JRC Scientific and Technical Reports

Possible Application of Short Range Communication Technologies in the Digital Tachograph System to Support Vehicles Filtering during Road Controls

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EUR 24894 EN - 2011

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JRC65951

EUR 24894 EN

ISBN 978-92-79-20798-3 (print)
ISBN 978-92-79-20799-0 (pdf)

ISSN 1018-5593 (print)
ISSN 1831-9424 (online)

doi: 10.2788/38011

Luxembourg: Publications Office of the European Union

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Printed in Italy

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Foreword

Council Regulation (EEC) No. 3821/85 sets out the legal framework that guarantees in an unequivocal way the recording of driving time and rest periods for heavy vehicles registered since the 1st May 2006. As such this regulation provides the national road safety authorities with technical means to contribute to road safety, to assure competitiveness among road transport operators, while guaranteeing minimum social standards for professional drivers.

Notwithstanding the fact of its success – even beyond the boundaries of the EU member states – a couple of innovations have been thought at in order to modernize the underlying principles and means of control of the social legislation (Regulation (EC) No 561/2006), and are currently the object of a revision of the Council Regulation (EEC) No 3821/85, to be communicated soon to EU Council and Parliament, together with a Commission Communication which will explain how to implement these necessary changes.

Following the reports from national control and police organisations on manipulations and frauds, the proposal foresees several measures to improve the efficiency and the effectiveness of the tachograph used to ensure that professional drivers respect the rules on driving hours and rest periods.

The proposal to revise Council Regulation No 3821/85 introduces a number of novelties which will require subsequent changes in the Annex IB of the same regulation, which lays down the technical specifications of the digital tachograph. Amongst other, the proposal foresees e.g. the introduction (1) of GNSS connection facilitating the daily work of drivers and supporting the work of enforcement officers during roadside checks, (2) of remote communication devices so that enforcement officers can avoid unnecessary checks and better target the roadside checks on fraudulent operators, and (3) of a standardised interface with Intelligent Transport Systems applications that the operators may wish to use.

The Proposal also foresees to upgrade the security mechanisms which need to be enhanced in order to continue to guarantee a high level of security and avoid fraud and tampering of the data recorded by tachographs.

The present report summarises the outcome of an initial feasibility study carried out by Rapp Trans AG, Basel, Switzerland, in close collaboration and under the supervision of the JRC. In particular, the report focuses on the possible use of a tachograph augmented with short range communication features.

Executive Summary

The Tachograph is a regulatory instrument to enforce the application of social regulations in road transport especially with the view to increase road safety. It records the **work and the rest times** of drivers as well as the **vehicle speed** over time with the aim to ensure that appropriate rest periods are taken by drivers and that a maximum of permissible speed is not exceeded.

Despite the mandatory installations of Tachographs, **driver fatigue still accounts for 20% to 30% of accidents in heavy vehicles traffic**. Under certain conditions, such as night time driving and in tunnels, up to 50% of accidents are attributable to drowsy or sleeping drivers. Accidents caused by driver fatigue tend to be of especially high severity since drivers do not or only react late by breaking or with other mitigation measures.

The original and prime functionality of the Tachograph is to document, i.e. to record the driving history of a driver and his vehicle. **Usually controls are rather inefficient**. A road-side inspection needs to flag a random sample of heavy vehicles down, park them, ask for a download of the Tachograph data on a chip-card and then analyse them. Throughput at a control site is very low. By its very nature, the Tachograph has been designed as an accurate recorder of driving history but not as a compliance device. In this respect, the Digital Tachograph and its analogue predecessor are alike.

The Digital Tachograph is mandatory equipment for all liable vehicles registered after 1st May 2006. Its specifications are laid down in Council Regulation No 3821/85. Currently the European Commission is revisiting these specifications and looking into potential areas for improvements.

One such potential improvement in an **amended specification** might be to furnish the Digital Tachograph **with short range communication capability**. This would allow control personnel that do checks on free-flowing passing vehicles at road side to interrogate them. Such a wireless interrogation of the Tachograph of a passing vehicle would supply information that would **assist control personnel to decide whether or not to stop the vehicle** for a more extensive check.

This report has reviewed available short range communication technologies and has identified CEN DSRC technology as best suited for this purpose. It is proposed that road side installations can interrogate the Tachographs in passing vehicles with this technology and obtain a set of data that would allow the control personnel to judge whether or not it wants to stop and inspect the vehicle.

The proposed short range communication would support control personnel in order to **increase efficiency and throughput of control operations**. The decision on which vehicles to check and which exact cases mean an infringement remains with sworn officers. The DSRC read out function cannot be used to build fully automated checking stations comparable to speed cameras. It is a filtering and support functionality only.

Proposed data to be communicated are taken out of the existing data catalogue for the Tachograph, such as current time, vehicle licence plate, latest card event, current continuous driving time and place where the daily work has begun. No new data is proposed.

The benefit to cost ratio is expected to be excellent, both for the vehicle owner who benefits from **being left unbothered in case he shows no signs of infringement** and for the road authorities who would enjoy a **ten-fold increase of checking efficiency**. The general public would benefit from increased road safety, for comparably low investments. Synergies with other applications, such as the enforcement of toll payments, do exist.

Implementation could be achieved in three to four years time from a technical point of view. Work on validating the technology proposal and on specifying and standardising the DSRC communication could commence immediately after the basic measure has been agreed.

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1 Rationale and scope

1.1 Background

The Tachograph is a regulatory instrument supporting road safety and the application of social regulations. It records the work and rest times of drivers and vehicle speed over time with the aim to ensure that appropriate rest breaks are taken by drivers and that maximum permissible speed is not exceeded. Tachographs have been in use for this purpose in Europe since the 1950s. Today the Tachograph is mandatory equipment for heavy vehicles and buses and for commercial vehicles like taxis in all Europe.

The **Digital Tachograph** is mandatory equipment for all liable vehicles registered later than 1st May 2006. Its specifications are laid down in **Annex IB** of Council Regulation No 3821/85 [Tachograph Regulation]. Currently the European Commission is revisiting these specifications and looking into potential areas for improvements.

One such potential improvement in an **amended specification** might be to furnish the Digital Tachograph with a **short range communication capability**. This would allow control personnel that do checks at road side to interrogate passing vehicles. Such an interrogation of the Tachograph of a passing vehicle would supply information that would assist control personnel to decide whether or not to stop the vehicle for a more extensive check.

This “filtering” of passing vehicles **would greatly improve efficiency**. Commercial vehicles would benefit from being checked in free-flowing traffic without being stopped or slowed down, unless control personnel see sufficient reason from remotely interrogating the Tachograph to flag down and arrest the vehicle. Control personnel would benefit from being able to have far higher throughput when setting up a checking point since vehicles only need to be stopped and analysed in more details where there is certain minimum evidence for non-compliance.

1.2 Scope of document

This report investigates feasibility aspects of equipping an amended Digital Tachograph with a short range communications capability for filtering vehicles during road controls.

Specifically, the report

- **sketches the concept of filtering** vehicles in road side controls for improved efficiency,
- **analyses** the **requirements** for a filtering application utilising short range technologies,
- **reviews** suitable short range communication **technologies,**
- **describes a suitable technological solution** in details,
- and **investigates** aspects related to **practical implementation**.

This report is an **initial feasibility study** that shall inform decision makers on the reasons speaking in favour of amending the Tachograph with short range communications capabilities, and on the implications and consequences of doing so. The report does not provide for a full specification but merely lays down principles and recommends elements to be included in the way forward.

2 The Digital Tachograph context

2.1 The Digital Tachograph

Driver fatigue in commercial vehicles is a major source of accidents. Legislation sets limits on the allowed driving times and defines minimum rest times between consecutive trips. The data recorded by the Tachograph are used by enforcement authorities, usually the police, to ensure compliance. Europe has a long history of using the Tachograph as a means to increase traffic safety. The Tachograph is mandatory for most commercial vehicles, including heavy vehicles above 3.5 tonnes and for buses carrying more than 9 persons.

Until a few years ago Tachographs have been **recording working hours and speed** on paper disks that were constantly turned by a clock mechanism. Speed is taken via a connection of the Tachograph to the gear box of the vehicle, in early days by a mechanical link, later by electrical pulses. In recent years the counting of pulses and the calculation of speed has developed from analogue electronics to a digital process, but regardless of the inner workings the recording media remained the paper disk.

The recording on disks was comparatively easy to fraud, so the interest grew to move to an all-digital device – the “Digital Tachograph”. The Digital Tachograph no longer records by writing on a paper disk but stores data in digital memory, which can be read out on smart cards.

Council Regulation No 3821/85 [Tachograph Regulation] and later amendments define the recording equipment that has to be installed in liable vehicles. The Tachograph Regulation defines two types of equipment, namely the **Analogue Tachograph in Annex I** and the **Digital Tachograph in Annex IB**. The Digital Tachograph supersedes the Analogue Tachograph and is mandatory equipment in all liable vehicles registered after 1st May 2006 according to Regulation (EC) No 561/2006 [Social Regulation].

The Digital Tachograph has mainly been a technological improvement over the Analogue Tachograph. Otherwise, **both types of Tachograph provide for essentially the same functionality** – as can be seen by the fact that the main part of the Tachograph Regulation equally applies to both types of equipment. Insofar the Tachograph Regulation does not make use of the additional capabilities that are offered by digital equipment.

Currently the **specification of the Digital Tachograph is being revisited** and specific improvements are being investigated, in order to enhance security, user friendliness and efficiency. One of the features that might be introduced in an amended Tachograph Regulation is a **short range communications capability**. Such a capability would allow control personnel to **interrogate from the road side** vehicles that are passing a control station **without interfering with traffic flow**. Such an interrogation would transmit summarising information about the current status of the Tachograph in a passing vehicle wirelessly via a short range radio link to the control personnel. This information would provide the personnel with intelligence whether or not a vehicle needs to be stopped for deeper analysis.

2.2 Recording and checking

The current Digital Tachograph is in its basic functionality equivalent to the Analogue Tachograph, which by design is recording equipment. The original and prime functionality of the Tachograph is to document, i.e. to record the driving history of a driver and of a vehicle. The Analogue Tachograph did the recording on paper, the digital successor does it on a digital medium, namely on digital memory inside the Tachograph and on smart cards inserted into the card slots of the Tachograph. The concept of recording on paper stems from measures that preceded even the Analogue Tachograph, namely handwritten manual records of work and rest hours (which are still in use, e.g., in Australia as the standard means of demonstrating compliance with the social regulations in road transport).

