REDUCTION
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Deliverable 6.3.1

First Report on Contributions to Standards

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4.0	22/08/2014	Minor corrections

Executive Summary

Implementation of car-2-car requires interoperability between all the communication equipment that will be available in the market. Hence a standardization of the protocols is urgently needed for such an implementation. Delphi being an international company, have decided to work in the standardization effort in the US and in the EU so that standards are monitored in the major markets and common grounds are found and used.

The first part of this deliverable describes the development process of the DVM-Exchange standard (DE for short), which will be an open standard for the interoperability of road traffic management systems, especially in the context of network management. Trinité Automation is one of the initiating companies developing this standard. The standard is needed in order to deploy a larger area of traffic management with traffic management systems from different vendors. This deliverable relates the current status of the standard, the key choices made in the course of 2011 and 2012, and the key challenges encountered. It also describes the network management approach on which the standard is based. Then, the deliverable documents DELPHI's efforts towards standardization.

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Glossary

AASHTO	American Association of State Highway and Transportation Officials
BSA	Basic Set of Applications
BSM	Basic Safety Message
C2C	Car-to-Car
C2X	Car-to-X (Infrastructure or Vehicle)

C2I	Car-to-Infrastructure
C2CCC	Car-to-Car Communication Consortium
C2P	Child-to-Parent
CAm	Cooperative Awareness Message
CALM	Communications access for land mobiles
CAN	Controller Area Network
CEN	Comité Européen de Normalisation; *(European Committee for Standardization)*
CENELEC	Comité Européen de Normalisation Électrotechnique; *(European Committee for Electrotechnical Standardization)*
DENm	Decentralized Environment Notification Message
DG-INFSO	Directorate General for Information Society and Media
DSRC	Dedicated Short Range Communications
DVM	Dynamic Verkeers (Traffic) Management
EFC	Electronic Fee Collections
ESO	European Standardization Organization
ETC	Electronic Tall Collections
ETSI	European Telecommunications Standards Institute
HTG	Harmonization Task Group
HTTP	HyperText Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISO	International Standardization Organization
IP	Internet Protocol
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
NEMA	National Electrical Manufacturers Association
NM	Network Management
NTCIP	National Transportation Communications for ITS Protocol
MAC	Media Access Layer
OCIT	Open Communication Interface for Road Traffic Control Systems
OEM	Original Equipment Manufacturer
P2C	Peer-to-Child
P2P	Peer-to-Peer
PHY	Physical Layer
PKI	Public Key Infrastructure
R&D	Research and Development

RDS	Radio Data System
RHW	Road Hazard Warning
SAE	Society of Automotive Engineers
SDO	Standardization Organization
SLA	Service Level Agreements
SPAT	Signal Phase and Timing
TMC	Traffic Message Channel
TNM	Traffic Network Management
TOPO	Topology Message
V2X	Vehicle-to-X (Infrastructure or Vehicle)
V2V	Vehicle-to-Vehicle
V2I	Vehicle-to-Infrastructure
USDOT	United States Department of Transportation
WAVE	Wireless Access in Vehicular Environments
WIFI	Wireless-Fidelity
WIMAX	Worldwide Interoperability for Microwave Access
XML	eXtensive Markup Language

1. Introduction

1.1 Project Overview

Reduction of CO2 emissions is a great challenge for the transport sector nowadays. Despite recent progress in vehicle manufacturing and fuel technology, still a significant fraction of CO2 emissions in EU cities is resulting from vehicular transportation. Therefore, additional innovative technologies are needed to address the challenge of reducing emissions. The REDUCTION project focuses on advanced ICT solutions for managing multi-modal fleets and reducing their environmental footprint. REDUCTION collects historic and real-time data about driving behavior, routing information, and emissions measurements that are processed by advanced predictive analytics to enable fleets enhancing their current services as follows:

1) Optimizing driving behavior: supporting effective decision making for the enhancement of drivers' education and the formation of effective policies about optimal traffic operations (speeding, braking, etc.), based on the analytical results over the data that associate driving-behavior patterns with CO2 emissions;

2) Eco-routing: suggesting environmental-friendly routes and allowing multi-modal lets to reduce their overall mileage automatically; and

3) Support for multi-modality: offering a transparent way to support multiple transportation modes and enabling co-modality.

REDUCTION follows an interdisciplinary approach and brings together expertise from several communities. Its innovative, decentralized architecture allows scalability to large fleets by combining both V2V and V2I approaches. Its planned commercial exploitation, based on its proposed cutting edge technology, aims at providing a major breakthrough in the fast growing market of services for "green" fleets in EU and worldwide, and present substantial impact to the challenging environmental goals of EU.

1.2 Work Package Objectives and Tasks

The goal of work package WP6 is to make the results of REDUCTION publicly available through peer-reviewed publications, conference presentations, press releases, Web pages, and contributions to standards. It consists of tasks relevant to dissemination (T6.1), exploitation (T6.2), and contribution to standards (T6.3). As far as the peer-reviewed publications are concerned, the academic partners of REDUCTION have set as their target to publish their work in premium quality IEEE journals, transactions and magazines. As far as the exploitation is concerned, the REDUCTION partners have set as their target to incorporate the ideas developed in the context of this three year period into industrial products, and train young researchers (offer PhD and MSc studies). Finally, as far as the contributions to standards is concerned, since the acceptance of a standards proposal is a time-consuming process, and it is not expected that it will happen within the running-time of the project, the partners of REDUCTION have set as a realistic target to develop new ideas, and measure their performance with respect to the currently established standards and submit these ideas for publication in journals/conferences, and afterwards to work them for a standards submission. In summary, partners will search for and use existing and contribute if possible to fleet-management standards used in the EU. Of particular importance is the effort of the partners involved in wireless communication tasks to detect any shortcomings of the established standards in that area, and improve them.

1.3 Objective of this Deliverable

This deliverable aims at task T6.3 and its objective is to review all available standards to see which are the most suitable to use and build upon. The results will feed into the standards being used in all work packages to be highly interoperable with other fleet-management systems not developed in REDUCTION. Solutions delivered by REDUCTION will build, wherever possible, upon existing open source/freely available standards. If for any scenario no current standard is sufficient, the most promising one will be extended accordingly. Contributions to standards are expected to arise by making significant extensions of existing standards. These will be communicated with the expert sub-committees of standard issuing organisations (e.g., ISO, IEEE) and approval of suggested extensions will be sought. Table 1 presents a summary of the objectives of this deliverable.

