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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 ([1]) standard, which will be an open standard for the interoperability of road traffic management systems, especially in the context of Network Management. Trinité 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.

The rest of this deliverable documents DELPHI's efforts towards standardization.
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1. Introduction

1.1 Project Overview

Reduction of CO2 emissions is the great challenge of the transport sector nowadays. Despite progress in vehicle manufacturing and fuel technology, additional innovative technologies are needed to address this challenge. According to the Int. Assoc. of Public Transport, a significant fraction of CO2 emissions in EU cities is resulting from public transport and other mass transport means, which are commonly organized into multi-modal transport fleets, because their vehicles have, on average, nearly substantial mileage and fuel consumption.

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, which 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 associates driving-behavior patterns with CO2 emissions.

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

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

REDDUCTION 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 results of REDUCTION are made publicly available through peer-reviewed publications, conference presentations, press releases, web pages and brochures. Generated intellectual property is carefully protected, e.g., patent filling. An exploitation and dissemination plan is specified to maximize the outcome and benefit of the project for individual partners. Partners will search for and use existing fleet-management standards used in the EU. Important contributions to these standards are made where applicable.

1.3 Objective of this Deliverable

This task is coordinated by and involves all participants. The currently available standards will be reviewed 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 organizations (e.g. ISO) and approval of suggested extensions will be sought.
2. Related Work and Reduction

Making REDUCTION a success a standard for Network management is a required. 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 CO2, C2C and C2I.

A standard will make it possible to extend easily. It is not necessary to go into details of other systems using the control based on traffic behavior.

Having an existing platform will give the benefit of implementing REDUCTION more easily.
3. DVM Exchange Standard

3.1 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 (\cite{2}).

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 (\cite{3}). Current descriptions of NM (\cite{4, 5, 6, 7, 8, 9, 10, 11, 12, 13}), 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 multidisciplinary 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 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 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.

3.1.1 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. The standard makes a number of assumptions about the two individual systems, and about their relationships.

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 serve 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.

3.1.2 Primary Goal of DVM Exchange

In this setting, 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.

3.1.3 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.**

### 3.1.4 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
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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 stan-
dard, 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.

3.1.5 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-wraper)
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
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-wraper has already been done, and it only needs to be extended with additional requests, if any.
4. Other Standards

4.1 Integrating traffic information using the Datex II standard

In Reduction, the different partners work on models for eco routing, multi modal eco routing, eco driving, prediction, V2V and V2I devices and communication. The information delivered from these systems is in essence the CO2 emission, fuel consumption, location, speed and travel time on certain segments/routes of the area’s that are measured.

![Reduction system architecture](image)

*Figure 3- Reduction system architecture*

The European standard for traffic systems to exchange data is Datex II. The Area Traffic Manager can use through the Datex II exchange, all the information from the partners to calculate an optimised Eco-friendly route.
4.1.1 Description of the Datex II adaption to Reduction

The interface description is based on the Datex II definition. There are some information fields needed for this interface, that are not defined in the Datex II standard. For those fields some information records are defined on top of the standard.

For security and authentication the standard VPN connection between two communicating systems is proposed.

There are two messages defined that needs to be exchanged between two communicating systems:

- A data message, containing data values that needs to be exchanged and
- A message reply, indicating the data message has been received successful or not successful.

The essential information that is exchanged within the data message is:

- CO2 emission, fuel consumption, travel time and velocity
- Identifier of the measured trajectory, to relate the same trajectory in two different systems.
- Location, length and geographical form of the trajectory, to allow display on a geographical map.

The data message structure makes it possible to exchange one or more trajectories within one message and for each trajectory one or more measurements.

The data message contains the following structure and field definition:

<table>
<thead>
<tr>
<th>XML Name (DatexII)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Record: ReductionInformation</strong></td>
<td></td>
</tr>
<tr>
<td>ModelVersion</td>
<td>(integer) Fixed value “1”</td>
</tr>
<tr>
<td>SequenceNr</td>
<td>(Int64) sequence number</td>
</tr>
<tr>
<td><strong>Record: ReductionSupplierIdentification</strong></td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>(string) Two letter country indentification. “nl, du, fr”, etc</td>
</tr>
<tr>
<td>NationalIdentifier</td>
<td>(string) Fixed value: “REDUCTION”</td>
</tr>
<tr>
<td>Language</td>
<td>(string) Fixed value: “en”</td>
</tr>
<tr>
<td>MeasurementType</td>
<td>Enumeration with values: trajectory or point</td>
</tr>
<tr>
<td>SensorType</td>
<td>Enumeration with values: CO2 detector, calculated, ...</td>
</tr>
<tr>
<td><strong>Record: PolutionMeasurement</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td><strong>PublicationTime</strong></td>
<td>(datetime) Current time</td>
</tr>
<tr>
<td><strong>StartTime</strong></td>
<td>(datetime) Start time of the measurement series</td>
</tr>
<tr>
<td><strong>EndTime</strong></td>
<td>(datetime) End time of the measurement series</td>
</tr>
</tbody>
</table>

**Record: ReductionLocation (there can be multiple locations or trajectories)**

| **LocationId**                | (string) Identifier of the location       |
| **TrajectDistance**          | (double) Unit: km. Distance of the measurement traject. Only filled in when it is a traject. |

**Record: ReductionLocationForDisplay (a location can have multiple points when it is a traject. This can be used to visually display the traject)**

| **Latitude**                 | (double) Latitude of the coordinate in WSG84 |
| **Longitude**                | (double) Longitude of the coordinate in WSG84 |
| **Zvalue**                   | (double) Height in meters above sea level (optional) |

**Record: GeneralComment (multiple comments possible per traject)**

| **Comment**                  | (string) Free text field                   |
| **DateTime**                 | (DateTime) Datetime of the comment         |
| **CommentType**              | (enum) Type of the comment                 |

**Record: ReductionMeasuredValue (multiple measurement records possible, for multiple start times). Each traject can have one measurement record for each minute or other time scale. The measurements are over the whole track.**

| **CO2Emission**              | (double)                                      |
| **FuelConsumption**          | (double)                                      |
| **Velocity**                 | (double) Speed in km/hour, of the measured vehicle |
| **TravelTime**               | (double) Traveltime over the traject in seconds. |
| **CO2Exhaust**               | (double) Specific exhaust value in ? Of the measured vehicle |
| **VehicleType**              | (enum) Typ of vehicle. Enum with the values: Car, Bus, Truck |
| **MeasurementStartTime**     | (datetime) Start of the specific measurement  |
| **MeasureMentEndTime**       | (datetime) End of the specific measurement. (optional) when not filled in the start and end time are the same. |

The message reply is the answer to the previous data message, indicating that the data is received. The result can be an acknowledgement or an error. In case of an error, the reason field can be used to give more information about the error condition that occurred.
The message reply contains the following structure and field definition:

<table>
<thead>
<tr>
<th>XML Name (DatexII)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledge</td>
<td>(Boolean) “0” (failed) or “1”</td>
</tr>
<tr>
<td>OrgSequenceNr</td>
<td>(Int64) sequence number of message for which this is a reply</td>
</tr>
<tr>
<td>Reason</td>
<td>(string) description of the error condition</td>
</tr>
<tr>
<td>DateTime</td>
<td>(DateTime) Time reply send</td>
</tr>
</tbody>
</table>

The Datex II definition of the above structures is described in an XSD Interface description, which is developed in detail in Deliverable 4.3.1. The partners of Reduction can use this XSD for implementation of the interface.
4.2 J1939 - Intra-Vehicle communication standard

4.2.1 Overview
The J1939 standard defined by the Society of Automotive Engineers is a recommended practice used for communication among vehicle components. This standard is very commonly in heavy duty vehicles as well as omnibuses in public transportation. Controller Area Network (CAN) is used for the physical layer and data-link layer. The bus-speed is 250kBit/s (defined in J1939/11 and J1939/15, generally used on trucks as well as omnibuses).