Hence since the early times the **paradigm** regarding compliance with work and rest hours regulations **has been mere recording**. The records are legally recognised documents that serve the purpose to allow authorities to check them for compliance with the regulations. Insofar even the latest Digital Tachograph is designed as a secure recorder and not as a device facilitating compliance checking. Also with the Digital Tachograph, compliance checking remains a cumbersome, inefficient process. Compliance checking is either done by scrutinising the records of the drivers or vehicles of a company by inspection at their premises, in a back office process, or by checks that are done directly at a vehicle, in a road side process.

The checks at back office serve the purpose to stop companies from infringing regulations repeatedly. Although such checks can be supported with tools that improve efficiency, like software to evaluate the digital records, the process remains time consuming and inefficient. Nevertheless it is the only conceivable measure to identify companies that infringe regulations as a matter of business principle.

Checking vehicles at road-side locations has an additional purpose. While back-office checks can only be done *post-factum*, i.e. after the infringement has occurred, road-side checks are done with life traffic, and offenders can be stopped from driving on. In terms of traffic safety it is certainly more desirable to stop an overtired driver from continuing his trip than to fine him for an offence several months later in a back-office check. Unfortunately, road-side checks are highly inefficient and cumbersome. Vehicles need to be pulled out of traffic and be fully stopped for inspection. The inspection takes several minutes since the control personnel has to interact with the driver, has to ask for the provision of data on chip cards or on paper, and then has to analyse the data regarding compliance with the rather complex regulations.

It takes a long time and several people just to find, **in the overwhelming majority of cases,** that **everything is fine**. The effort of taking a vehicle out of moving traffic and investigating the records for a prolonged period of time is certainly justified in case there is a high likelihood of an offence. It is difficult to justify such an effort on the authority's side and also such strong interference with the transport business for the large majority of compliant drivers and vehicles.

2.3 Efficient road-side checks with filtering

Road-side checks would become by orders of magnitude more efficient if only vehicles would need to be stopped and analysed in details where there is sufficient initial evidence that there might be an infringement of the Social Regulations.

Such evidence could be obtained by directly interrogating the Tachograph of a passing vehicle from the road-side without stopping the vehicle. All that is needed for this purpose is a radio connection between a road side antenna and the Tachograph to transfer some basic information about the status of the Tachograph (e.g. "Is the Driver Card inserted?") and about likely infringements (e.g. "Has there been an overtime warning to the driver?"). This minimum information would allow control personnel to filter out vehicles that have a higher likelihood than others to be infringing regulations, thereby greatly improving efficiency in the subsequent detailed check. The detailed check would be performed like today, i.e. by flagging the vehicle down, pulling it over to a suitable place for parking, and then inspecting the Tachograph records in detail. The only thing that changes is efficiency, since vehicles where the filtering short range radio interrogation shows little reason to justify an extensive check do not need to be bothered and can continue their trip unimpeded (unless the control personnel decides otherwise).

Benefits of this "pre-filtering" approach would be:

- **Control efficiency** is increased: Control personnel will be able to **focus on cases worthy of attention** instead of extensively checking a mass of vehicle than are compliant anyway.

- **Compliant drivers are not bothered**: Vehicles are only stopped in case of minimum evidence pointing towards a potential infringement; compliant vehicles continue their trips in free flow without being stopped or slowed down.
- Higher efficiency means **higher throughput**: Control personnel can only take a few vehicles out of the traffic stream, resulting in a very low inspection density. With the proposed pre-filtering approach, throughput is enhanced by orders of magnitude.

A short range communications capability would make the Tachograph not only a recording equipment but also a compliance device. Such a **change in paradigm towards efficient checking would greatly strengthen the importance of the Tachograph as a central measure supporting traffic safety**.

A simple example: Traffic safety in tunnels through the Alps

The Alps have a number of long tunnels that are frequented by heavy vehicles in North-South goods transport. Temperature inside the tunnels is high due to the geothermal energy streaming out of the rocks. Roads climb up the mountains for many kilometres before the tunnels start. Driving such roads with heavy vehicles is challenging and tiring.

Under these circumstances, driver fatigue is critical. Driving long narrow tunnels with large vehicles requires high attention. The strain of the climb and the warmth in the tunnel easily make drivers drowsy and often lets them go in and out of microsleep. In this situation accidents occur frequently. Tunnel accidents often have severe consequences, potentially killing many vehicle occupants especially in case of fire, but in any case severely interrupting traffic on those sensitive arteries of European transport.

Today little can be done in a systematic way against driver fatigue at such critical pieces of road infrastructure. Only a few vehicles can be inspected per hour, and chances are slim of stopping an overtired driver before he enters into a dangerous situation.

In case the Tachograph would have a filtering short-range communications capability as proposed, drivers in breach of the work and rest time regulations could be identified and stopped already at the ramps leading to the tunnel, without bothering the mass of compliant ones. Traffic safety in tunnels would be greatly enhanced.

3 Requirements of road controls

A pre-filtering functionality as proposed requires the Tachograph to have a short range radio interface for communication with road side controllers. Many technological options exist for such an interface, but not all will be equally suitable for this special purpose. This chapter establishes the requirements of the pre-filtering application regarding a short-range communication technology. Later chapters will review available technology and asses their suitability in view of the requirements of this chapter.

The exact processes on the road will vary between different environments – different countries will have different procedures, and different road types will need slightly different approaches. Nevertheless it can be expected that the basic process is as follows:

- In a first step, **passing vehicles are interrogated** via a short-range radio link between road-side equipment and the Tachograph.
- Only a **minimum amount of data is transmitted**, giving an indication of likely infringements. It is not intended to transmit large volumes of data, such as the history of the driver or the vehicle. The focus of attention is the current status of the Tachograph, not the history.
- A simple **display** device **at the road-side** shows the data to the enforcement personnel, highlighting irregularities and potential issues with regulations.
- The **enforcement personnel decide** whether or not to bring the vehicle to a stop at a place down the road. Note that the data transmitted via short-range radio only informs the personnel. The decision whether or not to check a vehicle remains with the control personnel as practised at present.
- Down the road, the **vehicle is identified and stopped**. The control is executed the same way as today.

One important requirement in order to set up such a process is that **it has to be clear which vehicle is in communication with the road-side equipment**. It has to be clear where the data is coming from, namely from the vehicle being aimed at, not from the one in front or behind, not from the vehicles overtaking on the other lanes, and also not from the ones travelling in the other direction.

Also, the communication has to take place with high reliability and security **under all traffic conditions**, from slowly moving queues to single speeding vehicles.

Naturally, **low costs** are also a central issue. The costs of incorporating this added feature into a next generation Tachograph should not lead to a noticeable price increase. Costs of the road side equipment are less sensitive since it will be installed in much smaller numbers, but in any case there should be a favourable costs-to-benefits ratio, namely between the costs of the filtering equipment and the benefits gained from more efficient operations of the control.

The following Table 1 establishes the requirements the proposed road control application poses to suitable short range radio technology.

Requirement	Justification
Communication distance 10-20 meters	Communication should be possible both from an overhead antenna mounted on a gantry over the road and from a road-side antenna mounted on a parked vehicle or on a tripod on the road banquet.
Narrow communications zone	The communication technology needs to allow pointing towards a vehicle. It has to be certain with which vehicle the communication is conducted. The vehicle needs to be clearly identified.
Vehicle speed up to at least 100 km/h	Compliance checking has to work with all commonly encountered vehicle speeds. Since the Tachograph also applies to certain light commercial vehicles such as taxis, speeds up to 200 km/h ideally should be

	managed, with 100 km/h as a minimum requirement for heavy vehicles.
Communication in multi-lane free-flow traffic	The interrogation shall not interfere with the free flow of traffic and shall especially not require that the traffic is constrained to certain lanes or speeds or in any other way. Lane changes, driving between lanes, etc. has to be supported.
Communication reliability in excess of 99.5%	Vehicles where no communication occurs or communication is interrupted will, in a distant future where all vehicles would be equipped with short range capabilities, be considered to be suspect and be pulled aside. This should occur only exceptionally.
Secure transmission protocol	The communication protocol has to ensure that data are transmitted correctly and cannot be falsified.
Privacy of transmitted data	It has to be ensured that only authorised persons can interrogate the Tachograph and access its data.
Free radio frequency	Radio frequency and transmission power need to be open for usage without special license.
Low cost in-vehicle device	The in-vehicle interface required for the communication shall not increase the price of the Tachograph noticeably.
Open standardised technology and protocol	Communication should not rely on proprietary technology but be based on an open and standardised radio link.
Well developed market	The technology needs to be readily available from many sources in an open, well established market.

Table 1: Requirements for short range technologies

4 Suitable short-range technologies

4.1 Introduction

This chapter investigates the suitability of known short range technologies for the proposed application of filtering vehicles for road controls by interrogating the Tachograph. Several radio technologies exist for wireless data transmission. A very good review regarding their characteristics and suitability for use in a vehicle environment has been done in a research project sponsored by the European Commission DG TREN, namely the project EVI, “Feasibility study on Electronic Vehicle Identification” [EVI Del. 3]. This chapter uses material from the EVI project, enhanced with additional sources and updated with more recent developments.

4.2 RFID

RFID stands for Radio Frequency Identification. This term summarises a wide range of technologies mainly used for tagging and tracking items (tagging freight containers, farm animals, books in a library) and for contactless smartcards. When applied to vehicles, the technology is often referred to as AVI (Automatic Vehicle Identification).

The data carrying element is generally known as tag. When a tag passes the electromagnetic field of a reading device, the tag will wake up and data will be transmitted wirelessly from tag to reader. All types and flavours of tags have been developed for different applications, from very cheap passive devices to prevent articles from being stolen in retail stores to sophisticated contactless payment cards that can both read and write payment information via a cryptographically secured protocol. RFID tags often require no power of their own but are powered from the electromagnetic field of the reader, which strongly limits operational range.