Objective to achieve	Task	Methodology
Network management	Interoperability of road traffic management systems	Further development of the DVM-Exchange standard
V2X communication (SAE J2735, SAE 2945)	Support for application processes	DRSC message sublayer
V2V multi-hop vehicle communication	Georouting capabilities	Extensions to the Geonetworking protocol (IEEE 1609.3)

Table 1. Summary table for the objectives of the deliverable.

2. Related Work and REDUCTION

In this section we will describe the basics of three standards that will play a crucial role in the design of REDUCTION. Although, REDUCTION's areas of interest are quite broad and the standards developed there are could also be part of this deliverable, we focus here exclusively on the standards that are absolutely related/necessary to REDUCTION.

2.1 The DVM-Exchange Standard

2.1.1 Introduction

Network Management (NM) manages road traffic in a way that takes the network context into account. It contrasts with the more common local measures for traffic management, such as traffic signals, ramp metering, and variable message signs, that have a geographic scope of at most one node in the network or just a short road segment. It is easy to solve congestion at one place by shifting it to some other place. This is what local measures often do and what NM tries to prevent. But NM is not a well-established method of traffic management. It is in the middle of the process of development, a process started in the mid-nineties and which is rather slow, due to a number of reasons, the most important one being the sheer complexity of traffic behavior in a network, especially dense traffic. The increasing levels of congestion in many densely populated areas in the world urgently need an effective NM, because local traffic management measures are limited in their capabilities for structural reduction of congestion. Speeding up the development process of NM would be welcomed by traffic management authorities at many places in the world.

A second important reason for the slow development of NM is that implementing NM systems is currently a tedious and expensive endeavor. This is due to the fact that one has to deal with the legacy roadside equipment, which stems from many different manufacturers and from different periods in the past and which was never designed to be part of a comprehensive NM system. Without a connectivity and interoperability standard, huge numbers of ad-hoc interfaces have to be built and maintained, which makes implementation attempts rarely viable beyond a limited pilot period [13].

There is a broad consensus that such a standard is needed. The key challenge in developing such a standard is however the fact that the theory of NM is itself under development. This is a difficult chicken-egg dependency [12]. Current descriptions of NM ([2][3][4][5][6][7][8][9][10][11][14][15][16][17][18]), of which we fully and unequivocally acknowledge their pioneering contributions, usually lack sufficient detail and formality and were mostly written by traffic engineers, not by multi-disciplinary teams. Happily enough, not all details of an NM theory are relevant to the standard. Below, a more formalized description is given of an approach to NM, for the purpose of standard development. It encompasses the key notions found in the aforementioned descriptions, fills in some necessary extra details, and is not, in any essential way, inconsistent with these descriptions.

A key property of the standard is that it defines cooperation between systems in terms of effects on traffic and not in terms of system-specific details. The latter would greatly reduce the general applicability of the standard. On the other hand, especially in case of legacy systems, this property may cause loss of functionality, when certain system-specific interactions between two systems are hard to translate into effects on traffic. To that end, a user defined part has been included in the standard.

DVM Exchange [1] offers a standardized way to allow traffic management in the situation given below. DVM Exchange uses an open protocol and an accepted traffic management methodology. The effectiveness of traffic network management (TNM) will increase tremendously if systems of different vendors and administrators work together.

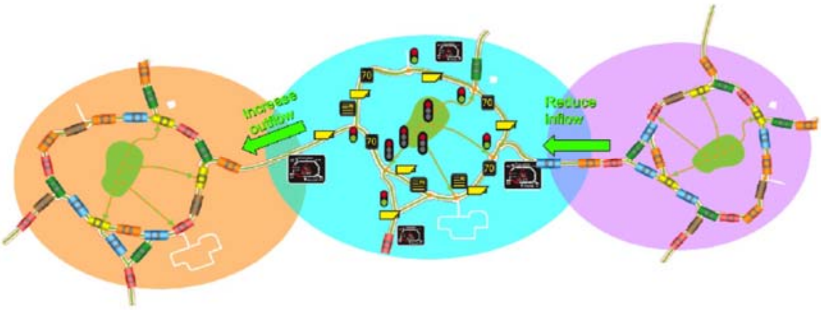

Figure 1. Present situation in traffic management.

Figure 1 demonstrates the present situation where traffic management services are invoked in the blue area, (see increase outflow and reduce inflow near the green arrows). If only one area is managed it can lead to a propagation of the problem to adjacent areas.

2.1.2 Overview of the DVM-Exchange standard

Usually, connecting traffic management systems is part of an overall plan for a given area, in which many systems have to be made interoperable. The standard is however described from the bilateral point of view: connecting two systems (Figure 2). The standard makes a number of assumptions about the two individual systems, and about their relationships.

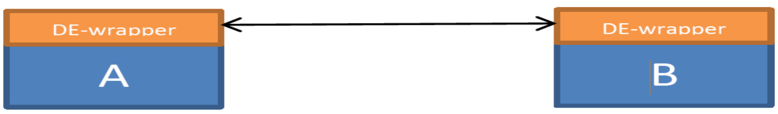

Figure 2. Two TM systems connected via DVM Exchange.

Each system has:

- an owner;
- a management area;
- a capability and a responsibility for traffic in its management area;
- in that area there are no other systems with overlapping responsibilities (case of connecting systems with overlapping responsibilities that share the same management area will be covered by the standard, but is omitted in this article).

The two systems have the following relationships:

- They are neighbors: management areas are non-overlapping and share part of their boundary (peer to peer case), or one area falls within the other area (child to parent case);
- They share one owner or the two owners know each other and interact;
- The two systems have a shared clock;
- The two systems are not otherwise connected.

For legacy systems, these assumptions are usually not fulfilled. It will often be necessary to make adaptations to the legacy systems to comply with these requirements. Often, for legacy systems, management areas are not defined, or if they are defined, they are overlapping. There can be several unrelated legacy systems having comparable effects on traffic without proper definition how they are related (which breaks the one-captain-per-ship principle). This spaghetti will have to be cleared first, before much can be done with the standard. It is tempting to leave existing management system configurations untouched and just replace the existing system-specific connections by DVM-Exchange connections. This may work in the short term, but this is not how the standard is meant to be used. In such cases, it will be hard to describe the interactions between systems in terms of desired effects on traffic that fit well within an overall TM approach for the given area. The standard includes a "user defined" section, that may server a purpose in this case, but is should be clear that objectives of the standard are not served by overloading the "user defined" part. User defined parts are usually ad-hoc for each pair of systems, and therefore will cause much interaction between system owners, for first realization and for maintenance.