4.2.2 FMS – Fleet Management Systems
The FMS-Extension to the SAE J/1939 is based on and fully compliant to the standards J/1939-21 and J/1939-71. The FMS-extension has been created by a group of market-leading heavy-duty manufacturers (IVECO, Daimler Trucks, SCANIA, MAN, and VOLVO) with the purpose in mind to have a common way to communicate with automotive components (ECUs) and the core FMS-component that manages large flees of heavy duty vehicles or public transport vehicles. For the scope of the REDUCTION project only a subset of available data is useful, which is namely the fuel consumption and vehicle motion information (yaw-rate and velocity). The fuel consumption information is carried by the parameter group numbers PGN 64777 (SPN 5053 & SPN 5054) as well as PGN 65257 (SPN 182 & SPN 250) of the J/1939 standard. The FMS-standard extension utilized in the Daimler EvoBus GmbH CITARO omnibus FMS-interface unfortunately does neither support information requesting nor trip fuel information. Also, any information about the data format within the Daimler EvoBus GmbH CITARO omnibus FMS-interface was obtained while researching the SCANIA FMS documentation, due to lack of support and strong resistance of the Daimler Company to provide any information on this matter.
4.3 Introduction to V2X standards

For the V2X area the networks can be divided in the following way:

**V2X – Three Distinct Networks**

![Diagram of V2X networks]

Figure 4: 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.
4.4 SAE Standardizations efforts for V2X

4.4.1 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 is 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.

4.4.2 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 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.
An extended version of the Basic System is shown in the following figure. The extension supports multi-channel, multi-interface operation, service management and IP-based Addressing.

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.

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 Plan 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 7: 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/](http://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.

Please click here to see a list of published ETSI TC ITS standards that are related to the European Commission Mandate M/453 on Cooperative ITS. By today's date, the list includes 63 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.
4.5 Delphi's position on common standards in EU/USA

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:

1. Improved interoperability and interchangeability of Intelligent Transportation Systems (ITS) across operational boundaries;
2. Reduced development and deployment costs for manufacturers;
3. Greater accessibility to international markets for manufacturers of connectivity equipment;
4. Increased competition and innovation amongst manufacturers which can help lower costs and expand service for consumers;
5. The potential for a more rapid deployment of ITS systems;
6 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.

4.5.1 Car-2-car consortium standardization work

Delphi is also an active member in the car-2-car consortium. Here we are mainly involved in the architecture and communication standards.

The block diagram below shows the basic ITS-subsystem that the car-2-car consortium understands:

<table>
<thead>
<tr>
<th>Positioning &amp; Time (incl. minimum data quality requirements)</th>
<th>Relevance Checking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Formats (e.g. CAM/DENM/SPaT/Topo)</td>
<td>Vehicle Data Provider (incl. minimum data quality requirements)</td>
</tr>
<tr>
<td>Rules for Message Generation / Revocation</td>
<td>Congestion Control (DCC)</td>
</tr>
<tr>
<td>Geo-Based Adressing</td>
<td>Congestion Control (DCC)</td>
</tr>
<tr>
<td>Geo-Routing Protocol</td>
<td>In-Car Security Levels (Protection Level, Secure HW)</td>
</tr>
<tr>
<td>ETSI ITS G5 European Profile Standard</td>
<td>C2CCC PKI (Certificate Distribution and Revocation)</td>
</tr>
</tbody>
</table>

Plausibility Checking (coarse, e.g. to prevent replay attacks)
Privacy via time-varying Pseudonyms
Secure Communication (Signatures, Certificates)

Present standards profile document, defines a minimum set of standards and fills missing gaps for creating an interoperable C2C-CC basic system supporting cooperative intelligent transport system (C-ITS) applications, with the aim of increasing road traffic safety and efficiency.

Delphi is particularly interested and contributed to the positioning and timing sub-charts: Positioning and timing protocol has several parts:

POS001 is fixed as the following: A car-2-car basic system should update its position at least 10
times /second when the vehicle is in safety related context.

The POS002 is fixed as the following: After at least one successful GPS fix, the Car-2-car basic system shall keep the system time deviation within 20 milliseconds of the ITS time as specified in the ITS guidelines published by the Car-2-car consortium. It was also decided that if the time cannot be updated due to missing GPS reception, the time deviation can be approximated based on the time passed from the last verified time synchronization, but only up to certain specified time which is not yet fixed.

The POS003 is fixed as the following: If a successful GPS fix is obtained, the C2C-CC basic system shall keep the system position deviation within 40 meters with a probability of 95% as measured inside a time interval of 30 seconds.

Delphi is working on the standardization of the management layer. The management layer consists of configuration management, Congestion control management based on network design limits (NDL) and Cross-layer information exchange via management. These standards are not set yet.

Delphi is also involved in the Car-2-Car Communication Consortium Antenna Task Force.