For RFID two basic frequency ranges with very different characteristics can be distinguished [RFID Handlungsbedarf]:

Frequencies below 30 MHz
Tags in this frequency range are used for access control, electronic article surveillance, identification of goods and animals and for proximity cards. RFID in this frequency range is not suitable for the Tachograph since reading distance is very small, from a few centimetres up to about 1 meter. In addition, this frequency range does not permit pointing a beacon of radiation onto a specific area, since with normal size antennas the radiation will be unfocussed and transmitted and received omni-directionally.

Frequencies above 30 MHz:
Here mostly 4 frequency ranges are employed since they are categorised by the radio frequency regulators ITU (globally) and CEPT/ECC (Europe) as licence free under certain power and spectrum limitations:

- 433.05 to 434.79 MHz range: Readers are low power (below 10 mW) with a reading range of up to a few meters. Low reading distance and low pointing accuracy make this range unsuitable for the Tachograph application.
- 865 to 868 MHz range: Readers my have larger power and reading distance is about 6-8 meters. Reading distance and pointing accuracy are insufficient for the Tachograph.
- 2446 to 2454 MHz range: This is the ISM band used e.g. by microwave ovens. Tags are also using this frequency range and have been used for road usage tolling in the past. In principle this frequency band is suitable for the Tachograph application, but has been superseded by the 5.8 GHz

and 5.9 GHz bands, where both a number of standards and a wide industrial basis with a broad range of products exist.

- 5.8 GHz and 5.9 GHz bands: See below for details. In these bands standards have been developed for road applications like electronic fee collection, vehicle-to-infrastructure and vehicle-to-vehicle communication, making these bands very attractive for the Digital Tachograph road control filtering application. See CEN DSRC (5.8 GHz) and CALM M5 / ITS G5 (5.9 GHz) below for details.

RFID technologies are generally unsuitable for the envisaged Tachograph application because of insufficient reading range and low pointing accuracy, with the exception of the bands above 2 GHz frequency.

Reading range increases and pointing accuracy increases with frequency, making the 5.8 GHz and 5.9 GHz ranges well suited for the application in mind. In these frequency bands standards for road applications exist, and are treated below under the headings CEN DSRC and CALM M5 / ITS G5, respectively.

4.3 DECT

DECT (Digital Enhanced Cordless Communication) is a standard that has been developed for cordless telephones with a range between the base station and the telephone receiver of up to 300 meters. DECT has become a wide-spread technology and a wide range of components is available.

In Europe, DECT works in the frequency band between 1800 MHz and 1900 MHz. Communication range can be up to 300 meters in free space and is between 30 and 50 meters in buildings, which is more than sufficient for the Tachograph application. Pointing accuracy would be low, requiring large antennas with about 1 meter in diameter in order to pinpoint to a specific vehicle.

DECT can be used in a mobile way but the allowed speed of movement does not exceed walking speed, i.e. no more than about 10 km/h. In addition, the DECT standard [ETSI EN 300 175] has been developed in the first place for cordless telephony. Simple data transmission can be implemented but standardisation stops at the transport layer. Standard data transfer protocols are not suited for the Tachograph application in mind. It is not possible, e.g., to wirelessly connect an in-vehicle device to a road-side station for a session. The DECT protocol rather foresees a permanent pairing between communication partners and not a quick ad-hoc connection.

DECT cannot cope with normal vehicle speeds. There is also no protocol that allows establishing an ad-hoc connection between a passing in-vehicle device and a road-side interrogator.

4.4 WLAN, HiperLAN, Bluetooth

In order to increase mobility of computers and flexibility of network access, data communication technologies for wireless local area networks have been developed, namely the American IEEE 802.11 (usually known as WLAN or Wi-Fi) and the European HiperLAN standards. Bluetooth is a standard for connecting various equipment wirelessly without the full network capabilities of the wireless LAN standards.

These wireless LAN communication standards work in free bands in the 2.45 GHz and 5.15–5.725 GHz frequency bands. Communication distance and pointing accuracy would be sufficient for the Tachograph application in mind.

These technologies are optimised for large-bandwidth data transmission between essentially static equipment. Neither of these technologies is suitable for high-speed vehicle applications. The transmission protocols cannot connect quickly enough and cannot handle the high power dynamics encountered in communications between road-side and in-vehicle equipment.

WLAN, HiperLAN and Bluetooth technologies cannot support communication with vehicles at high speed due to timing constraints.

4.5 Mobile communications (GSM, GPRS, UMTS)

Digital mobile communications technologies such as GSM(-DATA), GPRS and UMTS are widely used for data communications. Based on these technologies cellular radio networks with nation-wide coverage have been realised. Various frequency bands between 700 MHz and about 2.7 GHz are being used.

Equipment for these mobile communication technologies is readily available but costs for the in-vehicle part of the communication would be around € 100. In fact, these technologies are far too capable for the application in mind, namely transmitting a few bits of information over a few meters. The standards rather address the problem of transferring several Mbits in a session into the global data networks.

Pointing accuracy would be a problem with these technologies. Only in the highest frequency bands antennas that produce a narrow beacon would be sufficiently small to become practical. Indeed, for the UMTS technology the concept of a nano-cell has been introduced, where communication cell size is sufficiently small to enable pinpointing to a specific vehicle.

Common vehicle speeds do not create problems for mobile communication technologies as such. Problems arise rather from the protocol. Setting up and terminating a session cannot be done within a few milliseconds, and also not in an ad-hoc point-to-point fashion.

Mobile data communication technologies have been designed for a different purpose and the protocols do not support ad-hoc connections between a road-side interrogator and a passing vehicle.

4.6 CALM

CALM originally stands for “Continuous Air interfaces - Long and Medium Range”. Since about 2007 the abbreviation stands for “Communications Access for Land Mobiles”. CALM is a kind of umbrella standard that supports several different media.

The CALM series of standards has been created and is maintained by ISO TC 204/Working Group 16 (see http://www.isotc204wg16.org). CALM defines a set of wireless communication protocols and air interfaces for a variety of communication scenarios spanning multiple modes of communications and multiple methods of transmissions in Intelligent Transportation Systems (ITS). The CALM architecture is based on an IPv6 convergence layer that decouples applications from the communication infrastructure. A standardized set of air interface protocols is provided for the best use of resources available for short, medium and long-range, safety critical communications, using one or more of several media.

Several access technologies are supported, amongst them cellular mobile communications (e.g. GPRS, UMTS), infrared communications (CALM IR), 5 GHz wireless LAN systems (CALM M5) and 60 GHz systems.

CALM as such is not suitable for the envisaged Tachograph application, since it is a large series of standards that include, e.g. a management layer for handover between media. In CALM, a communication session may be started using one medium and seamlessly be handed over to a second medium in the same session.

Nevertheless, under the CALM umbrella two communications media have been standardised for road-related use that are of high interest for interrogating the Tachograph, namely CALM IR and CALM M5. These two short range technologies are dedicated to point-to-point communications specifically in the area of ITS. Short range technologies that are dedicated to specific application domain are known as “Dedicated Short Range Communications” or DSRC. Available DSRC technologies are investigated in the next sections.

CALM is an umbrella of standards for managing multiple media. As such, CALM cannot be applied for the Tachograph application in mind.

Individual media under the CALM umbrella, namely the DSRC technologies CALM IR and CALM M5, are suitable communication technologies and treated below.

4.7 Infrared DSRC (CALM IR)

Communication using infrared light is well known from TV remote controls, but it is also used in professional commercial applications, such as for tolling (e.g. in Malaysia and Korea) and for compliance checking purposes (in the German heavy vehicle tolling system).

Infrared light as a carrier medium has many advantages. The use of infrared light does not require a license. Almost any operating distance can be accomplished. Also data rates can be very high if required.

Infrared light requires a free line of sight. For the application in mind this does not present a problem. Conditions of snow, dirt and fog strongly reduce the signals, but today this can be handled automatically by adapting the transmission power. In the past strong background light such as sun shining directly into the receiver has also been a problem. This has also been overcome by managing the power budget of the communication link.

A distinct advantage of infrared technology is that communications zones can take any required shape by appropriately masking the infrared beams, creating light and shadow zones.

Standards are available for infrared short range communications that are specifically intended for road usage. The best developed standard regarding infrared DSRC is known as CALM IR [ISO IS 21215].

CALM IR fulfils all functional requirements of road controls established above (see Table 1), only the market is little developed. Few products are available and consequently prices are high (€50 - €100). IR products have not seen mass deployment and remain in certain niches.

Infrared DSRC, especially according to the CLAM IR standard, is functionally fully suitable for remotely reading out the Digital Tachograph. Drawbacks are a lack of a developed market for products and little practical deployment.

4.8 CEN DSRC (5.8 GHZ)

CEN DSRC is a communication standard developed by the European Standardisation Organisation CEN specifically for application in ITS. CEN DSRC supports communication over a limited distance, up to about 30 meters.

CEN DSRC operates in the 5.8 GHz range. Two bands are defined, namely a lower band at 5.795-5.805 GHz and an upper band at 5.805-5.815 GHz. The lower band is free for use in all Europe and supports two separate channels. The upper band provides for two more channels, but requires national approval and release. CEN DSRC offers a downlink bit rate of 500 kbit/s and an uplink rate of 250 kbit/s, which is amply sufficient for the purpose in mind.

Pointing accuracy is very good. Typical communication footprints on the road surface are about one lane wide and 8-10 meters long.

This DSRC standard has been optimised for high volume application in vehicles focusing on low costs of the on-board equipment. A CEN DSRC communication interface can be produced for about €10, in high volumes (more than 100 000 pieces) for as little as €5 per piece or even less. Low costs are achieved because CEN DSRC on-board equipment does not contain an active radio transmitter. The on-board equipment does not generate radio signals independently. The energy for the answering radio signal is obtained from the received road-side signal. CEN DSRC on-board equipment acts like a mirror that reflects back the road-side signal, and adds information by modulating the reflected signal.

CEN DSRC is accepted in all European countries and has found widespread deployment for tolling applications. Moreover, CEN DSRC is one of the three technologies supported by Directive 2004/52/EC [EETS Directive]. The EETS Directive requires Member States of the European Union to make their electronic road usage fee collection systems interoperable such that users can move throughout Europe using just one "toll collection box" and only one contract. This interoperable Europe-wide service is known as "European Electronic Tolling Service", EETS. The EETS Directive defines the framework of this new service, and an associated regulation, Commission Decision 2009/750/EC [EETS Decision], defines further details.

