Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

USE CASES C-ITS CORRIDOR (NL)

Part B: DUTCH C-ITS CORRIDOR PROFILE

(This report should be accompanied by 4 files which are referred to in par. 3.5, Annex A, B and D)

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Contents

1 Introduction

1.1 Purpose of this Document

The Cooperative ITS Corridor project is a Cooperation between Germany, Austria and The Netherlands for the deployment of Cooperative services which is shortly described in a joint document: Cooperative ITS Corridor Joint deployment [1]. On June 10th 2013, it was agreed by the Ministers of the three mentioned countries to start the deployment of initial services in the Cooperative ITS (C-ITS) Corridor Rotterdam – Frankfurt/M. – Vienna.
Eventually, details regarding the ITS infrastructure have to be shared and agreed upon between all involved parties. This includes members from the automotive industry.

Two cooperative ITS use cases are first planned for use in the Cooperative ITS Corridor:

- Road Works Warning (RWW): from the traffic control centers via the roadside infrastructure to the drivers.
- Basic Probe Vehicle Data (bPVD): vehicles transmit data about the current situation on the road to the roadside infrastructure and the traffic control centers.

This document concerns PART B (DUTCH C-TIS CORRIDOR PROFILE) of the report "USE-CASES C-ITS CORRIDOR (NL)". PART A (FUNCTIONELE BESCHRIJVING) provides a functional description of the use cases to be implemented in the Dutch C-ITS Corridor. This document, PART B, gives an overview of standardisation needs for the two C-ITS use cases for day 1 implementation [6]. The standards provide a wide range of implementation possibilities. The objective of this report is to limit the possibilities to those required and feasible for the Corridor project in the Netherlands. In a next step this report needs to be further discussed with the Amsterdam Group and the partners within the Corridor project .
Standards range from management standards to security standards to standards of a very technical nature. In this document we focus on the DENM [2] and CAM [3] standards which are used to carry the functional information of the RWW and bPVD use cases. These standards are profiled from the Dutch point of view[1] which is formed by Rijkswaterstaat (RWS).

1.2 Definitions, Terms and Abbreviations

Abbreviation / Term	Definition
CAM	Cooperative Awareness Message
C-ITS	Cooperative ITS
C-ITS-S	Central ITS Station
DE	Data Element
DENM	Decentralized Environmental Notification Message
DF	Data Field
GNSS	Global Navigation Satellite System

[1] The Dutch point of view is described (in Dutch) in part A of this document: "USE CASES C-ITS CORRIDOR (NL): DEEL A: Functionele beschrijving".

ITS	Intelligent Transport System
MTM	Motorway Traffic Management(system)
NDW	National Data Warehouse for Traffic Information
R-ITS-S	Roadside ITS Station
TCC	Traffic Control Centre
TMA	Truck Mounted Attenuator
V-ITS-S	Vehicle ITS Station
IEEE	Institute of Electrical and Electronics Engineers
PVD	Probe Vehicle Data
bPVD	Basic Probe Vehicle Data
RWW	Road Works Warning
ePVD	Extended Probe Vehicle Data
HMI	Human Machine Interface
IVI	In-Vehicle Information
ISO	International Organization for Standardization
SAE	Society of Automotive Engineers
RWS	Rijkswaterstaat

1.3 References

#	Description, URL
1	Cooperative ITS Corridor Joint deployment link
2	ETSI EN 302 637-3 v1.2.2 (2014-11). Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service.
3	ETSI EN 302 637-2 v1.3.2 (2014-11). Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service.
4	ETSI TS 102 894-2 v1.2.1 (2014-09). Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities. layer common data dictionary
5	Overview of Standards for First Deployment of C-ITS link
6	Amsterdam Group – Road Works Warning Functional Description, Version 1.0
7	Handboek wegafzettingen Autosnelwegen (CROW 96a)
8	Message Set and Triggering Conditions for Road Works Warning Service
9	Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band
10	SWP 2.1 Use Cases. Road Works Warning. WP 2 - System Definition. Version: 01.00
11	SWP 2.1 Use Cases. CAM Aggregation. WP 2 - System Definition. Version: 02.00
12	SWP 2.3 System Specifications. System Overview. WP 2 - System Definition. Version: 01.00

2 Scope

The profiling of the standards for the two use cases within the Corridor project is done with practical applications in mind. The focus for the RWW use case is on the DENM [2] standard and for the PVD service on the CAM [3] standard. These standards provide the framework for the functional content of the use cases.
Both standards are used to broadcast information: DENM from the road side and CAM from the vehicle. Standards or applications that receive, process, interpret or present/visualize the information are out of scope.