The objective of this task force was the following:

To provide the specification of relevant antenna-related quantities that determine the performance of V2V communications based on a chosen subset of relevant use cases and describes the testing procedures of the communication link for vehicle-to-vehicle (V2V) applications. It was the objective of the task force to provide the appropriate means to prepare standardization activities in the area of automotive antenna equipment for Car2Car communications, as well as identify the limits of the system.

The key objectives of task forces white paper was the following:

- Define critical use cases that provide quantitative numbers for the minimum requirements and pre-warn times for safety-relevant applications
- Provide the subset of required propagation models for different environments and conditions (line-of-sight (LOS), non-line-of-sight (NLOS)) in order to characterize defined use cases and realize detailed link budget analysis between transmitter and receiver.
- Define all standardization relevant antenna performance parameters that have an impact on the link budget from an antenna’s perspective.
- Description of measurements to be performed for the characterization of the antenna performance qualification and provide possible antenna patterns for the car to car communication.
- Provide examples of Link Budget Computation, to define the packet success rate.
The reference Model that will be used is the following, which depicts an abstract model of a car-2-car communication link:

The C2C communication link is composed of three parts: transmitter, radio channel and receiver.

The antenna frontend and its impact on the wireless channel predominantly define the available link budget between each node in a vehicular network.

V2V communications may only provide an improvement in traffic safety and reliability if every node within the vehicular network provides capabilities to attain a minimum communication range, which in turn leads to specific requirements for antenna performance.

Definition of Antenna Performance:

All parameters were summarized that have an impact on the antenna performance when the antennas are mounted on a vehicle. Some of the parameters are related to the communication channel itself. Other parameters depend on the aspects of vehicular integration, and they include:

- Polarization loss
- Effect of finite sized roof-top or other antenna mounting areas such as mirrors
- Effect of elevated roof top
- Influence of surrounding antenna hood
- Mutual coupling with additional antennas in the same mounting compartment
- Influence from roof insets, sun roofs or railings for roof antennas
- Additional implementation losses

Work was also done to define parameters which are necessary to characterize the antennas for C2C deployment. It was also pointed out that by characterizing only the antennas there is no guarantee that a successful communication link will be achieved. Distinction needs to be therefore made between antenna and communication link performance.

Antenna:
In order to guarantee link performance, two quantities need to be specified subsequently:

**TX antenna gain**

Minimum receive power at the receiver input port.

In order to combine antenna-related parameters (e.g. antenna gain) to yield the minimum link requirements, it is straightforward to define explicit EIRP values. In terms of EIRP values, the TX antenna needs to fulfill the following conditions:

- The minimum available antenna EIRP needs to provide sufficient link margin
- Due to the fact that with the state-of-the-art technology the maximum antenna EIRP of 33 dBr at any angular position according to ETSI standardization cannot currently be achieved, we define as an accepted EIRP value 23 dBr to 25 dBr.
- Due to limitations in antenna manufacturing and automotive mounting, the definition of a sharp minimum available antenna gain represents an unfeasible goal. Integration aspects may easily lead to a punctual degradation of antenna performance at a defined angular position in space. Therefore, stochastic metrics in terms of minimum antenna performance are to be defined.

To evaluate the performance of an antenna an additional stochastic metric which will be called *level crossing rate* is established. For each point on the measurement grid the TX antenna gain has to be determined and all values below a threshold \( P_{\text{TH}} \) have to be included as follows:

\[
p_{\text{cr}} = \frac{1}{N} \sum_{n=1}^{N} (G_n | G_n < G_{\text{TH}}).
\]

In order to define the level crossing rate two additional quantities need to be specified:

- the threshold value \( P_{\text{TH}} \) which is set to 3dBi
- the percentage value: \( p_{\text{LCR}} \) which is set to 90%

The stochastic performance metrics need to be evaluated within a specific solid angle. The limits of the solid angle depend on the relative position between communicating TX- and RX entities in the V2V link. Using the antenna spherical coordination system, we suggest to limit the range between the co-elevation angles of 80° (with 90° equivalent for the horizontal plane) and 110°. In azimuth, all angular values \( 0^\circ \leq \varphi \leq 360^\circ \) need to be considered.

The purpose of the elevation solid angle is to take into consideration the communication link between vehicles of different heights (e.g. trucks) or communication in different traffic vehicle positions (e.g. up/down hills).