For the EETS three technologies are prescribed, namely GPS for localisation, GSM/GPRS for wide area communications and CEN DSRC for short range communications. The new service shall be operational from 8th Oct. 2012 for heavy vehicles (3 years from issuing the EETS Decision) and from 8th Oct. 2015 for light vehicles.

There is a well developed marked for CEN DSRC equipment with heavy competition. All manufacturers of CEN DSRC equipment need to be registered according to a procedure defined in EN ISO 14816. The register currently lists about 30 manufacturers, see http://www3.nen.nl/cen278/. Large numbers of DSRC on-board equipment have been deployed in Europe, but also in Australia, most Asian countries, most South American countries and several countries in Africa, plus systems in the US and Canada. Charging systems with more than 1 million pieces of CEN DSRC equipment issued to users are, amongst others, Austria, France, Norway, Portugal, Spain and Turkey. Also the nation wide heavy vehicles systems in Czech Republic and in Switzerland are based on CEN DSRC. Further installations in Europe are e.g. in Greece, Ireland, Italy, and on the bridges over the belt.

CEN DSRC components are readily available thanks to mass deployment in tolling. The legal support of the technology on a European level as one of the pillars of the coming interoperable tolling service EETS will lead to an even wider deployment in the future. This legal support will also ensure a certain minimum lifetime of the technology with little risk that it quickly becomes superseded by new developments.

CEN DSRC is fully suitable for the filtering application for the Digital Tachograph. It is also well supported by a competitive market and is a mandatory part of the upcoming interoperable European tolling service EETS.

4.9 CALM M5 and ITS G5 (5.9 GHz)

CALM M5 is an extension of the 802.11 family of standards for wireless LAN specifically covering the requirements of ITS. More concretely, CALM M5 is the ISO 21215 standard that incorporates WAVE, which is the IEEE 802.11p wireless LAN standard, and adds certain management functions and the European spectrum allocation.

Loosely speaking, people often refer to CALM M5 as “five point nine”. In August 2008 the European Commission allocated part of the 5.9 GHz band for priority road safety applications, inter-vehicle, and vehicle-to-infrastructure communications [ETSI EN 302 571]. The European variant of CALM M5, with the European frequency allocation and frequency channel definitions, is standardised in ETSI, by TC ITS WG4 (“Media & media related”). This special European communication profile is known as “ITS G5”. Vehicle-to-vehicle and vehicle-to-infrastructure ITS applications in Europe are standardised on the basis of ITS G5 in cooperation of CEN and ETSI.

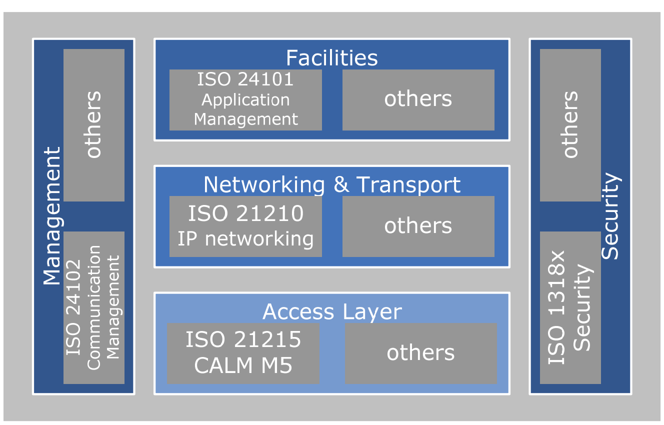

Figure 1: Architecture of CALM M5 / ITS G5

The communications stack of CALM M5 or ITS G5 is shown in Figure 1. The physical medium (carrier frequency, channel definitions, access control, etc.) is defined in an access layer. Communication bandwidth is high, 6 MBit/s by default, by far surpassing the requirements of the

Tachograph. The higher layers of the communications stack are a networking and transport layer based on IPv6 and a facilities layer that contains basic functionality to support applications. Communication management and security are defined in standards that cover the complete communications stack.

This technology is specifically **designed to support cooperative ITS applications**, i.e. safety critical applications in traffic management and control with vehicle-to-vehicle communications (V2V) and vehicle-to-infrastructure communications (V2I). This is an area of rapid development and high interest from the industry. It is expected that deployment of cooperative systems will lead to more intelligent traffic, where vehicles have knowledge about their immediate surroundings and about other traffic participants, which can improve support for the driver and can help to manage dangerous traffic situations.

Typical **communication distance is "mid-range"**, i.e. several 100 meters. One of the first application that has been specified is the broadcast of a Cooperative Awareness Message, CAM. Every vehicle broadcasts an awareness message about 10 times a second, consisting of the vehicle position, the type of vehicle and (optionally) vehicle heading, brake status, wipers status, etc. This allows other vehicles to become aware of the traffic situation in their immediate vicinity, and also the road side infrastructure to have detailed traffic information for management purposes. Protocols are also developed to support geo-routing, where messages hop from vehicle to vehicle, creating a kind of ad-hoc network, until the receiver of the message is reached.

CALM M5 or ITS G5, respectively, have not been developed for DSRC applications, i.e. for pointing at a single close communications partner, but rather for mid-range broad-cast type of applications. Nevertheless, in the United States CALM M5 is foreseen as the basis of a future interoperable tolling service. Products for tolling applications are being developed for the US market, although it turns out that restricting the communications range to a lane width, as is required e.g. in a barrier controlled classical toll plaza, is challenging. With CALM M5 / ITS G5 also the in-vehicle unit is an active transmitter which results in far **larger communication areas compared to a typical DSRC technology**. Especially reflections from objects in the foreseen communications zone may carry the signals over unexpectedly long distances, making pointing to a single vehicle difficult to achieve. Actually, for the purpose of a typical DSRC application, CALM M5 / ITS G5 is far too capable.

CALM M5, or actually for Europe ITS G5, is a very powerful communication technology, fulfilling the requirements for the Tachograph application that have been defined above, with some limitations regarding the pointing capability. Communication range and data rate of ITS G5 are far higher than what is required for the envisaged Tachograph application.

Few standards on application level, like the CAM broadcast application are available at the moment, but are currently being developed for European purposes in cooperation of the standardisation organisations CEN and ETSI. Applications that are on the horizon are all aiming at mid-range message exchange, and not at bi-directional DSRC type of communications. There are also no generic application layer commands defined, like the commands for "read", "write", or "initialise communication" as are defined for the CEN DSRC communications stack, see below.

The market for ITS G5 based products is not yet fully developed. Only a few devices are available at the moment. One has to recognise that ITS G5 is a very recent development, e.g. the approved 802.11p amendment was published on 15th July, 2010 (see the timeline of the group developing this standard, http:// grouper.ieee.org /groups/802/11 /Reports /802.11_Timelines.htm).

Ultimate costs of ITS G5 components are hard to predict since volumes are still small. Currently ITS G5 interfaces would amount to about €100, but this figure is almost meaningless because there is no mass market developed yet. It is expected that at least for Europe, "five point eight", i.e. CEN DSRC and "five point nine", i.e. ITS G5 will be deployed side by side. In Europe CEN DSRC will most likely remain the technology of choice for tolling related applications, not the least because of the support by the EETS legislation[1]. ITS G5 is expected to become the base technology for cooperative systems based on V2V and V2I communications.

Since ITS G5 is based on WLAN technology, it might be tempting to use ITS G5 also for in-vehicle communications. In case the Tachograph will in the future make data available also to other in-vehicle components, it would require having an in-vehicle communications interface, be it wired or wireless. Although based on a WLAN standard, ITS G5 does not support such in-vehicle applications.

ITS G5, the European development based on CALM M5, is capable in principle of supporting the filtering application for the Digital Tachograph, in fact its capabilities reach far beyond what is required. Challenges arise mostly because ITS G5 is being developed for cooperative systems applications and not for DSRC type of applications. As a result ITS G5 is not easy to control such that single-vehicle pointing can be achieved, and also there are no application standards being developed in Europe that could form a basis for the envisaged Tachograph application. A mass market is not yet established but wide spread deployment is expected in a decade. Costs are still high and ultimate prices hard to predict at the moment.

4.10 Summary on technologies

The technology review provided in this chapter has shown that only technologies dedicated to traffic-related applications have characteristics making them suitable for Tachograph interrogation.

Since the communication needs to be pointed to a specific identifiable vehicle, communication frequency has to be at least 2 GHz. Lower frequency radiation is hard to form into a directional beam unless very large antennas are being used, i.e. antennas with a diameter exceeding 1 meter.

Three technologies remain which are all functionally suitable for the requirements of the Tachograph. All of them are DSRC technologies, meaning Dedicated Short Range Communications – dedicated for the specific requirements of communicating with vehicles in free flowing traffic.

Infrared DSRC is standardised as CALM IR but has found little deployment. There is no well established industrial base. It is also not expected that this situation might change drastically in the future. Hence, despite its merits, Infrared DSRC is not a recommended option for the Tachograph interrogation interface.

CEN DSRC is also functionally fully suitable for the purpose, and is being used in high numbers in similar applications, namely in tolling both for the purpose of charging and for compliance checking. Its main advantage is low cost and widespread deployment with a competitive supplier market.

ITS G5 is an upcoming very capable communications technology for road-related applications, specifically foreseen for cooperative ITS systems. Products are not yet easily available and standardisation on application level is still ongoing. ITS G5 has been developed for mid-range message exchange and poses some challenges for DSRC-type of applications.

[1] In the USA tolling is not as widely deployed as in Europe, and especially there is no framework of interoperability. It is expected that future tolling systems in USA will be based on CALM M5.

Requirement	CALM IR	CEN DSRC	ITS G5
Communication distance 10-20 meters	up to 100 m	30 m	300 m
Narrow communications zone	yes	yes	achievable with some challenges
Vehicle speed up to at least 100 km/h	all vehicle speeds	all vehicle speeds	all vehicle speeds
Communication in multi-lane free-flow traffic	yes	yes	yes
Communication reliability in excess of 99.5%	yes	yes	yes
Secure transmission protocol	possible	possible	possible
Privacy of transmitted data	possible	possible	possible
Free radio frequency	yes	yes	yes
Low cost in-vehicle device	€50	€10	€100 (to come down)
Open standardised technology and protocol	yes	yes	yes (but no focus on typical DSRC applications)
Well developed market	no	yes	developing

Table 2: Dedicated Short Range Communications technologies compared

Summarising, **currently CEN DSRC is the best choice for the Tachograph**. Standardisation is completed in all aspects, there is a mature competitive market and costs are low. Thanks to a support by European legislation for the EETS a long lifetime of the technology can be expected.

