betalen voor Mobiliteit" (ABvM) are presented in [3]. In what follows these requirements are listed, analysed and interpreted.

Table 3: Basic MoT Requirements

System functionality	
Requirement [1]	Road user charging shall be based upon the distance travelled with a vehicle in the Netherlands
	This means, that • an autonomous OBU shall be able to measure the distance travelled inside the Netherlands, • a cooperative OBU together with infrastructure equipment allows to calculate the distance travelled inside the Netherlands. This requirement thus is not a requirement for an autonomous OBU.
Requirement [2]	Road user charging shall be differentiated on the basis of time
	This means, that an OBU shall be able to distinguish tariffs by means of the time, i.e. OBU • needs to know the time from a local or external clock, • needs to have access to time-dependent tariff information. It is not clear whether time of entrance to the toll road / section / area is meant, or any other time.
Requirement [3]	Road user charging shall be differentiated on the basis of the location of the vehicle
	This means, that an OBU shall be able to distinguish tariffs by means of its location, i.e. OBU • needs to know its location, either by autonomous measurement with e.g. GPS, or by means of localised communication, • needs to have access to location-dependent tariff information. It is not clear whether the location shall be identified only at the entry to a toll road / section / area.
Requirement [4]	Road user charging shall be differentiated on the basis of vehicle characteristics
	This means, that an OBU shall be able to distinguish tariffs by means of its own vehicle characteristics, i.e. OBU • needs to know its actual vehicle characteristics, either retrieved automatically by means of in-vehicle sensors or by means of user interaction, • needs to have access to characteristics-dependent tariff information. It is not clear what the characteristics to be considered are. This might involve user (driver) interaction.
Requirement [5]	Road user charging shall be introduced on all roads in the Netherlands
	Charging covering all roads in the NL may favour a GPS/Gallileo based positioning system, See comment to requirement [6].

Requirement [6]	Road user charging shall have adequate flexibility in its design to allow changes in the parameters for road user charging as mentioned in requirements [1] to [5]
	This may have an impact on • HMI functionality and capability, • memory capacity, • computation power, • secured interfaces to in-vehicle sensors, • real-time communication requirements.
Requirement [7]	Road user charging shall be 'free-flow'
	Considering requirement [11] this may be supported by the selected technologies.
Users	
Requirement [8] – [10]	
	Not relevant here.
Technological Requirements	
Requirement [11]	The road pricing system shall comply with the European directive on the interoperability of electronic road toll systems [4]
	This directive covers a wide range of issues, some of which are of technical / technological nature. See the details on the relevant requirements as discussed below in this document.
Requirement [12]	The road pricing system shall be sufficiently reliable to ensure correct and adequate road user charging. In particular, the road users shall be adequately protected against over-charging.
	This is a quite weak requirement that allows for a variety of interpretations. Considering requirement [11] basically a certain reasonable level of security may be supported by the selected technologies.
Requirement [13]	The road pricing system shall be sufficiently reliable to ensure correct and adequate road user charging. In particular, the road pricing service organisation shall be adequately protected against loss of income due to system failure.
	This is a quite weak requirement that allows for a variety of interpretations. Considering requirement [11] basically a certain reasonable level of security may be supported by the selected technologies in combination with infrastructure based equipment and procedures for enforcement.
Requirement [14]	The road pricing system shall adequately protect its users against discomfort.
	This is a quite weak requirement that allows for a variety of interpretations. The meaning is not obvious.
Requirement [15]	The actual costs for driving (road charge) shall be visible in the vehicle.
	This has severe implications on the system, i.e. to implement the need for a pre-information. Might be impossible considering e.g. existing laws in European countries. This is linked to what extent the OBU is able to efficiently receive updated tariff tables from the road side infrastructure and display those to the driver. This will have implications for the design of the communication channel and in vehicle information display design scenarios.
Requirement [16]	The road pricing system shall be sufficiently safe and easy to use (human machine interaction) to avoid dangerous behaviour and social exclusion.
	This has implications on the system design and HMI design.

Costs	
Requirement [17] – [18]	
	Not relevant here.
Implementation	
Requirement [19]	System developments for acceleration scenarios shall be able to migrate into the general road pricing system.
	The term "acceleration scenarios" needs to be specified. Not clear! Not considered so far.
Requirement [20]	The road pricing system shall be designed, developed and built in such way that different implementation scenarios can be supported.
	This is a quite weak requirement that allows for a variety of interpretations.
Requirement [21]	The road pricing system shall be designed, developed and built in such way that future developments can be incorporated
	This is a quite weak requirement that allows for a variety of interpretations.
Requirement [22]	The road pricing system shall have adequate capacity to charge the road use of 8.159.000 vehicles.
	Not relevant here.
Security and privacy	
Requirement [23]	The road pricing system shall have adequate security measures to: • Prevent fraudulent use of the system • Detect fraudulent use of the system • Recover from fraudulent use of the system
	This is a quite weak requirement that allows for a variety of interpretations. The set of requirements is not consistent. Either the system prevents fraudulent use, or it shall detect fraudulent use and shall recover from it. See also Requirement [13].
Requirement [24]	The road pricing system shall comply with national and international privacy regulations (Wet Bescherming Persoonsgegebens (WBP) and EU-directive 95/46/EC)
	Important for acceptance

8.2 EU Directive

The EU directive on EFC [4] describes the framework for the introduction of a pan-European road charging service. Article 2 of this directive presents requirements on the technological solutions. The requirements of other articles in the directive are not relevant here. The main relevant requirements are:

I. 1. (a) Satellite positioning is an optional technology for carrying out electronic toll transactions.

II. 1. (b) mobile communications using the GSM-GPRS standard (reference GSM TS 03.60/23.060) is an optional technology for carrying out electronic toll transactions.

III. 1. (c) 5,8 GHz microwave technology [6, 7, 8, 9, 10, 11, 12, 13, 14] is an optional technology for carrying out electronic toll transactions.

IV. 2. Operators shall make available to interested users on-board equipment which is suitable for use with all electronic toll systems in service in the member states using the technologies referred to in paragraph 1 and which is suitable for use in all types of vehicles …

Further on it is explicitly allowed:

V. 4. … on-board equipment may also be suitable for other technologies …

VI. 4. … on-board equipment may also be linked to the vehicle's electronic tachograph.

The directive recommends the GNSS/CN technology for new electronic toll systems, but does not require it. Especially continuation of DSRC based EFC systems is not prohibited.

A linguistic/logic analysis of these requirements results in the following findings:

- The requirements are inconsistent.
  - IV. invalidates the "optional" restriction contained in I., II. and III.
  - IV. includes the German TollCollect system, which – at least currently - is not covered by any one of the allowed technologies due to II., as TollCollect is not using GSM-GPRS but GSM-SMS.
- IV. seems to exclude a number of vehicles from the electronic road charging service, as e.g. a complex and expensive multi-technology OBU is not acceptable for
  - motorcycles,
  - vehicles for disabled people,
  - small and cheap vehicles, normally used by socially restricted people.

It is not clear,

- what V. means, i.e. other communication technologies, and / or other sensor technologies, and / or other application technologies,
- whether VI. means the odometer or the new electronic / digital tachograph according to [5].

Problems with the directive are already identified by the European Commission. Experts are in charge to evaluate the intended meaning. Results approved by the European Parliament and the Council are pending.

As the EETS is intended to impose no changes in the existing road side infrastructure in Europe, ref. [30], an EETS compliant OBU (EOBU) is assumed to have three main communication channels

- DSRC
- GPS
- GSM/GPRS

EOBU will be introduced to the market when the relevant specifications / standards are fixed by important stakeholders within ETC (CEN, EU, Transport operators). This process is uncertain for several reasons. For example the road side such that interoperability with an EETS compliant OBU will have to be designed:

- Agreement on transaction model that apply (possibly IAP)
- Security, key management for minimum access credential keys
- Fee calculation (Tariff structures)

9 DETAILS ON EXISTING IN CAR SYSTEMS

Disclaimer: The below information is retrieved from various websites and public documents as available at the time of writing. The text may therefore be obsolete, as there might be developments not disclosed to the authors.

9.1 LSVA Switzerland

9.1.1 Introduction

The LSVA system is a tax system for HGVs. The OBU, see the following figure taken from the Fela web-site, has the following major tasks:

- to acquire the distance travelled in Switzerland,
- to identify and handle tax free trips,
- to identify the vehicle class (weight),
- to report the data to the central accounting system.