2.2 The DSRC standard

Wireless vehicular communication has the potential to enable a host of new applications. The automotive industry is working to develop the dedicated short-range communication (DSRC) technology, for use in vehicle-to-vehicle and vehicle-to-roadside communication. The effectiveness of this technology is highly dependent on cooperative standards for interoperability. This section will briefly explain the content and status of the DSRC standards being developed for deployment. Although the standard includes IEEE 802.11p amendment for wireless access in vehicular environments (WAVE), the IEEE 1609.2, 1609.3, and 1609.4 standards for Security, Network Services and Multi-Channel Operation, the SAE J2735 Message Set Dictionary, and the emerging SAE J2945.1 Communication Minimum Performance Requirements standard, we will discuss in this deliverable only the SAE message sublayers, since it the area where DELPHI and UTH will work thoroughly.

For the V2X area the networks can be divided in the following way (Figure 3):

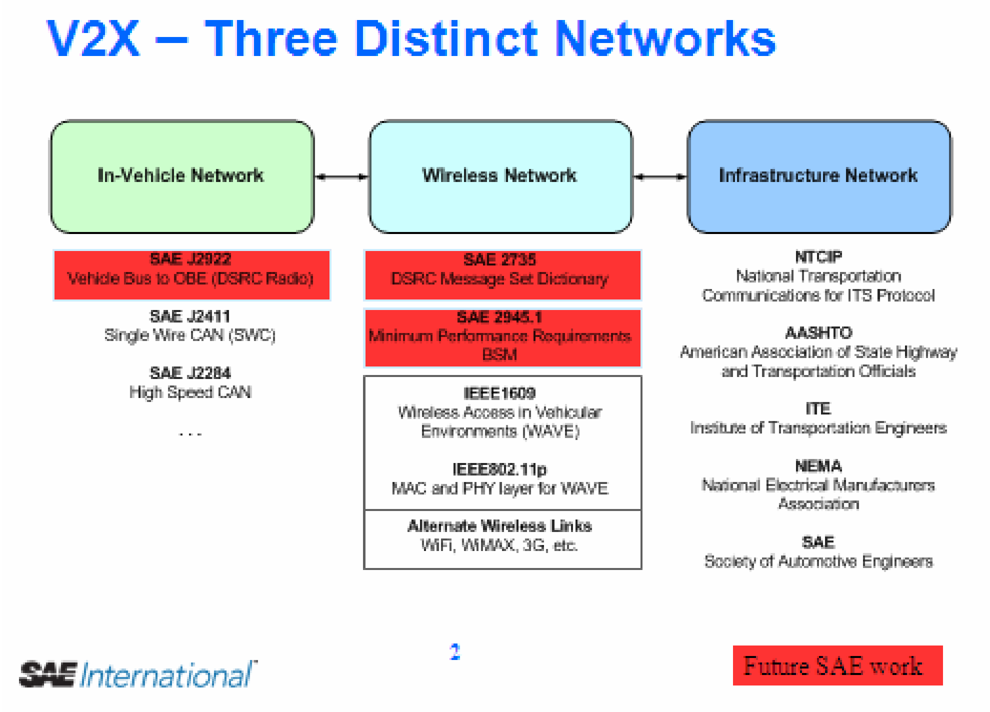

Figure 3. Red marked cells describe DELPHI's efforts in SAE.

Delphi will continually be active in the development of EU and USA standards by participating in committee activities in SAE, ETSI, etc. Due to Delphi's global presence, harmonized standards are desirable that allow common products to deploy world-wide with minimal configuration differences. Our intent is not to create closed standards, and we support open standards that enable quick adoption on a large scale. A specific example of such a harmonization is the use of SAE's Basic Safety Message (BSM) and the ETSI Cooperative Awareness Message (CAM). The exact format of both messages need not be identical but the essence of content and performance requirements should be compatible.

Within the SAE subcommittee, Delphi tried to address the same difficulty that the consortium REDUCTION is facing. We called it the standard J2922, which was chaired by Dave Anton. Here we lobbied the car manufacturer to give the market (suppliers and others) the CAN data, the reason being that the aftermarket safety devices and companies producing energy saving devices will benefit from this message information. For example: when it's known the fixed amount of energy is being used to travel from point A to point B, then the energy saving can be shown using such aftermarket devices. This effort by Delphi and others was not successful, since the OEMs resisted.

2.2.1 SAE Standardizations efforts for V2X

J2735 – DSRC Message Set Dictionary

Scope: This SAE Standard specifies a message set, and its data frames and data elements specifically for use by applications intended to utilize the 5.9 GHz Dedicated Short Range Communications for Wireless Access in Vehicular Environments (DSRC/WAVE, referenced in this document simply as "DSRC"), communications systems. Although the scope of this Standard is focused on DSRC, this message set, and its data frames and data elements have been designed, to the extent possible, to also be of potential use for applications that may be deployed in conjunction with other wireless communications technologies. This Standard therefore specifies the definitive message structure and provides sufficient background information to allow readers to properly interpret the message definitions from the point of view of an application developer implementing the messages according to the DSRC Standards.

In addition to being members of the major technical committee, a Delphi employee served terms as vice-chair and chair of the Traffic Information Subcommittee. This subcommittee focuses on traveler advisories, traffic probe reporting, vehicle platooning, and commercial vehicle communications.

Here the European car-2-car consortium reports the following standard:

The European ITS standards are defined by ETSI and CEN, as describe below. The over the air message set in split into several documents, mainly:

ETSI TS 102 637-2 "Specification of Cooperative Awareness Basic Service"

The Cooperative Awareness Messages (CAMs) are distributed within the ITS-G5 (802.11p) network and provide information of presence, positions as well as basic status of communicating ITS stations to neighboring ITS stations that are located within a single hop distance. All ITS stations shall be able to generate, send and receive CAMs, as long as they participate in V2X networks. By receiving CAMs, the ITS station is aware of other stations in its neighborhood area as well as their positions, movement, basic attributes and basic sensor information. At receiver side, reasonable efforts can be taken to evaluate the relevance of the messages and the information. This allows ITS stations to get information about its situation and act accordingly.