ITS G5 is a strong competitor in principle. ITS G5 is a developing technology and a concluding judgement on ultimate applicability for the foreseen purpose is not possible at the moment. Some reservations stem from the fact that ITS G5 is being developed for a range of applications that is very different to the envisaged short-range communication with the Tachograph. Since the field is rapidly developing it can be recommended to revisit the decision to go for CEN DSRC as soon the implementation agenda for the enhanced Digital Tachograph is defined and again judge the pros and cons on the background of the latest market situation.

5 CEN DSRC technology

5.1 History

CEN DSRC was developed and standardised in the late 1990s. In the mid 1990s, several flavours of DSRC in the 5.8 GHz frequency band have been developed by different companies. Specifications were close to each other but not equal. Several industrial players were each serving their niche markets and initially had little incentive to standardise the technology fully and thereby open their niche to competition.

After 1995 it became apparent that in order to achieve mass deployment and large volumes, standardisation is a must in order to provide the customers, mostly toll operators, with a competitive market and also to protect the investments made in the infrastructure. Standardisation took a long time since manufacturers were each fighting to make their own DSRC flavour the new standard. Standardisation was performed in CEN TC278 Working Group 9. The communication stack was fully standardised in about the year 2000.

Since that time the lower layers of the communication have remained unchanged, but standardisation on the higher layers has been ongoing, with new applications being defined and voted on as recently as 2010. It was originally believed that by standardising the mere communication link, interoperability would eventually be achieved. It took many years and negotiations on data contents and security features before a fully interoperable tolling application was defined in 2007 in [EN 15509]. This standard is now the basis for tolling vehicles seamlessly across national borders.

Besides standards for DSRC-based tolling, also an application standard for compliance checking in tolling systems based on satellite positioning and mobile communications has been created [CEN ISO/TS 12813]. This standard provides for **a very similar application as the one envisaged for the Tachograph**. The compliance check communication standard reads critical data out of tolling on-board equipment, such as current charging status and health status of the device.

A further application standard is [CEN ISO/TS 13141] which provides for a location-augmentation functionality. In this application, CEN DSRC messages are emitted by road-side equipment to assist GPS receivers in on-board equipment to improve their localisation result in difficult or critical situations.

The most complementary application for CEN DSRC clearly is tolling and related applications, such as access control, compliance checking and localisation augmentation. There have been attempts to use CEN DSRC also disseminate traffic information (France), to give public transport buses priority at traffic lights (Norway) and to manage the country's transit quota (Austria).

5.2 Principles and characteristics

Communication sequence

A CEN DSRC road side installation typically comprises a gantry, i.e. a bridge construction over the road, where so called DSRC beacons are mounted; see for example Figure 2. The beacons continuously emit a signal, asking upcoming on-board equipment (OBE) to connect.

Several times per second beacons emit a short message, the Beacon Service Table (BST). This message identifies the application of the beacon ("Electronic Fee Collection", "Compliance Checking", or in the envisaged case "Tachograph Interrogation") and whether the application is mandatory or not. A beacon service table can contain several application identifiers, since one beacon can conduct several applications in parallel with a single passing vehicle.

Upon reception of a beacon service table, the on-board unit of a passing vehicle will wake up and respond. Note that most CEN DSRC on-board units are powered from an internal battery that is sealed into the equipment and keeps it operational for about seven years. For this reason, DSRC on-board units are normally asleep and only woken up for usually less than a second to perform a tolling transaction.

Figure 2: Heavy vehicle passing a DSRC gantry

In the response to the beacon is the Vehicle Service Table (VST), where the on-board unit offers a communication address for the session and presents the applications it has available, for the beacon to choose.

After exchange of BST and VST the communication is established. The beacon can from this moment on individually address a single on-board unit in case there is more than one in the communication zone. After BST-VST exchange also link security is initialised, enabling both sides secure communication, with access control and authentication of messages.

CEN DSRC standards offer a number of basic services, such as “read”, “write”, “read with authenticator”, “signal OK on the HMI”, etc. A DSRC session comprises a succession of message exchanges, where a single message may contain more than one command. When the transaction is finalised, the beacon closes the session and releases the on-board equipment, which may fall to sleep again in order to save power.

The road-side equipment (RSE) remains the master throughout the whole communication session. The on-board equipment is the slave, and cannot become active, e.g. requesting data or sending commands is not possible for the on-board equipment.

Communication zone and duration

A communication zone is typically one lane wide (about 3 meters), but can be made wider if desired. Zone length is typically 10 meters at the height where the on-board equipment is mounted. Vehicles at 100km/h will pass the communication zone in about 350ms (milliseconds). A typical DSRC transaction lasts less than 50ms, even with several re-tries should bit-failures occur in transmission. This gives ample safety margin even for vehicles at higher speed.

Radiation levels

As mentioned above in the section on technologies, the DSRC on-board equipment is passive in a radio sense, i.e. it has no own source of radio energy. It is a mere reflector of the signals received from the road-side. Besides saving costs this has the additional advantage that there is no source of electromagnetic radiation in the vehicle cabin, making fears about possible health effects obsolete. Also the power emitted by the road-side beacon does not pose a health hazard. The emitted power is

2 W EIRP in main beacon direction, which is comparable to the emission generated by a usual cellular phone – with the notable difference that a cellular phone is held close to ones head, while a DSRC beacon is overhead several meters way, reducing radiation density by orders of magnitude. Since the beacons only emit into a narrow angle, total power is far less than the EIRP value suggests, typically less than 100mW.

5.3 CEN DSRC link Standards

Overview

The CEN DSRC communication link is defined in a number of standards according to the different layers of the communication. Figure 3 shows the architecture of the CEN DSRC communication link.

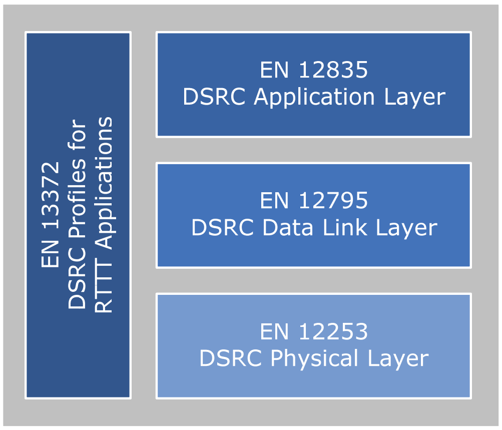

Figure 3: Architecture of the CEN DSRC communication stack

Physical layer

The physical communication layer is defined in [EN 12253]. The main characteristics of the physical radio link are:

- Two carrier frequencies in the 5.9 GHz ISM band (5.7975 GHz and 5.8025 GHz)
  two further channels can be allocated on a national basis (5.8075 GHz and 5.8125 GHz)
- Bit rate: 500 kbit/s download (RSE to OBE), 250 kbit/s upload
- Maximum transmitter EIRP: 2W
- OBE is passive, reflecting the carrier frequency of the RSE modulated with a sub-carrier generated by the OBE

Data link layer

Medium access and logical link control is defined in [EN 12795]. This standard defines the basic communication frame format, including start and end flags, the link address field, a field for controlling media access in up- and downlink, the data payload field and a frame-check sequence that allows the receiver to check the data frame for correct transmission, i.e. for freedom from bit-errors.

DSRC application layer

The DSRC application layer is defined in [EN 12834]. This standard defines communication initialisation, i.e. the BST-VST exchange described above, communication termination and basic commands like read (GET command) and write (SET command).

It is worth noting that the basic DSRC communication stack, including the application layer, does not provide for security services such as encryption or data authentication. In the CEN DSRC the philosophy is that security is not a link service but shall be handled by the individual application itself. Data shall be protected in an end-to-end sense and not only on link level.

Communication profiles

[EN 13372] defines communication profiles to be used for road-related applications. A profile is a coherent set of link parameters that binds all communication layers together, see Figure 3. Currently only one profile is defined, supporting confirmed and unconfirmed data exchange with a net data payload of 128 bytes per frame. Other profiles, e.g. for a mere broadcast application or for an application with higher payload per frame could be defined in principle, but no such need has arisen yet.

Test standards

CEN DSRC is fully supported by a set of test standards such that conformity of equipment can be proven by any accredited test laboratory;

- for the Physical layer: EN 300674 series of standards, [EN 300674]
- for medium access and logical link control: ETSI TS 102 486-1
- for DSRC application layer: ETSI TS 102 486-2

5.4 Application standards

Application standards for the CEN DSRC have primarily been developed for electronic fee collection and related applications like access control.

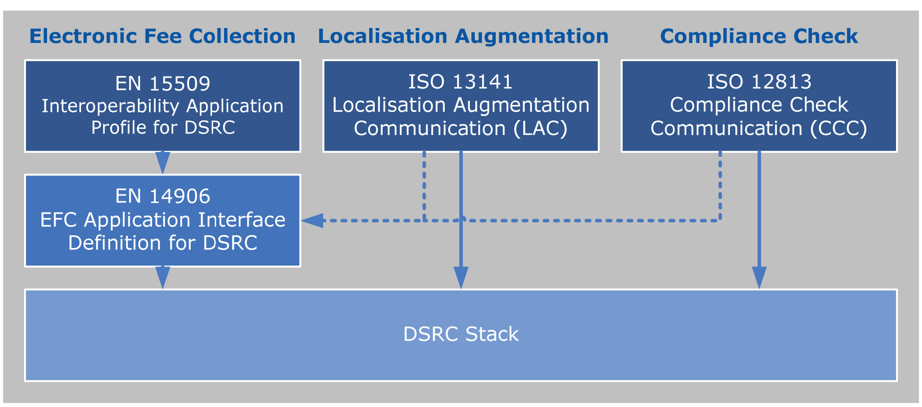

Figure 4: DSRC application standards in the area of electronic fee collection

As Figure 4 shows, the application standards make use of the DSRC communication stack as depicted in Figure 3 above. The earliest standard developed is EN ISO 14906, the “EFC application interface definition for DSRC”. This standard defines the basic vocabulary for electronic fee collection (EFC), namely the addressing and coding of all commonly used data elements for EFC, like the licence plate number, the vehicle weight and dimensions, the vehicle’s tariff class, the payment means used, etc. The standard also defines additional special functions or EFC (in addition to “GET” and “SET” that are already defined as part of the DSRC stack). Such functions are, e.g., GET_STAMPED and SET_STAMPED for authenticated reading and writing or SET_MMI for commands addressing the user interface of the OBE (e.g. buzzer, signal lights or display).