Figure 1: LSVA OBU

9.1.2 Specification:

Proprietary – owned by the Swiss Tax Authority

9.1.3 Components:

- DSRC
- GPS
- HMI (128x64 pixel graphic display, 10 buttons, 16 LEDs, buzzer)
- Smart card reader
- Internal battery
- IrDA 1.0 interface, up to 115.2 kBaud

9.1.4 In-vehicle Connections

- Odometer
- Car battery
- Trailer detection
- CAN bus

9.1.5 Installation

The installation of the OBU has to be done by an authorised service station.

9.2 GNSS/CN - TollCollect Germany

9.2.1 Introduction

The only GNSS/CN implementation known so far is TollCollect in Germany. Its specification is proprietary and not publicly available.

Satellite based EFC systems suffer from the following facts:

- Insufficient availability of the service, especially in Nordic countries and in urban environment
- No direct control of the satellites by the road operators.
  - Service may be switched of or restricted by USA military authorities. A similar situation is indicated for GALILEO.
  - Maintenance can not be requested and will not happen within reasonable time.
- The need for enforcement invalidates the benefits of the "autonomous" approach. The real cost and complexity of a road tolling system is given by its enforcement component!
- No agreed standard available.
- No support by majority of road operators.

The TollCollect system is an EFC system for HGVs applicable on German highways.

TollCollect uses two different OBUs. One was designed by the TollCollect consortium, the other was designed by the AGES consortium.

The TollCollect design, see the following figure taken from the web-site of TollCollect,

Figure 2: Grundig OBU

fits into a standard car-radio housing and uses an external IR/DSRC module installed behind the windscreen.

The AGES design, see the following figure taken from the web-site of TollCollect,

Figure 3: Siemens OBU

is a one-box solution installed on the dashboard behind the windscreen.

The OBU has the following major tasks:

- to acquire the distance travelled on toll-roads in Germany,
- to identify and handle tax free trips,
- to calculate the toll fee for each toll section,
- to report the gathered information on trips and related fees to the central accounting system.

9.2.2 Specification

Proprietary and not published – owned by TollCollect GmbH Germany

9.2.3 Components

- DSRC (only basic hardware – seems not to be used!)
- IR (claimed to be at least non-interfering with ISO TC204 WG16 – CALM IR)
- GSM-SMS
- GPS
- HMI (simple alpha numeric)

9.2.4 In-vehicle Connections

- Odometer
- Car battery

9.2.5 Installation

The installation of these OBUs has to be done by an authorised service station.

9.3 DSRC-OBU

9.3.1 Introduction

The current standard for EFC in Europe is DSRC, in the two variants developed in Italy and by CEN, with CEN DSRC having a much larger market share. It supports all used modes of EFC operation, including area tolling. The following incomplete list shows the major large scale EFC installations in Europe using DSRC:

- Autopass in Norway
- Autostrade in Italy
- Via Verde in Portugal
- Europpass in Austria
- LSVA in Switzerland
- TIS in France

The worlds most sophisticated DSRC based EFC system is the area tolling free-flow multilane system operated successfully in Stockholm.

There are further European DSRC based EFC systems e.g. in Germany, Spain, Denmark, UK, Czech republic, Croatia, Greece and Turkey.

As compared to GNSS/CN systems which allow to define new toll sections by means of digital data elements transmitted into the GNSS/CN OBU, DSRC based EFC systems are limited due to the need for installation of roadside equipment at new toll sections. However considering enforcement needs, this is not a real drawback for DSRC compared to GNSS/CN.

9.3.2 Specification

CEN-DSRC:

Public – base standards from CEN [6, 7, 8, 9] and conformance / test standards from ETSI [15, 16, 17]

Telepass-DSRC:

Public –standards from UNINFO [11, 12, 13, 14] European test standard in preparation at ETSI

9.3.3 Components

Single box solution:

- DSRC protocol processor
- EFC protocol processor
- Optional HMI (buzzer, LEDs, buttons)
- Internal Battery

9.3.4 In-vehicle Connections

Optionally:

- Car battery (not used today for normal OBUs)

9.3.5 Installation

The installation of the OBU can be done by the vehicle driver within a few seconds.

9.4 Digital Tachograph

9.4.1 Introduction

The digital tachograph according to the EU regulation [5] does not contain a medium or large range communication facility, but may be favourably integrated together with other ITS functionality.

The digital tachograph, e.g. designed by Kienzle in Germany, fits into a standard car-radio housing; see the following figure taken from the web-site of Kienzle.

Figure 4: Digital Tachograph

9.4.2 Specification

Regulation of the European Union [5].

9.4.3 Components

It contains as a minimum

- two slots for smart cards,
- a simple HMI,
- an interface to download information from the device,
- a printer, and
- a controller with memory.

9.4.4 In-vehicle Connections

- car battery
- crypto-odometer (input)
- electronic speedometer (output)

9.4.5 Installation

The installation of the digital tachograph has to be done by an authorised service station.

9.5 Infotainment Telematics Platforms

9.5.1 Introduction

Several Infotainment Telematics Platforms are available. The main focus of these platforms is on a dedicated integration of GPS and GSM into the audio system. Supported applications are, beyond others:

- Internet browser
- Navigation
- Electronic driver's log book
- Broadcast radio
- Audio CD Player
- MP3-player
- DVD Player
- Audio phone
- E-mail
- SMS

Although such Infotainment Telematics Platforms contain essential components of an ITS system, they lack the required functionality and flexibility needed.

9.5.2 Specification

As these Infotainment Telematics Platforms are commercial dedicated platforms, there are no standardised specifications available.

9.5.3 Components

Installed in a box of standard car radio size:

- GSM
- GPS
- Pentium PC with Microsoft operating system
- Hard disk (optional)
- Flash memory
- DVD-drive
- broadcast radio receiver
- audio power amplifier
- interface to combi-antenna equipment (GSM, GPS, Radio)

See as an example the TeleDrive PC in the following figure, taken from the web-site of IAV:

Figure 5: TeleDrive PC

The HMI is provided by means of a touch-screen, see the following figure taken from the web-site of IAV:

Figure 6: TeleDrive Touch Screen

It is not clear how such a big screen can be installed in a vehicle.

9.5.4 In-vehicle Connections

- Car battery
- Optionally provision of a CAN bus

9.5.5 Installation

Installation has to be done by an experienced service station.

10 IN-VEHICLE SENSORS DEVELOPMENTS

10.1 General

The information provided in this chapter does not claim to be complete, but reports the major activities relevant for the project ABvM.

10.2 Odometer

The odometer as still being the standard device for most vehicles is a simple device providing pulses, where every impulse indicates a specific characteristic travel distance. The new odometers, e.g. as required for the new digital tachograph [5], is a digital crypto device being matched to the digital tachograph in order to hinder manipulations. An example of such a crypto device is KITAS, see figure 4.

The majority of cars sold in Europe since around 1990 have electronic odometer signals. These are mostly part of in-vehicle electronic networks and are used for various engine/drivetrain/braking purposes. There are several reasons why it is difficult to use these signals:

a) These tachograph signals have no cryptographic integrity today since there are minimal threat scenarios in current applications. This means that they will be easy to tamper and introduce false signals. If the tachograph signals will be used for direct charging calculations, there is a need for additional security measures.

b) The physical interface and protocol are totally proprietary, and will often be different even between two different models of the same car brand. This requires adaptation and calibration routines as part of retrofitting equipment.

c) Since these signals and buses are used for safety critical functions, the OEMs are very reluctant to allow anyone to attach external equipment. The legal situation regarding warranties and liabilities will have to be researched and may require changes to European regulations.

10.3 Speedometer

The instantaneous speed of a vehicle is indicated by the speedometer of the vehicle and optionally by the GPS. It can be calculated based on the odometer pulse frequency.

10.4 Trailer Detection

Trailer detection is performed by simple electrical contacts in the electrical connector supplying the trailer. This device is not able to provide any information on the kind of trailer. Further on it is easily possible to manipulate this signal.

10.5 Vehicle Status

Modern cars provide digital information on the status of the vehicle. Access to this information is restricted to the on-board computer of the automobile manufacturer. The data elements are proprietary elements. Standardisation of these data elements has started at ISO TC 204 WG16 SWG16.3 "Probe Data", see also section 11.2.3.3.

10.6 Crypto License Plate Number / Electronic Vehicle Identification

As presented recently at ISO TC204 WG4, Japan is being developing a sensor connected to DSRC that allows to detect attempts to replace the original license plate by an other one. In addition, the original LPN is stored inside DSRC as a data element.

European initiates included the EVI project lead by Ertico, see EVI link. EVI started in 2003 and ended in 2005.