ETSI TS 102 637-3 "Specifications of Decentralized Environmental Notification Basic Service"

This document provides the specification of the DEN basic service, which mainly supports the road hazard (RHW) warning application. More specifically, the document specifies the semantics of the Decentralized Environmental Notification Message (DENM) and the DENM handling. A DENM transmission is triggered by a cooperative RHW use case to provide information about a specific driving environment event or traffic event to other ITS stations. The ITS station that receives the DENM is able to provide appropriate HMI information to the end user, who makes use of these information or takes actions in its driving and travelling. The concept of the DEN basic service is derived from the functional requirements of BSA as defined in ETSI TS 102 637-1: " Basic Set of Applications; Part 1: Functional Requirements" and operational requirements of BSA as defined in ETSI TS 102 637-4: "Basic set of applications; Part 4: Operational Requirements".

Further messages Signal Phase and Timing (SPAT) and Topology Message (TOPO) are currently only available in draft versions.

J2945 – DSRC Minimum Performance Requirements

Scope: This document specifies the minimum communication performance requirements of the DSRC message sets, the associated data frames and data elements defined in SAE J2735 DSRC Message Set Dictionary. The document consists of multiple sections. Each section describes a specific message set's requirements. For example, J2945-1 represents Basic Safety Message communication minimum performance requirements

Rationale: The SAE J2735 DSRC Message Set Dictionary defines the message and data format. However it does not standardize how the data and message shall be used, such as message transmission rate, channel usage, optional data usage in various situations. In order to achieve full interoperability, a minimum performance document is necessary.

Here the European car-2-car consortium reports the following standard:

By the nature of co-operative systems ITS station may need to rely on some performance metric of other cooperating stations. The profile working group of the Car-2-2Car Communication Consortium (C2CCC) is working on the definition of basic system addressing the need of market introduction. This Basic System (Figure 4) is a Vehicle ITS sub-system enabling a set of Day-One Use Cases. In the "C2CCC Basic System Standards Profile" document, C2CCC defines a Standards Profile as guideline for specification of the C2CCC Basic System. The resulting Standards Profile shall enable interoperability among implementations in vehicles of different partners with regards to the Day-One Use Cases, taking into account requirements such as security, information quality, and efficient use of spectrum in the 5.9 GHz range. Thereby, the profile is targeting the European market.

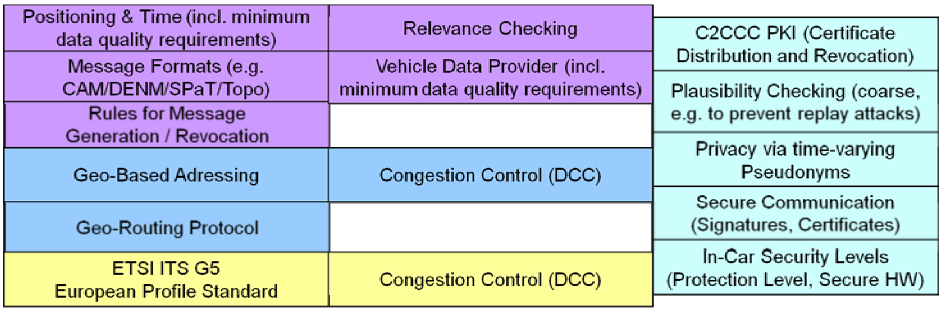

Figure 4. C2CCC basic system components.

An extended version of the Basic System is shown in Figure 5. The extension supports multi-channel, multi-interface operation, service management and IP-based Addressing.

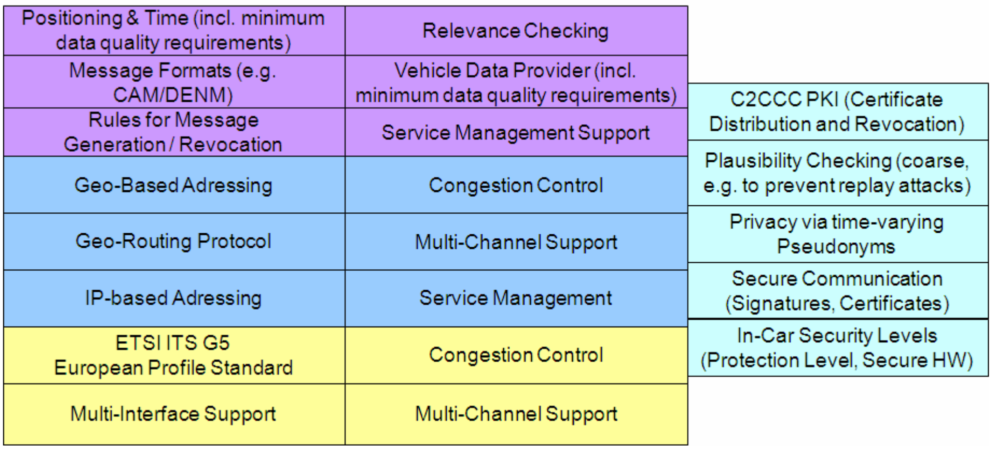

Figure 5. C2CCC extended basic system components.

The Standards Profile for the Vehicle ITS sub-system can then serve as basis for discussion and orientation for the definition of Standards Profiles for Personal and Roadside ITS sub-systems in joint efforts with other stakeholders. Because of very similar system requirements, it can be expected that many of the standards in the Basic System Standards Profile are also used in the Standards Profiles of Roadside and Personal ITS sub-system.

The European Commission invited on October 2009 the European Standardization Organizations CEN, CENELEC and ETSI to prepare a coherent set of standards, specifications and guidelines to support European Community wide implementation and deployment of Co-operative Intelligent Transport Systems (ITS).

CEN and ETSI formally accepted the Mandate M/453 in January 2010 and provided a joint Response to the Mandate in April 2010. The Response to the Mandate included a list of minimum set of standards for interoperability and the split of responsibility between these two European standards organizations (ESO). In April 2011 CEN and ETSI provided a status report on the standardization activities in accordance with the agreed split of responsibilities in the first response to the Mandate M/453.