Using this defined "language" for communicating over the DSRC, three specific applications have been standardised:

- **Interoperable EFC** [EN 15509]: This standard defines a DSRC transaction, i.e. rules for communicating a set of data for the purpose of charging vehicles for the use of road in an interoperable way. This way all DSRC based charging systems in Europe will appear like one and the same to the user, despite being in fact very different – with different legal background, different charging rules, different vehicle classification, different tariffs, etc. This standard is going to be one of the foundations of the interoperable European Electronic Toll collection Service EETS that shall become operational from October 2012 according to [EETS Directive].
- **Localisation Augmentation Communication** is defined in a further DSRC based application standard. [CEN ISO/TS 13141] defines a communication where a CEN DSRC beacon supports the GPS or GALILEO based satellite localisation of OBE used in tolling. Such augmentation is required in difficult parts of the road network, e.g. with complex motorway interchanges, where satellite localisation alone is not sufficient to resolve with sufficient reliability on which part of the network a vehicle is effectively travelling.
- The **Compliance Check Communication** (CCC) application comes closest to the envisaged checking application for the Tachograph. [CEN ISO/TS 12813] defines an application where tolling OBE are being read by a DSRC RSE for compliance checking purposes. Much like in the envisaged Tachograph application, the road-side reads OBE status, eventual pending warnings and other information that may indicate a user violation of the tolling regulations in force.

5.5 Equipment

A wide range of products is available using CEN DSRC. The most prominent products, produced in high volume are:

- **Self-contained DSRC tolling OBE (see Figure 5)**: Such OBE is battery powered, with a non-exchangeable battery that keeps an OBE operational for typically 7 years. Such OBE typically contain a minimal user interface, i.e. some buttons to change settings and a buzzer to give feedback on transaction success. DSRC tolling OBE are produced in the millions for charging both light and heavy vehicles either as a hands-free electronic option at classical barrier-controlled toll plazas such as in Italia, France and Spain or as a mandatory equipment for non-stop free-flow tolling such as in the Austrian and Czech truck tolling systems. Depending on lot size and additional features costs per piece are between € 15 and € 25. Such OBE need to be mounted directly behind the windscreen with an unobstructed view to the outside. Usually they are attached to the windscreen with adhesive tape.

Figure 5: Two self-contained CEN DSRC tolling OBE

- **DSRC interfaces as vendor parts (see Figure 6)**: Satellite-technology based tolling OBE use a mix of technologies for charging, namely GPS (or similar GNSS) for identifying location on the charged network, GSM communications for transferring the charging data to the back office, and finally DSRC for compliance checking. For such complex OBE, the DSRC interface is only a sub-component and usually procured from specialised vendor. The market for these vendor parts is not as well developed as for self-contained OBE since volumes of satellite based tolling OBE are much lower. Such complex multi-technology OBE are currently only used for charging heavy vehicles, with correspondingly lower volumes of vehicles. Note that also in this case the DSRC interface, or at least the antenna part, needs to be located just behind the windscreen. Prices are not publicly known, but it can be assumed that for volume production prices will be between € 5 and € 10.

Figure 6: Complex tolling OBE containing a CEN DSRC interface as vendor part

- **DSRC beacons for gantry mounting (see Figure 7)**: DSRC heads at the road side can provide differing functionality, depending on the needs of the application. For the Tachograph application, a simple DSRC beacon covering a single lane will most likely be sufficient. More complex products are also on the market allowing even triangulation of the OBE such that the exact position of the OBE can be tracked across lanes. Such high functionality is rarely required, in tolling e.g. only for combined tolling and enforcement stations employing besides DSRC readers also laser scanners for vehicle classification and several cameras to capture the situation. Here OBE need to be tracked through the station in order to ensure proper correlation of the information from all sensors. A simple DSRC gantry-mount beacon comes at a few thousand Euro. Including mounting, cabling etc., a single lane might be about € 10 000. Covering the rightmost lane is probably sufficient for the pre-filtering application for the Tachograph control.

Figure 7: DSRC beacon mounted on an overhead gantry

- **Hand-held and mobile DSRC readers (see Figure 8)**: A range of specialised products is available for the purpose of compliance checking by manned mobile patrols. Such products come in the form of “DSRC guns” for reading out data from passing vehicles (see Figure 8, left) and DSRC beacons for mounting in or on cars (see Figure 8, right). Further products are available, such as beacons for tripod-mounting for temporary placement at the road-side.

Figure 8: Handheld "DSRC gun" (left) and enforcement vehicle with a roof mounted DSRC antenna (right).

Besides these products for use on or at the road, also products for in-house use are available, such as DSRC stations for personalising OBE at customer service points. In general it can be said that because of tolling, a range of products is available that can be employed in a practically unchanged fashion for the purposes of supporting compliance checking of the Tachograph.

6 Definition of a Tachograph control application

6.1 Control process

Classical process

Today in an on-road control, part of the heavy vehicles traffic is waved down, parked at road-side or on a suitable area by the road and then inspected by personnel. Depending on national regulations and institutional setup, inspectors usually come from the police or from the road inspectorate. Checking a vehicle takes comparatively long time. It takes some minutes to stop and safely park a vehicle, then to address the driver, ask for a copy of the Tachograph data on a chip card or memory stick, and then analyse the data with support of special control equipment. Tachograph data reach back for a long time and usually some exceptional or suspicious events are found that require further investigation. This is done in discussion with the driver and looking at freight papers.

The control equipment usually used reads the downloaded data from the Tachograph and automatically analyses them for violations of the social regulations. If all is fine, the driver can resume the trip. Ideally, such a check results in about 30 minutes loss of time, usually with some waiting, manoeuvring and queuing up it will be around 40-50 minutes.

The majority of vehicles can continue unimpeded since most inconsistencies and suspicious events can be explained. This makes the control process rather inefficient. A random sample of vehicles is checked, without any prior indication of a likely infringement. In case of a 10% infringement rate, ten vehicles need to be thoroughly checked, taking several hours, before a substantial infringement case is found. This results in low efficiency of the control and may explain why on-road Tachograph checks are rather infrequent.

Future process

In case a DSRC read-out functionality would be available in the majority of vehicles, on-road controls would become far more efficient. A road-side DSRC reader can be fixed on a gantry, upstream of the check area, and communicating to the controllers the status of the tachograph and the vehicle identification. If mobile and temporary, a reader placed about 100m upstream of the control point would read a short message from the Tachograph, indicating whether the status indicates no infringements or whether there is high likelihood of an infringement. The information from the reader is only used to support the control personnel to filter interesting vehicles worth inspecting out of the traffic stream. The decision which vehicle to check still remains with the controllers. The information from the DSRC reader can be made available at the check point in different ways:

- The reader may wirelessly transmit the status information to a display device at the control point. Based on the displayed data, controllers decide whether or not to wave a vehicle down. Upon a decision, vehicles are identified in the approaching traffic via their licence plates and taken out for inspection.
- The reading head may have an indicator on its rear side (i.e. the side opposite the approaching traffic). This indicator is visible from the control site further downstream. This way, vehicles worth an inspection are identified easily.

This pre-filtering will increase efficiency of the control process by at least a factor of ten. The likelihood of detecting an infringement with an inspected vehicle is an order of magnitude higher, and accordingly, costs per detected case come down drastically.

Besides increasing efficiency, control density will increase drastically. Today only a small proportion of the heavy vehicle traffic can be waved down for inspection at a control. With the pre-filtering via DSRC, all heavy vehicle traffic passing a station will be subject to the monitoring, increasing control density enormously. Traffic safety will benefit directly from this increased density.

Intermediate process

During the years of migration, i.e. in the time where there is a mix of old Tachograph models and new ones on the road, inspections would work slightly different. Vehicles not equipped with the new Tachograph would still need to be inspected on a random basis with low efficiency. Over time the proportion of vehicle with new Tachographs would increase, making controls more efficient every year. Initially benefits for controllers would not be pronounced, but newly equipped vehicles would immediately benefit from the new technology. Chances of being checked unnecessarily would go down drastically, avoiding unnecessary time loss and hassle. This advantage potentially also contributes to accelerate the introduction of the new models.

Tachograph status read out via DSRC is a supporting function in order to increase the efficiency and throughput of control operations by filtering cases. The decision on which vehicles to check and which exact cases mean an infringement remains with sworn officers. The DSRC read out function cannot be used for fully automatic checking stations comparable to speed cameras.

6.2 Control data

Current and future versions of the Tachograph basically need to support the same data for reasons of equal treatment. It would not be acceptable for the trade that vehicles equipped with an amended functionality Tachograph would be treated more strictly than those equipped with a classical device. For this reason it is advisable to read out some of the already existing data and make them available to the controllers for judgement. It is not recommended that the Tachograph itself takes part in the pre-filtering functionality and decides via some logic whether to communicate "everything is OK" or "I have some indication for infringements". This decision is best left to controllers in a similar way as today, only that the data are made available already from the moving vehicle, avoiding the need to stop them if controllers decide that this is unneeded.

Also for another reason it is recommended to send raw data as they are stored in the Tachograph, without processing on-board. Controllers are better off if they are supplied with a set of data in order to gain some insight instead of simple binary "red/green" information. Controllers might well decide to focus on a certain type of likely infringement, like card mis-manipulation, on one day and on another type, like driving overtime, on another day. By scanning through the data dictionary of Appendix 1 of Annex 1B of the [Tachograph Regulation], the following data appear to be most interesting for communication via DSRC. The reference in brackets points to the section number in the data dictionary where the data element is defined.