EVI investigated the feasibility of an EU-wide Electronic Vehicle Identification system. It identified and assessed the main technical and non-technical issues facing EU-wide implementation - information that could contribute to future decision-making by the European Commission and the Member States. The feasibility study was to borne out of recommendations from a high-level group advising the European Commission (EC) on road safety matters of the importance of such as study, with a view to its potential for enabling public applications.

Further developments of EVI are subject to firm outcomes from standardisation process currently ongoing in ISO TC204. At this stage it seems that EVI standards are ready before 2007.

Comment [KE1]: Omskrives totalt….

11 DETAILS ON THE DEVELOPMENTS IN STANDARDISATION & TECHNOLOGY

11.1 General

The information provided in this chapter does not claim to be complete, but reports the major activities relevant for the project ABvM. Note that the authors of this document are leading or actively participating in most of the referenced committees and working groups.

11.2 Standards

11.2.1 CEN: DSRC and EFC

CEN TC278 is the main ITS standards development body. The secretariat is from the Netherlands, and the Chaiman is from Rijkswaterstaat. Most of the relevant standards work is originated from TC278 working groups, and there are three main groups of relevance for ABvM:

- Working Group 1: Electronic Fee Collection,
- Working Group 9: Dedicated Short-Range Communication
- Working Group 12: Automatic Vehicle and Equipment Identification

The following table is extracted from the Programme of Work section of the public CEN TC278 web-site.

WG	Work item	Title	Present status	Current document reference
1	00278152	Electronic Fee Collection - Application interface definition for Dedicated Short-Range Communication (review)	Adopted	EN ISO 14906:2004
1	00278188	Electronic fee collection – Conformity evaluation of onboard and roadside equipment to EN 15509		
1	00278187	Electronic fee collection – Interoperable application profile for dedicated short range communication	Under Enquiry	prEN 15509
1	00278114	Electronic Fee Collection - System architecture for vehicle related transport services	Adopted	CEN ISO/TS 17573:2002
1	00278193	Electronic fee collection - System architecture for vehicle related transport services (review)	Preliminary	
1	00278168	Electronic fee collection - Test procedures for user and fixed equipment - Part 1: Description of test procedures	Adopted	CEN ISO/TS 14907-1:2004
1	00278103	Electronic fee collection - Test procedures for user and fixed equipment - Part 2: Conformance test for the onboard unit application interface	Adopted	CEN ISO/TS 14907-2:2005

1	00278104	Electronic Fee Collection (EFC) — Application interface definition for EFC based on Global Navigation Satellite Systems and Cellular Network (GNSS/CN)	Parallel TC comments received	prCEN ISO/TS 17575
1	00278105	Electronic Fee Collection (EFC) - Guidelines for EFC security protection profiles	Adopted	CEN ISO/TS 17574:2003
1	00278192	Electronic Fee Collection (EFC) - Information flows between operators of EFC systems	Preliminary	
1	00278139	Electronic Fee Collection (EFC) - Interface specification for clearing between operators (review)	Adopted	ENV ISO 14904:2002
9	00278119	Dedicated Short Range Communication - Physical integration with the vehicle of On Board Units (OBU) for Electronic Fee Collection (EFC)	Deleted by BT	N/A
9	00278143	Dedicated Short-Range Communication - Application layer (review)	Adopted	EN 12834:2002
9	00278141	Dedicated Short-Range Communication - Physical layer using microwave at 5.8 GHz (review)	Adopted	EN 12253:2004
9	00278142	Dedicated Short-Range Communication (DSRC) - DSRC Data link layer: Medium Access and Logical Link Control (review)	Adopted	EN 12795:2002
9	00278144	Dedicated Short-Range Communication (DSRC) - DSRC profiles for RTTT applications (review)	Adopted	EN 13372:2004
11	00278173	Automatic vehicle and equipment identification - Numbering and data structures (review)	Adopted	EN ISO 14816:2005
12	00278157	Automatic vehicle and equipment identification - Reference architecture and terminology (review)	Adopted	EN ISO 14814:2006
13	00278182	Automatic vehicle and equipment identification – Electronic Registration Identification (ERI) for vehicles - Part 1: Architecture	Adopted in CEN	CEN ISO/TS 24534-1
14	00278183	Automatic vehicle and equipment identification – Electronic Registration Identification (ERI) for vehicles - Part 2: Operational requirements	Adopted in CEN	CEN ISO/TS 24534-2

15	00278184	Automatic vehicle and equipment identification – Electronic Registration Identification (ERI) for vehicles - Part 3: Vehicle data	Adopted in CEN	CEN ISO/TS 24534-3
16	00278185	Automatic vehicle and equipment identification – Electronic Registration Identification (ERI) for vehicles - Part 4: Secure communications using asymmetrical techniques	Adopted in CEN	CEN ISO/TS 24534-4
17	00278186	Automatic vehicle and equipment identification – Electronic Registration Identification (ERI) for vehicles - Part 5: Secure communications using symmetrical techniques	Parallel TC comments received	prCEN ISO TS 24534-5
18	00278201	Automatic vehicle and equipment identification - Interfaces	Adopted in CEN	CEN ISO/TS 17264
19	00278088	Automatic vehicle and equipment identification - Intermodal goods transport - Numbering and data structures	Adopted	CEN ISO/TS 17262:2002
20	00278089	Automatic vehicle and equipment identification - Intermodal goods transport - System parameters	Adopted	CEN ISO/TS 17263:2002
21	00278172	Automatic vehicle and equipment identification - System specification (review)	Adopted	EN ISO 14815:2005
22	00278090	Intelligent transport systems — Automatic vehicle and equipment identification — Intermodal goods transport architecture and terminology	Adopted	CEN ISO/TS 17261:2004

CEN TC278 WG1 was in charge to write the EFC base standard [10]. Test standards are in the process of being developed / finalised at WG1. TS 17575 Application interface definition for EFC based on Global Navigation Satellite Systems and Cellular Network (GNSS/CN) is another standard that is highly relevant for ABvM. This standard has unfortunately proven to be difficult to complete, and currently the work is progressing slowly.

On a more positive note, finallisation of EN 15509 "Interoperable application profile for dedicated short range communication" is being done now. Note that this interoperability profile is intended to be a Pan-European requirement. It may therefore be advisable for ABvM to be interoperable with this standards set - at least as a fallback option for occational users/visitors and for enforcement purposes.

CEN TC278 WG9 was in charge to write the set of base standards for DSRC [6, 7, 8, 9]. WG9 now is closed. Maintenance work and development of test standards is performed at ETSI.

CEN TC278 WG12 is in charge if ITS Identification standards. There is a wide set of standards available that should be considered, and in particular the recent set of standards related to Electronic Vehicle Identification (ERI – 24534-x) have good potential to support all privacy and security needs for ABvM needs. Note that this set of standards have been driven by Rijkwaterstaat.

As a conclusion, it is likely that the requirements from ABvM will fit well inside the current set of CEN standards, but there is a need to do some further work on profiling and application specification.

11.2.2 ETSI: DSRC and ITS

ETSI ERM TG29 developed the basic test standard [15] and the harmonised standards for conformance declaration [16, 17] for the DSRC physical layer based upon the CEN base standard [8].

Test standards for conformance declaration for the DSRC data link layer and the application layer based upon the CEN base standards [6, 7] are in the process of being finalised at ETSI ERM TG37, which is the "ITS"-TG at ETSI.

Further, ERM TG37 is working on test standards for ITS protocols as being developed at ISO TC204 WG16.

Finally ERM TG37 is working on various basic issues of ITS, amongst others eCall.

11.2.3 ISO – ITS

ISO TC204 is responsible for global Intelligent Trnasport Systems standards. This committee is closely cooperating with CEN TC278, and most of the work relevant for ABvM is done at the CEN working groups.

There is one working group in ISO TC204 that is highly relevant with no parallel European activity; namely Working Group 16 Wide Area Communication.