CEN and ETSI have agreed to jointly develop the response and work program under this Mandate with a list of minimum set of standards for interoperability and other identified standards and technical specifications to support Co-operative ITS services. This work program also defines an agreed split of responsibility between CEN and ETSI as well as a detailed description of the ongoing cooperation between the two ESOs. A task force has been established for this purpose and the ITS-SG monitors the activity.

As requested in the Mandate, the standardization work will require extensive cooperation and liaisons with European and National R&D projects, European industry and other stakeholders including the automotive industry, road operators and road authorities in order to ensure that the results of ongoing R&D activities and stakeholder knowledge and experience are brought into the standardization process.

As mentioned in the Mandate, standardization is a priority area for the European Commission in the ITS Action Plan1 in order to achieve European and global cooperation and coordination. Standardization for Co-operative ITS is already initiated within standardization organizations such as ISO, IEEE and SAE as well as in CEN and ETSI. The standardization activity in accordance with Mandate M/453 will therefore take account of the existing achievements worldwide and include these activities in the European standardization with the aim of achieving globally accepted technical standards for Co-operative ITS supporting future implementation.

Objective and policy background of the Mandate

The policy objectives that form the background for the Mandate are supported by CEN and ETSI and shape the proposed standardization activities. This includes, in particular, the European Commission Communication on i2010, the intelligent Car initiative and the European Parliament resolution towards European-wide safer, cleaner and more efficient mobility. Furthermore standardization is a key priority area of the ITS Action Plan and efficient steering of the European standardization activities for Co-operative Systems is important to achieve the objectives of the Action Plan. CEN and ETSI support the objective to develop and adopt common European Standards for Co-operative Systems and have taken the general policy objectives into account in the detailed planning of the standardization activities in accordance with the Mandate.

Minimum set of standards to ensure interoperability to be developed as ENs

The minimum set of standards is understood as a set of standards which forms the essential basis for the realization of Co-operative systems and simultaneously is open for extension with regard to applications and as well with regard to other technologies. Therefore a framing is defined by both a framework architecture and a communication architecture which supports the implementation of a basic set of applications as described in ETSI TR 102 638.

Division of Responsibility between CEN and ETSI

The long list of required standards indicates the division of responsibilities to lead work items between CEN and ETSI. The lead organization will establish the work item including a time schedule according to the overall roadmap of this Mandate. Contributions from the other organization and stakeholders are always welcome and, in some cases, necessary.

The division of responsibilities is centered on primary capabilities, with the competence of ETSI in the field of communications and the relation of ETSI to the Car-2-Car Communication Consortium with the experience of vehicle-to-vehicle applications. CEN has a focus on the overall framework architecture and on the roadside and traffic management applications, which mainly involve vehicle-to-road-infrastructure and infrastructure communications (Figure 6).

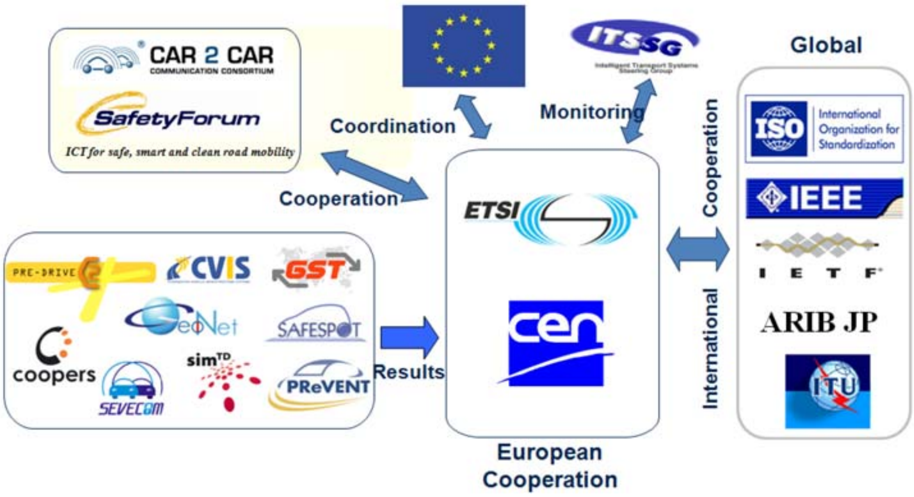

Figure 6. Cooperation overview - Mandate M/453 context.

A number of technical committees are actively providing standards for ITS:

CEN TC278 Road Transport and Travel Technology (www.nen.nl/cen278/) was the first purely ITS committee and started in 1992. This is a European organization with official national participation, and as such under governmental control. Active participation comes mainly from administrations, transport operators and their supplier industry. TC278 have produced 112 standards with about 30 more in various stages in completion. 16 working groups have been active throughout its lifetime, and produced standards for Electronic Fee Collections (EFC/ETC), Freight and Fleet Management, Public Transport, Travel and Traffic Information (RDS-TMC), Dedicated Short-Range Communication (DSRC), Human Machine Interaction, Automatic Vehicle and Equipment Identification and Architecture. Within the last few years some new working groups have been established on Recovery of Stolen Vehicles, eSafety (eCall) and the latest on Cooperative Systems.

ETSI TC ITS (www.etsi.org/its) is the most recent TC with active participation from governmental organizations and industrial stakeholders such as car manufacturers, their component suppliers and telecommunication network operators. TC ITS is continuing the work started in TC ERM TG 37, founded in 2004. Some work items are directed towards communications subsystems, with a special focus on communications within the spectrum dedicated for ITS by the Commission Decision 2008/671/EC. Other work items cover aspects such as application facilities, testing and data structures. There are about 75 work items under way in ETSI with some standards already being published and some being in the approval process including the first dedicated co-operative ITS standard (EN 302 665) as response to the Mandate 453.

Here (click) we can see a list of published ETSI TC ITS standards that are related to the European Commission Mandate M/453 on Cooperative ITS. By today (Feb. 11, 2014), the list includes 76 documents published.

ISO TC 204 Intelligent Transport Systems has started in 1993. There is a direct relationship with CEN TC 278. Some working groups of these two technical committees are joint groups under the Vienna Agreement so that finished Work Items automatically become both European and International Standards (EN IS). Among others TC 204 has working groups covering Integrated Traffic Management, Information and Control Systems, Wide area Communications (CALM), Nomadic Devices and Cooperative Systems.