- **current time**, e.g. the data element CurrentDateTime (2.45)
- **identification of the vehicle** by the data element VehicleRegistrationIdentification (2.113), giving the licence plate number and nationality
- **latest card event** as contained in the data elements CardEventRecord (2.16) and CardFault Record (2.18), giving information on pending events like driving without card, card insertion while driving, over speeding, tampering, etc.
- **continuous driving time** as defined in Annex IB under "I Definitions" letter (n), as shown in the default display of the Tachograph according to Annex 1B, I 15.1 and as used for the warning display according to Annex IB, I 16.1. A suitable coding for this data element would need to be defined.
- **place where the daily work has begun**, currently in the format of PlaceRecord (2.84) or in a future version amended with GPS position data.

Further data might be considered for inclusion, but because of reasons of equal treatment probably for use at a later point in time. Nevertheless it might be wise to include the data definitions in the transmission protocol for later activation if required. Additional data might be related e.g. to vehicle speed, which would allow having a quick check on calibration by comparing claimed speed by the Tachograph with actually measured speed on the road.

Data on the **fact that a control has taken place might be written back to the vehicle unit**, e.g. in the record CardControlActivityDataRecord (2.11). For this purpose a new type of control (e.g. "pre-filtering") would need to be defined in the element controlType.

6.3 DSRC application

As shown in the previous section, data to be communicated over the DSRC link can mostly be taken out of the data dictionary already contained in the current Annex 1B. The only additional definition required is a specification of the protocol on the DSRC link, i.e. the sequence of data exchanges that shall take place in a DRSC interrogation of the Tachograph.

A very good basis for defining such a DSRC application for the Tachograph is already available in CEN standardisation, as explained in Section 5.4. Actually, the control application defined for satellite localisation based electronic fee collection (Compliance Check Communication, CCC) is very close in concept to the envisaged application for the Tachograph, see [CEN ISO/TS 12813]. The CCC contains a message exchange sequence, security provisions and data elements that are very similar to the requirements of the Tachograph.

Similar to what is depicted in Figure 4, a Tachograph DSRC standard could also draw from basic functionality already defined for tolling in the base standard [EN ISO 14906]. Basic functionalities are e.g. (authenticated) read/write commands, a data addressing mechanism, and core data definitions, such as date and time, licence plate number and nationality. Other specific Tachograph control data definitions and coding need to be added in the standard. Security as defined for tolling, see e.g. [EN 15509] for the basic mechanisms that are also used e.g. in the compliance check communication, might also be suitable for the Tachograph, otherwise a separate security concept would need to be included in the standard.

It is recommended to specify the Tachograph DSRC application within CEN and not in an amended Tachograph regulation. Ideally, the regulation would only contain a reference to the harmonised CEN standard. Technical specifications are never perfect and need regular maintenance in order to remove errors and ambiguities. A regulation is a legal document and there is no easy process available for “debugging”. Standards have such processes in place. In fact, by internal procedure any CEN standard needs to be revisited periodically and a proper process to issue revisions and updates is in place.

6.4 Data protection and privacy

In general, no fundamentally new issues regarding data protection and privacy are expected in comparison to today. The envisaged DSRC application **only uses data that is already available in the Tachograph today** and applies them for pre-filtering. After the temporary use of this data for the control purpose it needs to be deleted by the road side reader. Only data collected by the control personnel in the subsequent physical control will be used for assessment and eventual prosecution. Hence the situation regarding data protection and privacy remains unchanged in this respect. Note that the proposed set of data for DSRC read-out contains no identification of the driver.

The only new aspect is that data are transmitted wirelessly and not only via physical media such as the driver or control cards. Hence the data needs to be protected from **distortion in transmission** and from **deliberate manipulations**, e.g. by users sending a set of “sanitised data” not stemming from the Tachograph directly. Standard authentication elements like signatures as they are used today in DSRC based tolling will serve this purpose.

Another issue is the question of protecting the data from **unauthorised read out** by third parties. Data needs to be access protected such that only DSRC stations operated by an empowered authority can read or write Tachograph data. Again, standard read and write access control elements as foreseen in any DSRC communication today will serve this purpose. This assures that only “official” equipment, i.e. equipment that has been issued to a competent authority, can read data from the Tachograph. Only authorised institutions will receive the required access keys that need to be available in the readers.

This authorisation can e.g. be safely contained in a Secure Access Module, which is a secure storage chip for cryptographic keys, much like a SIM-Card in a mobile phone or the chip on a payment card. These provisions are already contained in the usual EFC beacon products for use in electronic tolling, for very similar (payment related) security reasons.

In principle, a small leak remains: In case a DSRC reader is stolen, third parties might abuse the reader and gain access to the Tachograph data. Although there is little reason to do so (what is to be gained?) one might want to close this small security hole. A proper security analysis, i.e. a risk and threat analysis would show whether or not this is required. In any case it would be technically easy to lock the equipment in a way that it is only operational as long as authorised personnel have unlocked it. Unlocking might be done, e.g. by identifying oneself with a controller card, using the already defined security mechanisms of the card.

A final remaining issue is **protecting data on the link from being intercepted by an eavesdropper**. DSRC transactions used for tolling purposes foresee no specific protection for this case. Firstly it is unclear what benefit an eavesdropper could draw from intercepting the communication, secondly no truly private data are being transmitted and thirdly it is very hard to intercept the weak signals sent by DSRC OBE. Note that DSRC OBE is passive and only reflects and modulates the carrier signal emitted by the road-side reader. It is very hard to receive the signals because of their faint nature, especially for a receiver that does not have the carrier signal and the link timing information regarding uplink and downlink windows readily available. This is why data on the DSRC link for tolling purposes is not being encrypted to date. It has to be seen in a more detailed analysis whether data for the Tachograph application need to be encrypted in order to exclude any possibility of eavesdropping. In practice, for the reasons given, eavesdropping will not be an issue though.

7 Implementation

7.1 Integration of a DSRC interface into the Tachograph

If the Tachograph regulation is amended with the additional DSRC functionality, and also the DSRC application as discussed above has been standardised, there are little obstacles to an integration of a DSRC interface into Tachograph products within a short time.

A competitive market for vendor products of DSRC interface components does already exist. Also standardisation of all link-related issues is mature, and only some Tachograph specific data need to be added which will not require any major effort but rather simple software changes or even mere changes to equipment parameterisation.

Regarding integration of a DSRC interface into the Tachograph only two small challenges can be identified at the moment. The first challenge results from the **real-time nature of the DSRC communication**. Since the whole communication has to take place in the fraction of a second that the vehicle is under a beacon, requirements on response times of the equipment are rather high. This means in practice that the response data for the DSRC link need to be already prepared by the Tachograph before the communication starts. Reading them out of memory and formatting them for transmission on the fly is normally too time consuming. Hence it is usual procedure that DSRC data is prepared in a special part of memory and updated regularly such that upon passage of a beacon a response can be sent without delay. This special real-time requirement should not pose significant problems for implementation but simply needs to be considered when designing software architecture.

A second design challenge results from the need for a **DSRC antenna facing the outside** of the vehicle. Today the Tachograph is usually integrated into the dash-board of heavy vehicles. This requires a separate antenna that is placed at a convenient place with unobstructed view out of the vehicle front. For the Tachograph this is a new requirement. Considering that a satellite localisation functionality is being discussed for the new Tachograph which will also need an antenna to receive GPS or GALILEO satellite signals it can be expected that industry will be able to find suitable solutions for combined antenna placement. For tolling OBE such solutions have been found both for dash-board mounted OBE and for OBE integrated into the DIN slot.

7.2 Road-side installations

As described in section 5.5 regarding available equipment, RSE can be either permanently mounted, typically on a gantry spanning over the road, be temporarily placed at the road-side on tripods or even be mounted on top of an inspection vehicle that either checks traffic while flowing with the traffic or while parked kerbside.

Standard equipment may be used with some software adaptations. Tripod mounted and on-vehicle equipment usually already comes with some display and can be used directly. Permanent DSRC installations are normally connected to a back-office and have no local communication or display. Such functionality would need to be added. It can be expected that such add-ons come at moderate costs only, since requirements on data volume and on display capabilities are modest.

The costs for road side installations will mostly stem from the required engineering work and not from the DSRC equipment itself. Depending on the situation, engineering efforts are required for mounting and cabling, for software development and for integration and testing.

7.3 Costs and possible synergies

On the vehicle side the bare DSRC interface component will amount to about € 5 to € 10, plus costs of integration of the antenna into the vehicle. It can be assumed that the costs for the integration of an antenna will surmount the bare DSRC component price. Since this heavily depends on design and possible synergies with the need to also install a GNSS antenna for the Tachograph, total costs on vehicle side are hard to estimate.

Synergies with other telematics devices or applications in the vehicle cannot be expected. Even if there is an additional DSRC OBE or interface in the vehicle for tolling purposes, sharing this resource is not possible. Both tolling and Tachograph require strict equipment certification procedures which up to now has stopped all initiatives to share resources among devices. It is not foreseeable that this situation might change in the near future. Note that the legal background, the institutional setup and equipment life cycle differ considerably between road usage charging and the Tachograph. The DSRC is also a low-price functionality making it more cost effective to have two dedicated and optimised DSRC components in a vehicle than to go for a complex shared component. CEN DSRC protocol has been designed for multi-application real-time purposes and can easily handle several OBE and applications in one vehicle simultaneously.

Costs for road-side readers, whether gantry, tripod or vehicle mounted are around a few thousand Euros a piece. It can be expected that only low volumes will be ordered and therefore the mere equipment price tells little about the total price, which will be dominated by other project and engineering costs.

Readers are not standard catalogue items but usually procured as parts of a larger system. Hence, single unit prices are not easily available. From prices quoted in recent EFC system procurements and especially from maintenance contracts for such systems with lists for spare parts, it can be estimated that a bare beacon head for will cost between € 3 000 to € 5 000 in low volumes, irrespective whether it is for gantry, tripod or on-roof mounting. To this costs for communication and signalling components have to be added, plus the appropriate housing and mounting components. All in all this might double the price, especially if also some software development needs to be done. At the road-side, there is more potential for **synergies with other DSRC applications**. High numbers of DSRC gantries have been deployed for tolling purposes. In principle, it would be comparatively easy to upgrade their software and add an application for Tachograph readout. Obstacles can be seen on the institutional side, since governance over these installations lies with different institutions, and not with the police, road inspectorate or similar. Also, some adaptations are required, e.g. regarding signalling the results to the control personnel downstream.