11.2.3.1 TC204 WG16 Activities

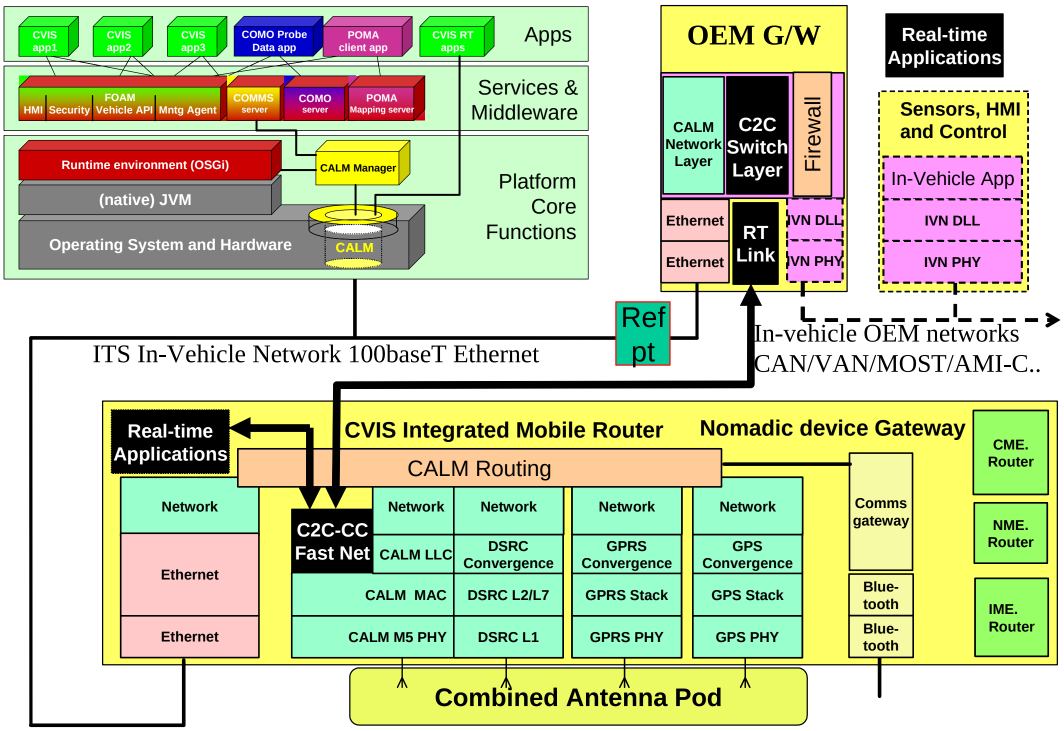
The five sub-working-groups of ISO TC204 WG16 are developing ITS technology:

- SWG 16.0: CALM - Architecture
- SWG 16.1: CALM - Media
- SWG 16.2: CALM - Networking
- SWG 16.3: Probe Data (vehicle sensor data format including privacy of data)
- SWG 16.4: Application Management (including payment functionality)
- SWG 16.5: Emergency Notifications

For further information on TC204 WG16 please visit the web-site portal.

11.2.3.2 CALM

The scope of CALM is to provide a standardized set of air interface protocols for medium and long range, high speed ITS communication using one or more of several media, with point-to-point and point-to-multipoint capabilities, and networking protocols, and upper layer protocols. This service includes the following communication modes:



- Vehicle-Infrastructure
- Infrastructure-Infrastructure
- Vehicle-Vehicle

Although some communication media, e.g.

- CALM IR [22],
- CALM M5 [23],
- CALM Millimetre Wave [24],

are dedicated to CALM in order to achieve specific properties related to the highly dynamic mobile ITS environment, the main focus of CALM is on the networking [18, 19], i.e. the parameterised automatic mapping of applications / services onto media making use of the Internet Protocol version 6 (IPv6). The CALM network is using standardised interfaces to interact with the media and the applications and the CALM management. For e.g. safety related applications / services with requirements for low latency, the air interface does not need to use IPv6 and its large protocol header.

An OEM interface is provided to the automobile manufacturers.

The specific needs of the other regions America and Asia are considered by their preferred media and protocols, e.g.

- Japanese DSRC [26],
- IEEE WAVE [27, 28], which will be part of CALM M5.

Important existing media being incorporated into a CALM system are e.g.

- European Cellular Networks G2 / G3 [20, 21],
- GPS and GALILEO receivers.

The CALM standards were developed to avoid one of the big problems in the auto industry; namely the proliferation of boxes that needs to communicate with the external world. The current situation is that every new application will need its own box with HMI, communications, processing and storage, power connection and so on. This is primarily a safety issue because of e.g cognitive overload, but also bad for reliability/maintainability, total cost, interference between systems and so on. This is recognised by the OEMs, the ITS industry and the Commission, and forms part of the basis for the co-operative systems initiatives in 6FP and 7FP.

Safety is a very hot topic, and using communication systems to reduce traffic accidents is a political imperative. The technology focus is around the CALM M5 standards in the 5 GHz range. This gives the needed range (up to 1000 m) together with a good data rate (6-54Mbit/s) and low latency (below 1ms). This technology is an extension of IEEE 802.11 Wireless LAN called 802.11p Wireless Access in the Vehicular Environment (WAVE). A USA-specific variety is called 5.9 DSRC which is causing some confusion in regions with established DSRC technology. The CALM M5 is a superset that links the fast safety messages with the overall CALM architecture under a written agreement with IEEE 802.11.

Please note that CEN DSRC is an integral part of the CALM architecture. Since CEN DSRC is operating at 5.8 GHz, and CALM M5 is operating at 5.9 GHz, there is too much cross interference for separate systems. The solution recommended by ETSI/CEPT is therefore that any 5.9 GHz WAVE/M5 system also needs an optimised CEN DSRC function that will operate in this interfering environment. Therefore CEN DSRC will continue to work and be a part of CALM indefinitely.

As already mentioned, most OEMs have very concrete ideas on introducing CALM or CALM-like functionality. The timing and content of these functions is of course commercial secrets. Discussions with OEM executives indicate that the next generation of vehicles being planned now, will include major parts of the CALM architecture. For instance the leader of VII in the U.S. (Bill Jones) stated recently that the eight major OEMs had agreed to equip all vehicles sold in the U.S. with DSRC 5.9 (an American specific subset of CALM M5) from 2010 onwards.

Nobody can accurately predict when these systems will come or what components will be included, but there is a very clear agreement in the ITS field that this will happen relatively soon. It is therefore clearly recommended that ABvM include CALM/CVIS at least in the long-term vision.

CALM is mostly influenced by European experts and has a good level of acceptance in Europe. Several 6FP R&D projects have decided to use CALM standards; foremost is the CVIS project. We therefore recommend to view CALM as a European technology in a similar way as CEN DSRC is.

11.2.3.3 Probe Data

SWG16.3 deals with services provided inside a vehicle, i.e. with the provision of data that are being prepared inside the vehicle.

Several OEMs with BMW in the lead is standardising the vehicle sensor data including speed and distance, position, environmental data etc. This data is intended to be made available on standard in-vehicle interfaces. The basic standard is now available in final draft format.

In addition cryptographic protection and integrity seals are put on the data in a subsequent standard available as a committee draft.

11.2.3.4 Application Management

The majority of the work in CALM focus on network layer and below. A draft of the API functionality needed to write CALM-aware applications is now available. It is likely that this draft will be modified by the much more advanced GST concept that is now further developed in CVIS.

11.2.3.5 Emergency Notifications

There are currently two drafts for emergency notification protocols. One is the European eCall, and the alternative is called Automatic Crash Notification (ACN). eCall is a specific GSM-based protocol intended to be implemented in a hardened, stand-alone box, while ACN is an integrated function intended to use the available medias of CALM for instance. This is a controversial field for the moment, but since it is subject for regulations it could be a factor where ABvM service could piggy-back.

11.2.3.6 IETF - ITS

The Internet Engineering Task Force is assisting ISO TC204 WG16 for development of IPv6 protocols dedicated to mobile use in vehicles. Mainly the following two activities are conducted:

- NEMO Network Mobility
- MONAMI6 Mobile Nodes and Multiple Interfaces in IPv6

This work is highly relevant since several projects like ABvM would greatly benefit from a ubiquitous network. High mobile network protocols have been developed for invivible connection of vehicle computers to central system operations, and including relevant nodes. Some work continues on route optimisation, load balancing between communication medias and so on.