The following table defines the specification of antenna parameters. It was suggested by the group to evaluate the level crossing rate at a threshold value of \( P_{\text{TH}} \) that completely consumes the
available link margin at a percentile of 75%.

Practical implementations of single antennas suffer from notches in its polar diagrams. To overcome this problem multiple antenna systems can be used. The calculation of the level crossing rate shall consider this aspect by choosing the maximum gain value of all antennas at each grid point.

Average TX antenna gain

The average TX antenna gain is calculated by

\[ G_{av} = \frac{1}{N} \sum_{n=1}^{N} G_n, \]

where \( N \) is the number of grid points of TX antenna gain values and \( G_n \) the gain in the given solid angle.

**Specification of minimum antenna performance**

<table>
<thead>
<tr>
<th>No.</th>
<th>Performance Definition</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Average antenna TX gain in angular range 0°≤( \theta )≤360° and 80°≤( \phi )≤100°</td>
<td>dBi</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Percentile of level crossing rate in angular range 0°≤( \theta )≤360° and 80°≤( \phi )≤100°</td>
<td>pLCR %</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>Maximum antenna TX EIRP in angular range 0°≤( \theta )≤360° and 80°≤( \phi )≤100°</td>
<td>EIRP</td>
<td>33dBm</td>
</tr>
</tbody>
</table>

Polarization

A vertical polarization was recommended by the group.

Communication range

It is clear that an antenna or antenna array that meets all demands regarding average gain and percentile of level crossing rate is not the only factor to assure a successful communication link. Therefore aside from the antenna characterization, a metric that allows for the overall system verification in a given communication range is also defined.

The packet success ratio is defined as the percentage of correctly received packets by an arbitrary receiver which is sent by the C2C-CC basic system.

For a vehicle to pass the communication range test, a packet success ratio of 90% is defined.

Measurement and Performance Qualification

Different measurements needs to be performed for the characterization of the antenna with and
without the system. The focus is the measurement of the communication range and the consequently verification of the level crossing rate and values given in the table above. Before doing these measurements, it should be ensured that in-system sensitivity measurements have been done.

Antenna measurements

The gain measurements can be performed in an anechoic chamber where the antenna is placed on a roof phantom of a vehicle. Such typical measurements allow for both angle planes to be recorded and for the calculation both of the average antenna gain and the percentile of level crossing rate of the AUT (antenna under Test). The measuring procedure is the same standardized procedure used for all antenna measurements in anechoic chambers.

The angle resolution for the antenna radiation pattern both in the elevation and the azimuth plane must be as high as possible but at least one degree ($\theta \leq 1^\circ$) and the measured angle range should be performed for the angle range listed in table 2. The reason for wanting a high measurement resolution is to record as accurate as possible the radiation pattern of the antenna, when the antenna is mounted on a vehicle.

Communication range measurements

The communication range measurements will be conducted in a calibrated outdoor vehicular antenna measurement range test scenario. These measurements are also based on typical outdoor gain measurements techniques of antennas. A turn table allowing a 360° car rotation as well as an elevation angle setting facility must exist in the measurement site.

Test scenarios

The measurements can be performed under two different scenarios. These scenarios differ from each other by the distance between the transmitter (TRX) and the receiver (TRY) as well as between the transmit power $S_{\text{cal}}$ (e.i.r.p).

The following figure gives an overview of the general scenario and table below lists the main differences between them.
A stationary reference station TRX is located in $D$ from the vehicle under test CAR. The reference station antenna is at height $H$ above ground. TRX is calibrated using the transmit power $S_{\text{cal}}$ in the direction of CAR. In that case the received signal strength at CAR is given by $S_{\text{rx,cal}}$. TRX shall be able to modify the transmit power quasi continuously, e.g. by using a tunable attenuator and also to transmit with high packet rate, i.e. not controlled by DCC.

The receiver of TRX must be able to drop all received packets with received signal strength below a tunable threshold $S_{\text{drop}}$ normally set to the CCA threshold SCCA.

TRX and CAR are started at least $T_{\text{warmup}} = 5$ s before the test run.

During the test the vehicle rotates slowly. Alternatively the vehicle may drive a small circle of radius $r \leq r_{\text{max}}=10$ m.