Potential **synergies between the Tachograph application and tolling enforcement stations** are especially interesting. Such stations are equipped with classification devices (typically laser scanners), with DSRC beacons and with video cameras, see Figure 9 for an example. Three laser scanners for vehicle classification and four DSRC beacons are visible on the front gantry. The rear gantry carries four video cameras plus flashes to capture licence plates. Such an installation would be perfectly suitable for simultaneously checking the Tachograph. The rich information available both from the tolling DSRC communication and from the Tachograph read out would enable very comprehensive checks of heavy vehicle compliance.

Figure 9: Station used for enforcement in tolling.

7.4 Cost effectiveness

Already without deeper analysis, cost effectiveness appears to be high. Assuming that adding DSRC functionality to the Tachograph would cost around € 20 per piece it is obvious that over a typical heavy vehicle lifetime, compliant users will have considerable time savings from not being stopped and scrutinised. Depending on the specific transport, the value of time will be in the region of € 30 to € 100 per hour. Hence 5 to 10 minutes delay per inspection quickly adds up and with a few avoided inspections the **DSRC functionality will pay off for the vehicle operator**.

For the control personnel, cost savings are even more obvious. Since ultimately only truly suspicious vehicles will be stopped and inspected, control efficiency and effectiveness increase dramatically. Assuming that toady about 5% of trucks being controlled are found to be infringing and with the DSRC read-out after the migration period this figure raises to 50%, efficiency is increased by a factor of ten in terms of man-hours spent per infringement detected. An investment of between € 10 000 for a small installation and € 50 000 for a large, multi-lane installation will generate its pay-back rather quickly.

A two person team can thoroughly check no more than about 20 vehicles in a shift. Assuming a 5% infringement rate, only one of those vehicles would need to be prosecuted. In other words, in one daily shift, only one dangerous vehicle is taken from the road. If the pre-filtering raises the average rate of infringers found per checked vehicle to 50% as assumed above, ten dangerous vehicles would be detected, removed from the road and prosecuted. Even assuming an average labour cost of only € 1000 per two person shift, finding 10 infringers today costs easily € 10 000 and with pre-filtering will only amount to € 1000 – which easily paid by the fines collected.

Most benefit would result from **increased traffic safety**. Depending on authors[2] it is estimated that between 20% and 30% of heavy vehicle accidents can be attributed to driver fatigue. Under special conditions like driving past midnight, fatigue is thought to be responsible for up to about 50% of accidents. Accidents involving driver fatigue tend to have increased severity, since a drowsy or sleeping driver neither breaks nor shows any other reaction to reduce the accident's severity. Road-side checks, and only with the new DSRC pre-filtering functionality, will have sufficient effectiveness to actually remove overtired drivers from the road. Today, driving overtime is not visible from outside and there is little risk of being stopped and inspected. With overtime driving becoming more visible and controls more efficient, drivers can be stopped more effectively. This is especially interesting at critical locations, such as prior to entering very long tunnels, where concentration needs to be high but drowsiness easily creeps in because of high temperature and of the uniform surroundings.

7.5 Implementation planning and migration issues

Given that respective legislation is passed by the end of this year (2011), implementation can be carried out in a few years' time. Since a market for DSRC equipment is already established and especially test and certification procedures are available, integration of such equipment into Tachograph products should be possible in less than two years. This is certainly not on the critical path regarding implementation planning.

More time might be required to define specifications for the interface. First it would be advisable to **collect a complete set of application requirements** by engaging with the competent compliance checking authorities. Questions to be addressed are: What are the exact control scenarios? Which data are required? Are there any national legal requirements regarding such road checks? This can be done in a dedicated study within a few months time.

Based on this input, **standardisation at CEN** can be undertaken. Actually it is advisable to start the process in CEN even earlier to allow the required formal steps to be taken in parallel with establishing the exact requirements. Formal steps are e.g. the establishment of a formal new work item that needs to be assigned to a specific working group. Due to commenting rounds and voting procedures, standardisation can be a lengthy process but is typically finalised in about two years, especially if there is support by resources from interested stakeholders. Note that the industry can already work in parallel since not all details of data coding need to be known beforehand when working on integration of a new functionality.

Hence, there is little barrier introduction of a DSRC feature in new Tachographs **in 3 to 4 years from now**.

Actual deployment on **road-side will have to wait for a longer period of time**. In case first vehicles with new Tachograph models appear on the road around 2017, setting up road side readers only makes sense one or two years later, with larger scale deployment probably not before 2020. Before that time only few vehicles will be equipped with the new Tachograph and operating a pre-filtering installation makes little sense. However, training and start of operations can be planned using portable-tripod equipment in this phase. On international transit routes this break will come even earlier, since heavy vehicles in long-distance international transport are renewed rather frequently. Some heavy-duty international fleets are not older than 3 years, such that the proliferation of new Tachographs might be rather quick especially in this sector which is particularly exposed to driver fatigue.

[2] see e.g. [ten Toren 2003], [Walzl 2007], [Otmani et.al. 2005], [NTSB 1995]

8 Summary and recommendations

The business case that favours the introduction of a Tachograph control pre-filtering DSRC application is strong. Checking efficiency will increase by an order of magnitude.

This report shows by analysing available technologies that CEN DSRC best fulfils the requirements posed by such an application. A competitive market with a wide range of products already exists for CEN DSRC technology due to mass deployment for road use charging purposes.

The report proposes a set of control data for transfer over the DSRC link and a way forward to achieve a full specification. In order to achieve a complete and stable set of specifications, the following steps are recommended to be taken, once the basic measure as such is agreed:

- **Collect definitive application requirements** through interaction with the competent stakeholders (police, road authorities). Establish control scenarios, data requirements and security requirements.
- Based on these application requirements, message content needs to be defined by specifying **which data out of the data catalogue** of Annex IB shall be transmitted.
- It is recommended to **validate the technology proposal** with the industry, especially to identify potential obstacles early on.
- **Specification of a Tachograph Compliance Check Transaction is recommended to be undertaken in CEN and not as a part of a new regulation**. The CEN standard would define transaction sequence, data and associated security in a harmonised standard that would be referred to in the Tachograph legislation.

9 Abbreviations

AVI	Automatic Vehicle Identification
BST	Beacon Service Table
CALM	Continuous Air interfaces - Long and Medium Range (before 2007) Communications Access for Land Mobiles (2007 and later)
CALM IR	CALM using InfraRed
CALM M5	CALM using Microwave in the 5 GHz spectrum area
CAM	Cooperative Awareness Message
CCC	Compliance Check Communication (defined in CEN ISO/TS 12813)
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CEPT	Conférence Européenne des Administrations des Postes et des Télécommunications
DECT	Digital Enhanced Cordless Communication (a standard for cordless telephony)
DIN	Deutsche Industrie Norm (here used for DIN slot, i.e. the standardised bay for electronic equipment in vehicles)
DSRC	Dedicated Short Range Communications
ECC	Electronic Communications Committee (which is a part of CEPT)
EETS	European Electronic Tolling Service
EFC	Electronic Fee Collection
EIRP	Equivalent Isotropic Radiation Power
EN	European Norm
ETSI	European Telecommunications Standards Institute
GNSS	Global Navigation Satellite System (such as GPS or GALILEO)
GPRS	General Packet Radio Service

GPS	Global Positioning System
GSM	Global System for Mobile Communications
HMI	Human to Machine Interface
IEEE	Institute of Electrical and Electronics Engineers
IPv6	Internet Protocol version 6
IR	InfraRed
ISM	Industrial, Scientific, and Medical applications of radio energy
ISO	International Organisation for Standardization
ITS	Intelligent Transportation Systems
ITS G5	European communications standard developed on the basis of CALM M5
ITU	International Telecommunications Union
LAN	Local Area Network
OBE	On-Board Equipment
RFID	Radio Frequency Identification
RSE	Road-Side Equipment
SIM	Subscriber Identity Module (a SIM Card is the security device in a mobile phone)
TC	Technical Committee (of a standardisation organisation like CEN, ISO or ETSI)
UMTS	Universal Mobile Telecommunications System
V2I	Vehicle to Infrastructure (communications)
V2V	Vehicle to Vehicle (communications)
VST	Vehicle Service Table
WAVE	Wireless Access in Vehicular Environments (IEEE 802.11p)
WG	Working Group (of a standardisation Technical Committee, see TC)
WLAN	Wireless Local Area Network

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CEN ISO/TS 13141	CEN ISO/TS 13141: 2010 - Electronic fee collection — Localisation augmentation communication for autonomous systems.
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EN 12834	Road transport and traffic telematics - Dedicated short range communication (DSRC) – DSRC application layer.
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European Commission

EUR 24894 EN - Joint Research Centre – Institute for the Protection and Security of the Citizen
Title: Application of Short Range Communication Technologies in the Digital Tachograph System to Support Vehicles Filtering during Road Controls

Authors: B. Oehry, L. Haas, V. Mahieu, S. Scheer,
Luxembourg: Publications Office of the European Union
2011 – 42 pp. – 21 x 29.7 cm

EUR - Scientific and Technical Research series

ISSN 1018-5593 (print)
ISSN 1831-9424 (online)

ISBN 978-92-79-20798-3 (print)
ISBN 978-92-79-20799-0 (pdf)

doi: 10.2788/38011

Abstract:

The existing Digital Tachograph is a regulatory instrument (mandatory by Council Regulation since 1^{st} May 2006) to enforce the application of social regulations in road transport especially with the view to increase traffic safety. It records the work and the rest times of drivers as well as the vehicle speed over time with the aim to ensure that appropriate rest periods are taken by drivers and that a maximum of permissible speed is not exceeded.

The original and prime functionality of the Digital Tachograph is to document, i.e. to record, the driving history of a driver and his vehicle. Nevertheless controls by the road safety authorities are rather inefficient while time-consuming. The proposed update to the existing regulation would rather guarantee the Digital Tachograph as a compliance device rather than as an accurate recorder of driving history. Basic innovation is the application of short range communication technologies (like RFID) allowing the road authorities to scan by-passing vehicles and thus increasing the throughput by the order of ten.

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LB-NA-24894-EN-N

EUROPEAN COMMISSION

Publications Office

ISBN 978-92-79-20799-0