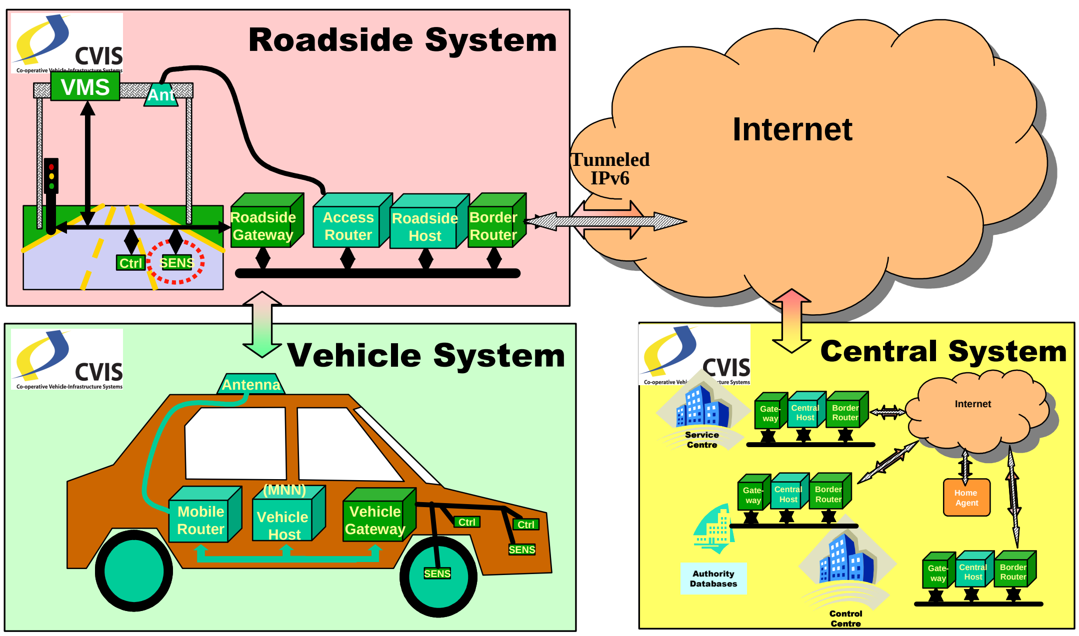
For more details please visit the web-site of IETF.

11.3 Research Activities and Initiatives

DISCLAIMER: The following projects are still in their start-up phase. This means that central parts of the work are not yet defined and that the initial results are not yet published or approved by the Commission. The statements below are therefore solely the views of Q-Free and do not represent the official position of these projects even though the authors of this document hold central positions and responsibilities in CVIS and SAFESPOT.
Note that the Dutch Ministry of Transport, Public Works and Water Management is a partner in several of these projects.

11.3.1 CVIS

CVIS is the largest ITS Integrated Project in the 6th Framework Programme. About 1/4 is technology developments that can be considered as an implementation validation of technology as standardised at ISO TC204 WG16 CALM. Please see the CVIS web-site.



CVIS is considered to be the central actor for the service architectures started by the GST project, as well as the technical platform as described below. Several of the R&D projects that actively can utilise these platforms and architectures are in contact with CVIS and the Commission to do so. There are also many commercial actors that are participating in this work and that have stated their intentions to extend the CVIS results into commercial products and services. Likewise CVIS has a good direct participation from the OEMs, and indirectly via cooperating projects all the major OEMs are involved. In addition there are very good cooperation on a technical level with other regions and countries like Japan, Korea and USA, and there are high-level initiatives to formalise these contacts.

The focus for the ABvM project can mostly be found in the following sub-projects of CVIS:

The Core Architecture Group (CAG)

The Communication Technologies SP (COMM)

The Co-operative Monitoring SP (COMO)

The Positioning, Mapping and Location Referencing SP (POMA)

The Framework for Open Architecture Management SP (FOAM)

CAG is a management activity that is mainly responsible to develop architectures and coordinate the different elements of CVIS. The first set of architectures is due to be approved in August 2006, and will be open published.

COMM will specify, develop, produce and support an open communications and application platform. This platform is intended to be used in all CVIS sites as well as in the co-operating prjects. The platform will also be available for national R&D projects.

The communications module is a CAR PC based Mobile Router containing at least the following air interfaces

- GSM – GPRS,
- GPS/GALILEO,
- CALM M5 / WAVE,

  Microwave technology based on the IEEE 802.11 WLAN standards
- DSRC, integrated with CALM M5,
- CALM IR.

There is also support to introduce other air interfaces, and for instance COOPERS intend to extend this mobile router with broadcast receivers.

The application processing part of this platform is the same CAR PC configured to run applications in a host computer. The kernel of this is an extension of the GST project that supports secure management of application/firmware components via an infrastructure service management hierarchy. This will for instance allow secure upload of new applications and certificates in a trusted environment, so that when a foreign vehicle enters the Netherlands it can automatically load and start the ABvM service.

COMO will develop a relatively open gateway, probably in cooperation with C2C-CC and SAFESPOT. This gateway will allow sensor data to flow from existing in-vehicle sensors and formatted into standard representation. A COMO server functionality in the vehicle host and roadside host will perform data fusion from several soureces, and make this info available to internal and external data users.

POMA: Today in-vehicle navigation & telematics systems use GPS positioning information, sometimes augmented with inertial sensor data, and a digital map. Performance is acceptable for navigation, but is insufficient for many cooperative systems applications, such as supplementing loop sensors for vehicle detection at traffic lights. A much greater position accuracy and reliability is required for safety applications where precise inter-vehicle relative positioning is needed. To support the cooperative applications proposed in CVIS, the POMA sub-project will develop advanced positioning and mapping solutions that can be implemented at the vehicle and infrastructure level and that can cooperate through the communication means that will be developed in the project. The technologies behind this will be advanced GPS and Galileo supplemented with other sensor input (odometer through the vehicle gateway, several GNSS antennas, communication antenna positioning etc). The development of these solutions will be driven by the CVIS application requirements while ensuring, through active participation of OEMs and infrastructure solution providers, that they are commercially viable.

FOAM: The GST (Global System for Telematics) project is nearing its end. Many of the results from this project will be incorporated in the CVIS architecture, and implemented in the CVIS Hosts. The FOAM sub-project aims at creating an open end-to-end application framework, connecting in-vehicle systems, roadside infrastructure and back end infrastructure. The internal functions include HMI integrated with the vehicle HMI, CALM networking, trusted processing and a JAVA/OSGi concept with small downloadable applets. As part of the service set, FOAM will provide a generic secure payment service that can be configured freely based on infrastructure service definitions.

CVIS has a strong list of partners that covers most of the main ITS actors. There are indicators that this project has the role of trendsetter for ITS co-operative systems. The close interaction with all relevant standardisation bodies also points to a long-term stability that is needed for European-wide deployments.

The CVIS communications platform will be made available to other research projects and initiatives, e.g. SAFESPOT.

11.3.2 SAFESPOT

Within the 6th Framework Programme the SAFESPOT project aims on understanding how intelligent vehicles and intelligent roads can cooperate to produce a breakthrough for road safety, see their web-site. SAFESPOT is a very close partner to CVIS where the focus is on vehicle-to-vehicle situations and prevention of accidents. There are close technology and architecture work between the projects where the goal is to have a common architecture and use the same communications platforms as far as practicable.

The aim is to prevent road accidents developing a Safety Margin Assistant that detects in advance potentially dangerous situations and that extends in space and time drivers' awareness of the surrounding environment. This requires very good positioning accuracy and reliability and highly accurate maps.

The Safety Margin Assistant will be an Intelligent Cooperative System based on vehicle-to-vehicle and vehicle-to-infrastructure communication. SAFESPOT will use the communications platform being developed in CVIS.

11.3.3 RCI

RCI is an EU research activity managed by ERTICO. The goal is to identify the details of the technological platform required for the intended pan-European EFC service as requested in the EFC directive [4].

The project selected two industry consortia that shall develop a demonstrator each.

Results or detailed plans are not yet available.

11.3.4 COOPERS

The COOPERS project is also belonging to the same cluster as CVIS and part of the inner circle of developments here. The intention is to look at re-use of existing infrastructure for safety applications. This includes the use of exisiting CEN DSRC plazas, use of RDS-TMC, VMS and so on in a more intelligent and co-operative environment. COOPERS will be based on the same architecture and the same communications/host platforms as developed by CVIS.

11.3.5 eSafety / COMeSafety - Communications for eSafety

eSafety is a joint initiative of the European Commission's DG Enterprise and DG Information Society, industry and other stakeholders and aims to accelerate the development, deployment and use of Intelligent Integrated Safety Systems, that use information and communication technologies in intelligent solutions, in order to increase road safety and reduce the number of accidents on Europe's roads.

Within the 6th Framework Programme the COMeSafety project supports the eSafety Forum with respect to all issues related to vehicle-to-vehicle and vehicle-to-infrastructure communications as the basis for cooperative intelligent road transport systems.

Only indirectly relevant for road tolling. See also their web-site.

11.4 Industrial Developments

11.4.1 Coexistence of CEN-DSRC and UNINFO-DSRC

11.4.1.1 Dual-protocol Chip Set

In a joint approach the Italian road operator Autostrade and the semiconductor manufacturer STMicroelectronics developed a set of semiconductor chips, i.e. the so-called "dual-protocol chip-set", that support the implementation of the CEN DSRC EFC protocols and the Telepass protocols in a single OBU.