In addition to these three committees, there are several other organizations that produce standards relevant to ITS as part of their work:

- IETF is producing Internet standards with relevance to ITS, in particular the MEXT group is producing Mobility EXTensions for IPv6 which support the rapidly changing network topology and addressing in a car/roadside environment. These extensions have been incorporated in CALM and ETSI standards.
- IEEE P1609 is dedicated to the upper communications layer for 802.11p with a focus on North American needs.
- IEEE also provides the essential base standard for 5.9GHz communications, known as 802.11p.
- SAE has a group defining data elements for the payload of ITS applications (SAE J2735).
- ISO TC211 Geomatics covers maps, location referencing and basic data formats.
- ISO TC22 works on standards related to land vehicles and cooperates closely with ISO TC204. Several vehicle-internal ITS standards have been developed there, in particular HMI and sensor standards.
- ITU-T and ITU-R have some activities, but these are mostly coordination and not currently producing technical standards.

3. Framework and Methodology

3.1 REDUCTION and DVM Exchange

The primary goal of the DVM Exchange is to reduce the amount of interaction between system owners concerning the details of connecting the two systems, especially the IT-technical details. This includes interaction for first realization and for maintenance. The standard offers a framework in which it is easier to make the necessary agreements on the cooperation of the two systems for purposes of traffic management.

3.1.1 Requirements for DVM Exchange

A number of requirements have been formulated, that guide the development of the standard. We mention only the most important requirements:

- Generality and Extensibility: the standard is intended for all types of systems involved in traffic management, for current and for future TM measures. The standard is such that it can be extended with new TM measures, while remaining backwards compatible with earlier versions of the standard.
- Using the standard should not cause any functional loss.
- In order to achieve this, the standard includes a "user defined" part, which guarantees that existing, system-specific connections, that are hard to express in effects on traffic, can still be expressed in the standard.
- The standard supports SLA (Service Level Agreements)-based cooperation between two owners, including those in which one party pays for the services of the other.

3.1.2 High-level description

Seen at a high level, the standard defines asynchronous Client-Server interaction between systems. Interactions exist of request-reply pairs, together called an exchange. The terms client and server only have meaning the context of such an exchange: the client takes the initiative and sends the first message, the server answers to this, and executes the request or rejects it. Requests are formulated such that they are idempotent: requests can be repeated many times without changing the intended effect on traffic. The protocol is stateless, or at least as stateless as possible. The standard allows for system failures or partial failures, but this behavior is not within the scope of this deliverable.

Structure of the DVM Exchange interface

The DE interface has the following parts:

- The content (= the data exchanged), in which there is a generic part and a specific part. The specific part in turn consists of a regular part, and a user defined part.
- Semantics: the meaning of the exchange. The regular part always has a meaning in terms of an effect on traffic at points (cross sections of roads in one direction).
- The sequence of messages.
- The underlying interface.

The sequence of messages is kept simple: just request-reply interactions. The underlying interface is chosen to consist of the Web Services interface over HTTP. This is a well-known, mature and well supported interface which covers the required functionality. This choice means that the content part is expressed in XML, following XML schemas. Technically the standard consists largely of xsd-files, just like the comparable OCIT standard (XXX). XML also plays an important role for the extensibility requirement mentioned above, as it offers an inherently extensible data format.

Content of Requests

The content part consists of a generic part and a specific part. The generic part consists of basic administrative data that are needed in all requests: identifications for the client and the request and the time stamp for the request, to mention the most important ones.

The specific part has regular content, which fits within the intentions of the standard, and a user defined part. The latter cannot be described in further detail. It is really user defined. It should be kept well separated from the regular part. In the XML code, there is a separate element containing this part.

For the regular part, we distinguish three different cases:

- p2p (peer to peer) requests
- p2c (parent to child) requests
- c2p (child to parent) requests.

Orthogonally to these 3 cases, we distinguish the following types of requests, although not all types are relevant in all cases:

- Traffic management (TM) requests
- Information requests
- Administrative requests
- Configuration requests
- Escalation requests.

The TM requests are relevant in the cases p2p and p2c. Their meaning is that the client asks for an effect on traffic at one or several boundary points of the server's management area. In the case p2p, the points are on the shared boundary between client and server. In the case p2c, the points are on the boundary of the child. A TM request contains the following fields:

- a point (or set of points);
- an effect on traffic at that point (or set of points), expressed as a quantity and an absolute value;
- a characterization of traffic to which the effect applies (all traffic or trucks or public transport, etc., and/or the intended destination);
- a priority;
- an indication of time (starting time, end time, duration, etc.).

In the case of p2p, the server may consider to execute the request or to reject it. This depends on the server's configuration. In the case of p2c, the request is mandatory, and can only be rejected if the child is unable to execute it. In the reply the server tells the client whether the request is going to be executed or is rejected.

The content of the priority field is still under discussion. Currently, it is a numerical value which expresses the priority of the client's management area, to be compared with the priority of the server. Other ways are under consideration but not yet available in detail. Higher values mean higher priority. A server may be instructed by its parent to execute requests from higher priority clients.

Information requests are requests in which the client asks for the traffic state (current or near future) at a boundary point, known by the server. This applies to all three cases (p2p, p2c and c2p). Usually, the smallest area that has the point on its boundary is most likely to have information about it.

Administrative requests serve the functioning of the interface. It may include requests about the status of previous requests, may stop previous requests, may define shared names to be used in future requests, etc.

Configuration requests apply to the p2c case. In a configuration request, a parent instructs one of its children how to handle external requests. For instance, a parent can set priority values for its children. This is still largely to be defined. Until then, in operational use of the standard, configurations will have to be set by hand.

Finally, in the c2p case, there is yet another category of requests, namely the escalation requests. They deal with cases in which two peers have a problem they cannot solve with p2p requests and ask a common parent to solve the problem. The details of this kind of requests are still to be defined.

3.1.3 How to use the standard

The typical way to apply the standard is as follows. Again we describe this as if it were a bilateral affair, which in reality will usually involve more than two TM authorities. In addition, we will only consider the peer to peer case (i.e. two authorities are at an equal level; TM authorities may also have authority relationships). We assume there are two TM authorities that would like to cooperate in the union of their neighboring TM areas. They both own TM systems, which need to be made interoperable for this cooperation. The two owners make agreements about how they will manage traffic together in their joint area, which priority settings are appropriate for their areas and which requests are needed between their systems. If things turn out well, and the legacy systems are not too far from the assumptions mentioned above, then most of these requests will fit into the regular part of the standard. Remaining requests will be included in the user defined part. Once this set of requests is defined, each owner procures or develops a DVM Exchange interface (or DE-wrapper) for its own system, covering the defined set. The interface does not need to cover the complete DVM Exchange interface, but only a subset. In the DE interface, each request is translated into a system specific request that approximates the desired effect on traffic (or the information requested) as well as possible.