The measurements need to be taken on an angular grid with $M$ positions in elevation and $N$ positions in azimuth. The angular grid has to be defined according to the measurements requirements and the plots representing the values of the EIRP shall be drawn with an angular resolution not larger than $2^\circ$.

EIRP shall be measured at least at three frequencies including the start, center and end frequency in a frequency interval between 5.875 GHz and 5.925 GHz. The EIRP value is measured from the transceiver output. This means that all relevant additional components (e.g. cables and connectors) are considered during the measurement.

In case of a multiple antenna system, the EIRP shall be determined in accordance with the used diversity method. For example in case of switching diversity, the EIRP outgoing from each antenna shall be measured. Consequently, the best antenna for each angle shall be chosen and the EIRP is then verified in accordance to table mentioned in page 29. The car-2-car consortium paper also mentions several other criteria, where other members worked.
5. Risk assessment

The risk that is associated with this activity of the project is stated as the following:

All the partners that are involved in the standardization activity within this project evaluate the risk of deviation from the description of work as none. The standardization, as described above, is an activity that is well within the time frame as that stated in the description of work.

Moreover the partners also plan to carry this work further for the last year of the project and bring it to a conclusion.
6. 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.
References


## Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>BSA</td>
<td>Basic Set of Applications</td>
</tr>
<tr>
<td>BSM</td>
<td>Basic Safety Message</td>
</tr>
<tr>
<td>C2C</td>
<td>Car-to-Car</td>
</tr>
<tr>
<td>C2X</td>
<td>Car-to-X (Infrastructure or Vehicle)</td>
</tr>
<tr>
<td>C2I</td>
<td>Car-to-Infrastructure</td>
</tr>
<tr>
<td>C2CCC</td>
<td>Car-to-Car Communication Consortium</td>
</tr>
<tr>
<td>C2P</td>
<td>Child-to-Parent</td>
</tr>
<tr>
<td>CAm</td>
<td>Cooperative Awareness Message</td>
</tr>
<tr>
<td>CALM</td>
<td>Communications access for land mobiles</td>
</tr>
<tr>
<td>CAN</td>
<td>Controller Area Network</td>
</tr>
<tr>
<td>CEN</td>
<td>Comité Européen de Normalisation; <em>(European Committee for Standardization)</em></td>
</tr>
<tr>
<td>CENELEC</td>
<td>Comité Européen de Normalisation Électrotechnique; <em>(European Committee for Electrotechnical Standardization)</em></td>
</tr>
<tr>
<td>DENm</td>
<td>Decentralized Environment Notification Message</td>
</tr>
<tr>
<td>DG-INFSO</td>
<td>Directorate General for Information Society and Media</td>
</tr>
<tr>
<td>DSRC</td>
<td>Dedicated Short Range Communications</td>
</tr>
<tr>
<td>DVM</td>
<td>Dynamic Verkeers (Traffic) Management</td>
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<tr>
<td>EFC</td>
<td>Electronic Fee Collections</td>
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<tr>
<td>ESO</td>
<td>European Standardization Organization</td>
</tr>
<tr>
<td>ETC</td>
<td>Electronic Toll Collections</td>
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<tr>
<td>ETSI</td>
<td>European Telecommunications Standards Institute</td>
</tr>
<tr>
<td>HTG</td>
<td>Harmonization Task Group</td>
</tr>
<tr>
<td>HTTP</td>
<td>HyperText Transfer Protocol</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<tr>
<td>IETF</td>
<td>Internet Engineering Task Force</td>
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<tr>
<td>ISO</td>
<td>International Standardization Organization</td>
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<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>ITE</td>
<td>Institute of Transportation Engineers</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation Systems</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
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<tr>
<td>NM</td>
<td>Network Management</td>
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<tr>
<td>NTCIP</td>
<td>National Transportation Communications for ITS Protocol</td>
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<tr>
<td>MAC</td>
<td>Media Access Layer</td>
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<tr>
<td>OCIT</td>
<td>Open Communication Interface for Road Traffic Control Systems</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>P2C</td>
<td>Peer-to-Child</td>
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<tr>
<td>P2P</td>
<td>Peer-to-Peer</td>
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<tr>
<td>PHY</td>
<td>Physical Layer</td>
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<tr>
<td>PKI</td>
<td>Public Key Infrastructure</td>
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WP6   D6.3.2 Second Report on Contributions to Standards

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