This approach has demonstrated the feasibility of multiple non-compatible DSRC protocols operated quasi-simultaneously in a single device.

The design is validated in real operational environment, but commercial deployments are not known.

Implementations without usage of this chip-set are possible.

11.4.1.2 Technology Mix at Roadside

In Italy it was demonstrated in real operational EFC sites, that harmless operation of the CEN DSRC protocol in one toll lane and simultaneous operation of the Telepass protocol in the adjacent lane is possible.

11.4.2 Coexistence of DSRC and Infrared

TollCollect GmbH requested a dual protocol OBU that combines the CEN DSRC EFC protocol with the IR protocol. It is claimed that the IR protocol follows the ISO standard [22].

The purpose of IR is enforcement. Most of the toll-gantries in Germany contain video technology, but IR emissions are not measurable. Some new additional side-mounted installations obviously contain IR equipment.

So far, the DSRC component in the TollCollect OBU do not seem to be activated.

11.4.3 DSRC as a Generic Mobile Payment Means

The Portuguese road operator has efficiently demonstrated that a DSRC OBU is a reasonable payment means accepted by the users. Even OBUs dedicated to road tolling system Via Verde in Portugal can be used to e.g. pay at a petrol station, for parking and for access to historical sites. A further developed version of the DSRC OBU with simple HMI, alpha numeric display and buttons, is efficiently in use for parking management / payment in Lisbon. See [29] for more details.

11.4.4 Car2Car Communications Consortium

The C2C-CC is a non-profit organisation initiated by European vehicle manufacturers, see their web-site.

Objectives of the C2C-CC are, e.g.

- to contribute to an open standard for car-to-car communication systems based on wireless LAN components and to guarantee European-wide inter-vehicle operability
- to enable the development of active safety applications by specifying, prototyping and demonstrating the car-to-car system
- to promote the allocation of a royalty free European wide exclusive frequency band for car-to-car applications
- to push the harmonisation of car-to-car communication standards worldwide.

Considered applications will mainly evolve the three areas

- advanced driver assistance,
- decentralised floating car data,
- user communications and information services.

C2C-CC's radio system is derived from the standard IEEE 802.11. There is a co-operation between the C2C-CC and the standardisation groups ISO TC204 WG16 (CALM) and ETSI ERM TG37. The goal is to harmonize the C2C-CC's radio design with the standards.

The C2C-CC is contributing to the research activities CVIS and SAFESPOT.

11.5 ANPR – EFC

Video based systems for automatic number plate recognition are being discussed and tested. Video signal processing and OCR have achieved a high level of performance. However the following considerations are valid:

- The technical possibility of making video photos / clips from road users bears the potential risk to violate existing law related to privacy of data, and suffers from a poor acceptance by the population.
- Video photos / clips never shall be used in a systematic way to track vehicles. In an EFC system, exactly this would be needed in order to calculate the correct fee.
- Video photos / clips have to be restricted clearly for prosecution of violators.
- Video photos / clips are not reliable for enforcement, as the license plates of vehicles will be replaced to conceal the real identity of a vehicle.

11.6 Automotive Displays

11.6.1 Introduction

Nowadays automotive displays mainly are small alpha numerical displays for a very limited number of characters; see e.g. the examples of the TollCollect OBU, the Kienzle Digital Tachograph and the Fela LSVA OBU.

Navigation and infotainment systems, more and more being introduced even in medium size cars as a standard component, require more comfortable graphical displays, both for two-dimensional and for three-dimensional presentation of highly dynamic scenes. Optionally these displays will be coloured displays or black/white displays.

The more powerful displays, as after-sales equipment, suffer from the limited available installation space. Thus such displays will have to be provided by the "dashboard manufacturers".

In what follows some exemplary technical details.

11.6.2 Fujitsu

Fujitsu recently published the following graphical controllers that might be suited for generic ITS displays, see their web-site:

- 3-D controller: For RGB display resolution of 1.280 x 1.024 Pixel. Supports OpenGL ES 1.1 standard for Embedded Accelerated Graphics
- 2-D controller: For RGB display resolution of 1.024 x 768 Pixel

Comment [KE2]: Dette var bra detaljnivå sammenlignet med resten???

11.6.3 Siemens VDO

Siemens VDO, see also their web-site, developed the Head-Up display as being installed in BMW cars series 5 and 6.

For navigation purposes, nowadays they are using a 6,5 inch colour display.

For future ITS devices, a 8,8 inch colour display is announced.

12 LINKS

12.1 Directly related links

Car2Car Communications Consortium	http://www.car-to-car.org
CEN TC278	http://www.nen.nl/cen278
CVIS	http://www.ertico.com/en/activities/efficiency__environment/cvis.htm
eSafety	http://europa.eu.int/information_society/activities/esafety/index_en.htm
ETSI portal	http://portal.etsi.org
Fela Management	http://www.fela.ch/et.html
IETF	http://www.ietf.org
ISO	http://www.iso.org
ISO TC204 WG16 portal	http://www.tc204wg16.de and http://www.calm.hu
SAVESPOT	http://www.safespot-eu.org/pages/page.php
TollCollect	http://www.toll-collect.de
Via Verde	http://www.viaverde.pt/ViaVerde/vPT/Homepage.htm
Stockholm	http://www.stockholmsforsoket.se
EVI	http://www.ertico.com/en/activities/activities/evi_website.htm

12.2 Supporting links

Fujitsu Automotive Graphics Display Controller	http://www.fujitsu.com/de/news/pr/fme_20060214.html
Siemens VDO Displays	http://www.siemensvdo.de/press/releases/interior/2003/SV-200309-009+-d.htm
IAV – Ingenieurgesell-schaft Auto und Verkehr	http://www.iav.de/de/1_engineering/fahrzeugelektronik/telematik_infotainment/teleDrive.php
Kienzle Automotive	http://www.kienzle.de/p_fe_fahrtschreiber.html

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Summary

This document comprises deliverable D4 “Risk assessment for in-car integration of the OBU” ([1]) of research topic 6 “Integration with in-car platforms” ([2]) of the project "Anders Betalen voor Mobiliteit" of the Ministerie van Verkeer en Waterstaat, The Netherlands.

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Ministerie von Verkeer en Waterstaat, The Netherlands, 26.6.2006

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TERMS AND DEFINITIONS

ABvM	Anders Betalen voor Mobiliteit
CALM	Continuous communications Air interface for Long and Medium Range
	Work title of ISO TC204 WG16
CVIS	Cooperative Vehicle Infrastructure Systems
DSRC	Dedicated Short Range Communications
	Work title of CEN TC278 WG9
EFC	Electronic Fee Collection
	Term used for all types of road charging, being a tax or a fee.
Galileo	European – civilian – global navigation satellite system (under construction)
GPS	Global Positioning System
	American – military –global navigation satellite system (in operation)
GSM	Groupe Spéciale Mobile
MMI	Man Machine Interface.
	Set of display, keyboard, audio output, voice recognition functionality available to a human to interact with a digital system. Here part of the OBE.
OBU	On Board Unit
	This term is wide-spread used for a battery-powered devices performing EFC, mainly based on DSRC, and normally installed at the windscreen of a vehicle.
	More generic it indicates the part of an ITS implementation being installed inside a vehicle. Synonyms to the generic meaning are OBE, in-car platform and in-car system.
	Dedicated to this project it means the EFC part of an OBE.

13 INTRODUCTION

The analysis of possibilities to integrate KMP functionality in generic in-car systems and the subsequent formulation of favourable and realistic integration scenarios has yielded three scenarios (see [5]). These potential approaches are characterized by the usage of:

- Monolithic OBU
- In-Vehicle Computer
- CALM router.

For each of these approaches applies that currently a 100% compliant and readily available off-the-shelf solution is not available. This means that developments will be necessary to realize the required KMP functionality. These developments may not be restricted to the technical area, but may also address organisation and legislation.
It is obvious that future developments of whatever type constitute risks. Risks that may jeopardize a successful planning and implementation of KMP. To get some insight into the risks involved with the identified scenarios, a (high level) risk assessment has been conducted.

The risk assessment has been broken down into following parts:

- discussion of a general approach that allows for classification of risks (section 14)
- identification of risk areas (section 15); it should be noted that, due to the different stages of maturity of the components involved, it is not feasible to address the same risk areas for all scenarios
- classification of identified risks for each of the scenarios (sections 16, 17 and 18).