The user defined parts are communicated to the DE organization, in order to serve the further development of the standard. The same holds for the way the interfaces are implemented. This information obligation is required by the license that is needed in order to make use of the standard.

When using the standard, one should keep in mind that for any two systems, it will be easier to realize interoperability by an ad-hoc connection, specific for the two systems. It is a considerable effort to fit the connection into the format prescribed by the standard. One will have to resist this temptation, lest one will end up with many ad-hoc connections and a huge maintenance problem (that's the current situation and the main reason the DVM Exchange standard is being developed). Making sure that the connection fits with the standard, will make it easier to realize other and future connections with the system, because then, the bulk of the work for the DE-wrapper has already been done, and it only needs to be extended with additional requests, if any.

3.2 REDUCTION and DSRC standard

Delphi observes the standardization process on ITS worldwide. In November 2009 the United States Department of Transportation (USDOT) and Directorate General for Information Society and Media (DG INFSO) signed a Joint Declaration of Intent on Research Cooperation. The goal of the declaration is to:

> "Support, wherever possible, global open standards in order to ensure interoperability of cooperative systems worldwide and to preclude the development and adoption of redundant standards."

The EU / US joint approach towards Cooperative ITS resulted in the creation of Harmonization Task Groups (HTG). Experts from the EU and the US with support from Japan are working on an analysis of existing standards from various standardization organizations (SDOs) used for system specifications in the EU, US and Japan. These HTGs have to deliver reports on gaps (missing standards), overlaps (conflicting standards), and interoperability test specifications for testing equipment designed for usage in the US and the EU. Further on these HTGs will provide recommendations to SDOs on how to improve the global situation with standards for C-ITS.

Although a major focus of these HTGs is on systems using 5.9 GHz communication technology, the full scope of C-ITS is to be considered. It was made very clear that C-ITS is not at all limited to the 5.9 GHz access technology, and the car-centric road-safety and traffic-efficiency applications currently under development at ETSI. Complementary elements of C-ITS are developed e.g. jointly at CEN TC278 WG16 (under EC mandate M/453) and ISO TC204 WG18, at ISO TC204 WG16.

Throughout 2012, the harmonization task groups #1 (Security and Management Protocols) and #3 (Joint protocols for safety and sustainability services) created a series of reports that discuss the status of harmonization of ITS standardization activities between the EU and the US. Furthermore, the HTG gave recommendations for future directions of standardization activities.

The goal of the harmonization effort is not to define interoperable systems. An ITS station equipped with an European ITS stack, won't be able to cooperate without changes with an ITS stack in the US and vice versa. Development and adoption of coordinated harmonized international technical standards contribute to the following benefits:

- Improved interoperability and interchangeability of Intelligent Transportation Systems (ITS) across operational boundaries;
- Reduced development and deployment costs for manufacturers;
- Greater accessibility to international markets for manufacturers of connectivity equipment;
- Increased competition and innovation amongst manufacturers which can help lower costs and expand service for consumers;
- The potential for a more rapid deployment of ITS systems;
- Leveraging of international expertise and reducing redundant efforts.

Delphi, as a tier-1 supplier, is focused on the practical impact on ITS harmonization. Since, frequency regulation in the 5.9 GHz area covers similar bands for EU and the US, similar hardware developments are expected for both markets. Frequency regulation is more restrictive in EU than in the US. So, on-board equipment designed for the EU will also fulfill spectrum requirements in the US. Higher layer software stacks are similar, but slightly different. On one hand, direct interoperability is not addressed by harmonization. On the other hand, use cases and the security approach are very similar. If requirements for secure handling of security certificates are coherent, ITS vehicle systems might be switched from one system to the other by a firmware update. For example, messages defined in SAE J2735 for the US or by ETSI TS 102 637-2 and ETSI TS 102 637-3 for EU follow the same system design and require similar message handling and processing power. It is to be expected that OEM specific partitioning of the specific in-vehicle system will have more influence in the design of mass market products than differences in the ITS stacks. In summary, the yellow boxes of Figure 7 are the standards that will be adopted by REDUCTION for the wireless communications tasks.

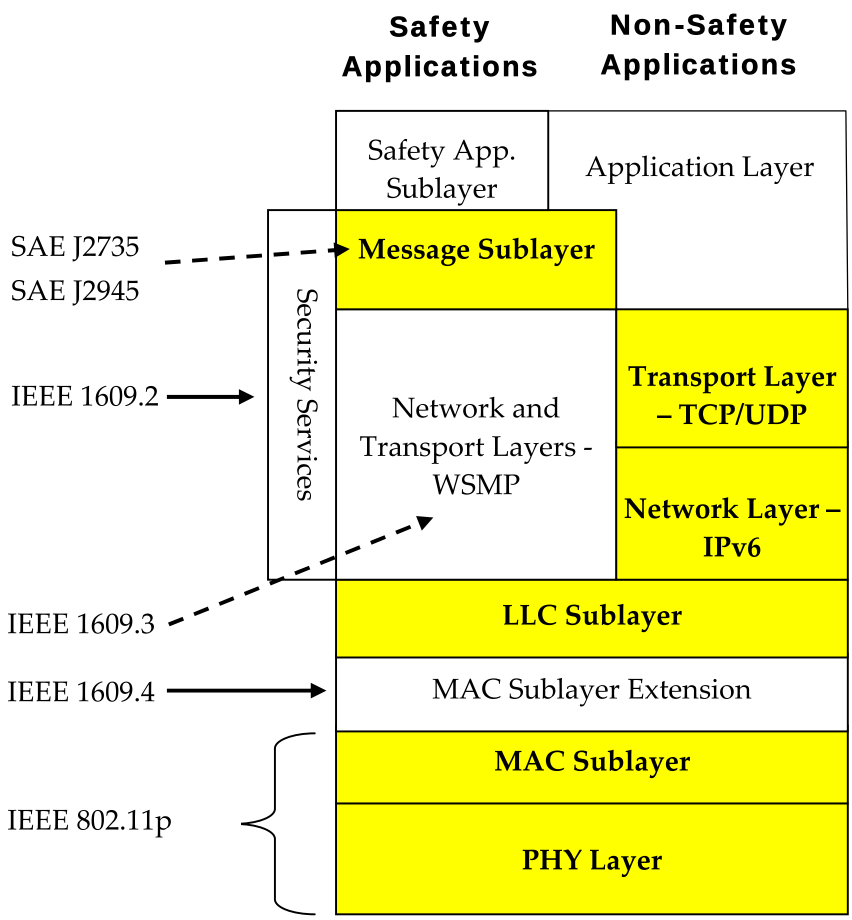

Figure 7. DSRC layered architecture. Standards to be adopted by REDUCTION (those in yellow).