Section 19 presents some conclusions that can be drawn from the numerical results from the risk assessment.

14 APPROACH

A risk can be associated with a condition that may occur with a certain probability, where the condition results in an adverse deviation from one or more pre-defined goals. As such risk can be characterized by following two items:

- the probability that the specific condition occurs
- the severity of not reaching the goal when the condition occurs.

To quantify risks the following procedure has been adopted:

- a Probability Class (PC) is assigned, according to the following scale for probabilities:

  0 can not occur

  1 small probability to occur

  2 likely to occur

  3 will occur

- a Severity Class (SC) is assigned, according to the following scale for severities:

  0 negligible impact

  1 minor impact for KMP

  2 considerable impact for KMP

  3 fatal impact on KMP

  Note that "impact" can have many forms, varying from delay, loss of money, extra manpower, public disapproval to (political) loss of face.

- the combination of Probability Class and Severity Class leads to a Risk Quantifier (RQ); in Table 1 it has been defined how the RQ results from PC and SC:

	Probability Class			
Severity Class	0	1	2	3
0	0	0	0	0
1	0	2	3	4
2	0	3	4	5
3	0	4	5	6

Table 1: Risk Quantifier as a result of Severity Class and Probability Class

Note that the scale for RQ is logarithmic of nature. This means that a change in RQ value from 3 to 4 implies a change in "damage" by an order of magnitude.

15 RISK AREAS

Risk areas can be divided into:

- technical risks; this involves:
  - risks related to the (further) development of (new) components
  - risks related to installation and preparation for operation; this includes preparation of all vehicles participating in KMP
  - risks related to operation of KMP, affecting both Operator and Road User
- process risks; involves risks that are considered a threat to reaching the goals as to:
  - time: KMP system must be up and running at the envisaged time
  - money: costs within budget
  - quality: performance in accordance to requirements
  - organisation: adequate at all stages of development, installation and operation
  - information: adequate and accurate for all parties involved.

For the three envisaged scenarios applies that at this stage not sufficient details are available to explore in full depth the risk areas indicated above. For that reason a selection has been made. Table 2 presents an overview of the risk areas that are considered relevant.

Identified risk area
Additional development
Mass production of equipment for 8M vehicles
Installation of equipment in 8M vehicles
Primary KMP requirements
Standards
System requirements
Time frame
Legislation
Maintenance

Table 2: Overview of risk areas relevant for integration scenarios of KMP functionality in in-car systems

Note that in this overview no attempts have been made to separate strictly between technical risks and process risks. The reason is twofold:

- distinction between the two is often difficult
- for the execution of a high-level risk assessment it is not relevant.

16 RISK ASSESSMENT FOR SCENARIO 1: MONOLITHIC OBU

Table 3 presents for scenario 1 (Monolithic OBU):

- applicable risk areas conform Table 2
- relevant risk issues per risk area
- nature of impact when risk issue is compromised
- appraisals for Probability Class (PC) and Severity Class (as defined in section 15) per risk issue
- resulting Risk Qualifier (RQ) conform Table 1
- clarifying comments.

Risk area	***Risk issue***	***Impact***	***PC***	***SC***	***RQ***	***Comment***
Additional development	Communication features to support: • distance travelled • actual time • location • determination of actual costs	Delayed availability Processing capacity Memory Power consumption	1	1	2	The requirement that the actual fee shall depend on distance travelled, actual time, location and on-board presentation of actual costs require this information to be supplied externally.
	New functionality for derivation of: • distance travelled • actual time • location • presentation of actual costs	Processing capacity Memory MMI Power consumption	1	1	2	The requirement that the actual fee shall depend on distance travelled, actual time, location and on-board presentation of actual costs require this information to be extracted from externally supplied data.
Mass production of equipment for 8M vehicles	Timely start of production	Delay in distribution Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash flow	0	3	0	Manufacturing of large quantities takes time, even with multiple production plants. That means that production shall start early enough to not only produce the units, but also to allow for distribution and installation. Several vendors can produce the same type of unit such that this should reduce the probability of the risk to zero.

Installation of equipment in 8M vehicles	User must obtain unit	Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash flow	1	2	3	High demands are imposed on distribution channels. Scandinavian and South Europe EFC system experiences have proven that these demands can be met at acceptable costs
	User must conduct installation	Nuisance for user Back-Office costs	1	1	2	Poor installation may result in unreliable transactions, inducing nuisance for the user and extra efforts for the Operator. However, Scandinavian and South Europe EFC system experiences have proven that installation does not require special skills.
	Configuring vehicle characteristics	Loss of income	1	1	2	Since the fee depends on vehicle characteristics, manipulation with vehicle characteristics is an attractive way to fraud the system. Calls for adequate procedures.
Primary KMP requirements	Compliance to requirements	Reduction of originally envisaged functionality	1	1	2	It is conceivable that one or more KMP requirements must be sacrificed in view of costs.
Standards	Interoperability	For non-compliant systems interoperability may be hampered	1	1	2	Interoperability does not seem to be a problem if other systems adhere to European directive [4]. There currently is no reason why the Monolithic OBU system should not adhere to [4].
	Privacy regulations	Massive rejection by public	0	3	0	It must be assumed that only a law can be passed that enables KMP if national and international requirements have been respected.
System requirements	Stable set of system requirements	Delay in start of mass production of 8M OBUs Delay in installation Delay in lift-off Delay in cash flow	2	3	5	A stable set of concise system requirements is a prerequisite. Imperfections, conflicts, ambiguity and (last minute) changes will jeopardise development and installation of a KMP system. Especially when it comes to the Monolithic OBU, freezing the requirements is imperative since functionality can not be changed once production has started.

Time frame	Envisaged time span for realisation of Monolithic OBU	General delay	1	1	2	Assuming a stable set of KMP requirements, realisation of Monolithic OBUs does not require developments that constitute a substantial risk as to the time and efforts required (although they may be considerable).
	Envisaged time span for realisation of operable KMP system	General delay	1	3	4	Especially the erection of a nation wide network is considered a far from trivial operation with ample possibilities for delay.
Legislation [2]	Enforcement rules	New system requirements	1	1	2	Currently it is unclear how enforcement will be conducted. Special attention shall be given to the matter who is to (take the) blame in case of malfunction of either the OBU or the external DSRC network.
Maintenance	Replacement of defective OBU to be conducted by user.	Nuisance for user Load on Helpdesk Back-Office costs	3	1	4	Though the system can assist in detecting faulty OBUs, it is the user who shall take action. Failure to do so will, apart from nuisance (and possibly costs) for the user, require extra efforts for the Operator to handle these situations. Note that this situation will occur every time a battery expires (prematurely).

Table 3: Risk assessment for scenario 1 (Monolithic OBU)

[2] The risk implied in the fact that for introduction of KMP a legal basis shall be provided, with all uncertainties that come with a political decision process, is explicitly ignored here

17 RISK ASSESSMENT FOR SCENARIO 2: IN-VEHICLE COMPUTER

Table 4 presents for scenario 2 (In-Vehicle Computer):

- applicable risk areas conform Table 2
- relevant risk issues per risk area
- nature of impact when risk issue is compromised
- appraisals for Probability Class (PC) and Severity Class (as defined in section 15) per risk issue
- resulting Risk Qualifier (RQ) conform Table 1
- clarifying comments.

Risk area	*Risk issue*	*Impact*	*PC*	*SC*	*RQ*	*Comment*
Additional development	system platform	Delayed availability Delay in distribution Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash flow	2	3	5	Though the parent technologies are available (satellite positioning, communication, vehicle sensors, smart card technology, displays), yet some time may elapse before conclusions are reached upon critical decisions (GPS versus Galileo, GSM versus DSRC, interoperability, MMI, etc). For the appraisal of SC it has been assumed that at the time of introduction of the In-Vehicle computer no other form of KMP system is operational.
	interfacing with vehicle	Not possible in some vehicles Extra costs for adaptations Unexpected high content of occasional users	2	2	4	For installation of an In-Vehicle Computer interfaces to odometer, car power and possibly inertial sensor and aerial are required. These may not be available or suitable, requiring adaptations to the vehicle or special options for the In-Vehicle Computer. Also the required space (motorcycles) may not be available.
Mass production of equipment for 8M vehicles	Timely start of production	Delay in distribution Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash flow	3	3	6	Manufacturing of large quantities takes time, even with multiple production plants. That means that production shall start early enough to not only produce the units, but also to allow for distribution and installation.