3.3 REDUCTION and standards

In summary, the standards which REDUCTION will be based upon and those that will be extended are illustrated in Table 2. Most of them concern the wireless communication tasks and Figure 7 illustrates their position in the protocol stack.

Standard	WP	Field trial	REDUCTION contribution	Specific contribution
IEEE 802.11p	WP1, WP5	CTL	X	N/A
IEEE 1609.3	WP1, WP5	CTL	X	N/A

ETSI TS 102 636-4-1	WP1, WP5	CTL	√	Extension to Geonetworking: a) cross-layering, b) refrain from continuous retransmission when not needed
SAE J2945	WP1, WP5	CTL	X	N/A
SAE J2735	WP1, WP5	CTL	X	N/A
Bluetooth	WP4, WP5	TRI	X	N/A
DVM Exchange	WP4, WP5	TRI	√	Initial definition of the standard

Table 2. REDUCTION's work related to standards.

4. Risk Assessment

A late standardization of DVM Exchange is a significant factor that will partially affect REDUCTION's operation, but such delays are expected when dealing with standards. We consider as non-existing the danger of DVM Exchange abandonment. Presently, the stage of development is appropriate and mature to be adapted by REDUCTION, and therefore it is not a high risk decision. At the time of updating this report (Feb. 11, 2104), we can observe intense activity on DVM Exchange standardization (http://www.dvm-exchange.nl/standaarden/).

DSRC technology has the potential to support many different types of applications. This technology depends fundamentally on standards-based interoperability. The core standards expected to be used are reaching a critical level of maturity. Several have been published within the past 2 years: IEEE 802.11p, IEEE 1609.2, IEEE 1609.3, and IEEE 1609.4. A version of SAE J2945.1 Minimum Performance Requirements has also been published. Recent testing of basic interoperability among independent DSRC implementations is encouraging. While the status of standards today is healthy, a number of challenges remain. Some of the most critical are as follows:

- Development of SAE J2945.1 Vehicle BSM Communication Minimum Performance Requirements, to specify BSM rate and power constraints.
- Development of a "communications security" framework to supplement the algorithms and frame formats specified in IEEE 1609.2. This framework will define aspects of the public key infrastructure (PKI) over which vehicles will be provided security certificates and certificate revocation notices, as well as a means by which the security infrastructure can be notified if a vehicle detects a misbehaving device. Some aspects of this framework may be documented in IEEE 1609.2, while others will be captured in government regulations.
- Development of a Channel Congestion Control algorithm, especially for the safety channel. While DSRC congestion will not be a problem in the early stages of deployment, the long life cycle of vehicles suggests that even the initial in-vehicle devices have a capability to react to channel congestion by mitigating their own contribution. This capability can then be refined with experience. Congestion control is likely to be standardized eventually, perhaps in SAE J2945.1.
- Policy and Business issues, many of which will not require technical standardization but

which nevertheless are important for deployment, including: enforcement of regulations and standards, certification of devices, field testing and analysis of field data to prove benefits, a decision regarding the potential subsidy of equipment to promote fast market penetration, and harmonization of standards between the United States and other regions of the world.

Nevertheless, the state of development of DSRC is mature and can be safely used for the REDUCTION's purposes.

Since it is customary that all changes and amendments to standards do not radically modify the standard, we feel safe that our decisions of adopting these standards are wise and appropriate.

5. Conclusion

Network management is hard but also much needed by traffic management authorities around the world. The congestion problem is a huge drain on economic resources. For its development, and for easy, cost-effective deployments of network management, an open interoperability standard is indispensable. The DVM Exchange initiative is an attempt to fill in this need. It reflects what is currently known about NM and it tries to be extensible in a backwards compatible way, for future NM measures and approaches. Key elements in its approach are the Hierarchical Model for recursive decomposition of a network, expressing interoperability in terms of effects on traffic on boundary points between the management areas of the two systems involved. Big challenges in the deployment of the standard will be the adoption of the NM approach on which the standard is based and the way to handle legacy systems. The standard has included the "user defined" field in order to ease this transition. Making use of a standard for Network management is a required for REDUCTION. Stepping out of vendor specific definitions will lead to interoperability with other fleet-management systems. Using a generic approach that is based on traffic behavior as mentioned in DVM-Exchange will make this possible. The first version of DVM-Exchange will be operational in the Netherlands in 2013. Work to be done is adding requirements related to REDUCTION, in specific NM measures for CO_2, V2V and V2I. A standard will make it possible to extend easily.

Vehicles utilize a variety of wireless technologies to communicate with other devices. This report focuses on one specific technology, Dedicated Short-Range Communication (DSRC), which is designed to support a variety of applications based on vehicular communication. DSRC is currently under active development. DSRC can be used for many other applications beyond safety applications. Most of these involve communication to and from RSUs. For example, DSRC can be used to assist navigation, make electronic payments (e.g., tolls, parking, fuel), improve fuel efficiency, gather traffic probes, and disseminate traffic updates. It can also be used for more general entertainment and commercial purposes. The word “Dedicated” in DSRC refers to the fact that the U.S. Federal Communications Commission has allocated 75MHz of licensed spectrum in the 5.9 GHz band for DSRC communication. This spectrum is divided into several channels. The term “Short Range” in DSRC is meant to convey that the communication takes place over hundreds of meters, a shorter distance than cellular and WiMax services typically support. REDUCTION will be based entirely on the DSRC layered architecture, and in this report we have highlighted which are the specific areas where REDUCTION partners will focus their efforts in improving these standards.

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