Installation of equipment in 8M vehicles	Network of authorised service stations	Dissatisfied users Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash	3	3	6	Installation of In-Vehicle Computers is too complex to be handled by users. For that reason authorised service stations shall be mobilised. Coverage of these stations shall be such that users requiring service can be handled without excessive travel or delay. Apart from recruiting and training personnel and supplying adequate tools for configuring and testing, there is the matter of retrieving relevant information on virtually all 8M vehicles concerned.
	Distribution to authorised service stations	Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash flow	2	2	4	Demands of service stations will depend on amount and type of vehicles to be serviced, which may be difficult to predict.
	Installation only at authorised service stations	Nuisance for user Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash flow	2	1	3	Users must be alerted that vehicle shall be offered at authorised service station. Waiting times to be expected.
	Configuring vehicle characteristics	Loss of income	1	1	2	It has been assumed that at the time of installation the In-Vehicle Computer is also configured as to vehicle characteristics.
Primary KMP requirements	Compliance to requirements	Reduction of originally envisaged functionality	0	1	0	Considering that one of the prime requirements of the In-Vehicle Computer is to fulfil the KMP requirements, this possibility can be excluded.
Standards	Interoperability	For non-compliant systems interoperability may be hampered.	1	1	2	One must assumed that during the development phase of the In-Vehicle Computer adherence to the European Directive [4] has been respected. Still this is a risk

	Privacy regulations	Massive rejection by public	0	3	0	It must be assumed that only a law can be passed that enables KMP if national and international requirements have been respected.
System requirements	Stable set of system requirements	Delay in start of mass production of 8M In-Vehicle Computers Nuisance for user Delay in installation Delay in lift-off Delay in cash flow	2	3	5	A stable set of concise system requirements is a prerequisite. Imperfections, conflicts, ambiguity and (last minute) changes will jeopardise development and installation of a KMP system. Probably the In-Vehicle Computer will have facilities for downloading new applications after production of the unit. Yet it shall be realised that as soon as installation has started, applications can only be changed at high costs and considerable nuisances.
Time frame	Envisaged time span for realisation	General delay	2	2	4	Realisation of a KMP system based on In-Vehicle Computers does not require developments that constitute a substantial risk as to the time and efforts required (although they may be considerable).
Legislation [2]	Enforcement rules	New system requirements	1	1	2	Currently it is unclear how enforcement will be conducted. Special attention shall be given to the matter who is to (take the) blame in case of malfunction that can be traced to the In-Vehicle Computer: • user, or • service station that performed installation, or • In-Vehicle Computer manufacturer, or • vehicle manufacturer?
	Interface In-Vehicle Computer with vehicle	Public disapproval Extra costs for user	2	1	3	Retrofit of an In-Vehicle Computer into a vehicle may render vehicle manufacturers quality warrants void, especially if essential vehicle sensors are shared.
Maintenance	Repair of In-Vehicle Computer only at authorised service stations	Nuisance for user Load on service stations	1	2	3	Though the system can assist in detecting faulty In-Vehicle Computers, it is the user who shall take action and reports at the

		Back-Office costs				service station. Failure to do so will, apart from nuisance (and possibly costs) for the user, require extra efforts for the Operator to handle these situations.

Table 4: Risk assessment for scenario 2 (In-Vehicle Computer)

18 RISK ASSESSMENT FOR SCENARIO 3: CALM ROUTER

Table 5 presents for scenario 2 (In-Vehicle Computer):

- applicable risk areas conform Table 2
- relevant risk issues per risk area
- nature of impact when risk issue is compromised
- appraisals for Probability Class (PC) and Severity Class (as defined in section 15) per risk issue
- resulting Risk Qualifier (RQ) conform Table 1
- clarifying comments.

Risk area	*Risk issue*	*Impact*	*PC*	*SC*	*RQ*	*Comment*
Additional development	KMP application	Delayed availability Unexpected high content of occasional users Delay in lift-off Delay in cash flow	1	1	2	It is expected that automotive manufacturers will provide in a decade a CALM/CVIS platform that will also be capable to handle tolling applications. It may assumed that by that time modules from which a KMP system can be assembled have become available, reducing the task to compose a KMP application to a relatively simple and straightforward one.
Mass production of equipment for 8M vehicles	-	-	-	-	-	No longer a KMP activity, but a task for the (suppliers of the) automotive industry.

Installation of equipment in 8M vehicles	Network of authorised service stations	Nuisance for user Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash	1	2	3	What remains to be installed in the CALM router is the KMP application, and possibly KMP typical vehicle characteristics. It has been assumed that this shall be done at specialised service stations, since it shall be clad with strict security measures to avoid fraud. Coverage of these stations shall be such that users requiring service can be handled without excessive travel or delay. Recruiting and training of personnel shall be in accordance with complexity of the tasks to be performed. Note that, since CALM routers will only be available in relatively new cars, only a fraction of the 8M vehicles are candidate for installation of the KMP application.
	Installation only at authorised service stations	Nuisance for user Delay in installation Unexpected high content of occasional users Delay in lift-off Delay in cash flow	1	1	2	Users must be alerted that vehicle shall be offered at authorised service station. Waiting times to be expected.
Primary KMP requirements	Compliance to requirements	Reduction of originally envisaged functionality	0	1	0	It seems safe to assume that the KMP application will satisfy all KMP requirements.
Standards	Interoperability	For non-compliant systems interoperability may be hampered.	0	1	0	It has been assumed that by the time the CALM routers are available, all non-compliant systems have been upgraded to accepted standards.
	Privacy regulations	Massive rejection by public	0	3	0	It must be assumed that only a law can be passed that enables KMP if national and international requirements have been respected, and that the KMP application will adhere to this law.

System requirements	Stable set of system requirements	Nuisance for user Delay in installation Delay in lift-off Delay in cash flow	2	1	3	A stable set of concise system requirements is a prerequisite. Imperfections, conflicts, ambiguity and (last minute) changes will jeopardise development and installation of a KMP system. Though the CALM router allows for updating the KMP application, it shall be realised that as soon as installation has started, applications can only be changed at high costs and considerable nuisances.
Time frame	Envisaged time span for realisation	General delay	2	3	5	Realisation of a KMP system based on CALM routers depends largely on the pace of large scale research activities and automotive industry. Furthermore, attention and efforts seem to focus more on safety issues than on toll applications.
Legislation [2]	Enforcement rules	New system requirements	1	1	2	Currently it is unclear how enforcement will be conducted. Special attention shall be given to the matter who is to (take the) blame in case of malfunction that can be traced to the CALM router: • user, or • vehicle manufacturer?
Maintenance	Repair of CALM router only at authorised service stations	Nuisance for user Load on service stations Back-Office costs	1	2	3	Though the system can assist in detecting faulty CALM routers, it is the user who shall take action and report at the service station. Failure to do so will, apart from nuisance (and possibly costs) for the user, require extra efforts for the Operator to handle these situations.

Table 5: Risk assessment for scenario 3 (CALM router)

19 CONCLUSIONS

An attempt has been made to derive some conclusions based on the results of the risk assessments for the scenarios as presented in Table 3, Table 4 and Table 5. The following procedure has been adopted:

- for Table 3, per risk area, maximum values for RQ have been determined
- this has been repeated for Table 4 and Table 5

- the sum of all maximum RQ-values per scenario has been determined.

The results have been collected in Table 6.

Identified risk area	***Monolithic OBU***	***In-Vehicle Computer***	***CALM router***
Additional development	2	5	2
Mass production of equipment for 8M vehicles	0	6	-
Installation of equipment in 8M vehicles	3	6	3
Primary KMP requirements	2	0	0
Standards	2	2	0
System requirements	5	5	3
Time frame	4	4	5
Legislation	2	4	2
Maintenance	4	3	3
Sum of max RQ-values	**24**	**35**	**18**

Table 6: Maximum RQ-values per risk area for all three scenarios

Though it is obvious that the outcome for the sum of the maximum RQ-values results directly from the assignment of underlying PC- and SC-values for each of the discerned risk issues, yet the following conclusions can be drawn:

- there is a clear distinction in the typical RQ-totals per scenario: an implementation based on the CALM router is less risky than one based on In-Vehicle Computer and Monolithic OBU.
- the differences in score are such that even a somewhat different appraisal of PC-and SC-values will not affect the sequence.

What this outcome not reflects is that the likely time frames for realization are also quite different: For the Monolithic OBU it could be a zero to five years, for the In-Vehicle Computer more likely in five years, while for the CALM router estimated are within five to seven years. Additionally cost estimates and related commercial assessments are not thoroughly addressed for each scenario, hence such assessments must a be performed separately based on relevant cost impact studies.