2.1 Constraints and pre-conditions

In part A "Functionele beschrijving", a complete overview is given of all the constraints and pre-conditions regarding the first deployment of the Corridor use cases. The most relevant are:

- The focus is on Motorways only;
- National guidelines (e.g. CROW) are leading;
- HMI is out of the scope;
- Only Co-operative use cases are investigated;
- Only fixed roadside ITS stations (R-ITS-Ss) are considered. Mobile (portable) roadside ITS stations are not discussed within this document;
- Work need to be harmonized and lined up with the Amsterdam Group and with the German and Austrian (Eco-AT) partners.

2.2 Road Works Warning

The DENM standard is profiled for the Short Term Static and Unplanned (ad-hoc) Road Works types of Road Works Warning only. Long Term Road Works and Short Term Mobile are not part of this document. Definitions of those types can be found in [5].
In the Netherlands, CROW provides guidelines on how to setup road works safety measures. Various road works layouts are depicted in the CROW publication "Handboek wegafzettingen Autosnelwegen 96a" [7]. Those layouts are the primary input for the profiling of the DENM standard. An overview is provided (Annex A) which shows to what extent layouts from CROW 96a are possible with DENM.
As a starting point the documents "Amsterdam Group – Road Works Warning Functional Description" [6], "Message Set and Triggering Conditions for Road Works Warning Service" [8] of the Amsterdam Group and [10] from ECo-AT are used.

In-Vehicle Information
In the initial phase of the Corridor project it was decided by the Amsterdam Group to use the DENM standard for the Road Works Warning use case. At the time of writing, a new standard 'In-Vehicle Information' (IVI) is under development. Eventually, when completed, this new standard will most likely be a good alternative for the RWW use case. Some restrictions within DENM like usage of parallel lanes and hard shoulder at inner side of the road, will not exist within IVI.

2.3 Basic Probe Vehicle Data

PVD is an important part of (infrastructure based) C-ITS, providing valuable data about the traffic status on the road, transmitted by "C-ITS equipped" vehicles. For the first implementation it is expected that only the CAM messages will be broadcasted by the vehicles. Within the Corridor the bPVD use case will therefore be built on aggregated CAM messages [3] emitted by the vehicles. The roadside ITS

stations (R-ITS-Ss) will aggregate these CAM messages from the coverage area of the R-ITS-S. This is similar to the approach used by Austria as described in [11] from the ECo-AT project.
It must be noted that for this use case there is a strong dependency on the industry. It is based on data that needs to be provided by the vehicle manufacturers. Without their involvement and willingness to act, this use case will not be feasible.

Using the CAM standard, many properties and/or attributes of vehicles can be broadcasted (and received by a R-ITS-S). This includes data types similar to loop detector data (LDD), like speed, but also, the status of the vehicles lights and the vehicles length. This information enables road operators to indirectly detect for example (possibility of) fog through the vehicles fog-light status. The length is included as form of backwards compatibility, because currently in the Netherlands the length is used to classify vehicles. Other data types like cruise control settings can also be transmitted using CAM, however but that will not be part for Day 1 applications in the Netherlands.
The profile defined by Austria is used as a starting point for the Dutch PVD profile. Germany does not actively participate in the PVD use case.

An extended PVD (ePVD) use case is also defined in [5]. This use case also enables data collection (buffering) while out of range of a R-ITS-S. When in range, the data is transmitted for a more detailed picture of the status on the road. However, this extended service is out of scope, because the current CAM standard is insufficient for the extended version. The extended version would require additional standardization efforts to specify in what way the CAM messages would be buffered and sent. Besides that, there would have to be made agreements with the car manufacturers to implement this “buffering” technique.

2.4 Common standards

Standards mentioned above are part of the Facilities layer. Other required standards from the Facilities and other layers may also need profiling, but less extensive. Also, those profiles are of a more general nature, not specific for any use case. Other standards are listed per layer by name in par. 3.3 and par. 4.3.

3 Road Works Warning

3.1 Service Summary

The Road Works Warning use case informs drivers of road works ahead, their relevant parameters and associated obstructions (e.g. closed lanes) and restrictions. The purpose is to alert the driver in time to increase awareness and to inform of potentially dangerous conditions. Short range communications ITS-G5 [9] will be used because of the ad-hoc and dynamic nature of the information.

Two types of road works are considered:

1. Short Term Static
   The road works in the Short Term Static category are planned road works. Therefore there is sufficient time to determine the parameters of the road works and thus the values for each of the data elements of a DENM.
2. Unplanned (ad-hoc) Road Works
   Ad-hoc road works are deployed fast and thus DENMs are likely filled in a different way, possibly less complete, than DENMs for planned road works. Other than the planned aspect, the ad-hoc road works themselves are similar in layout to Short Term Static.

In general, 3 scenarios can be foreseen:

- RWW is distributed from the trailer via portable R-ITS-S mounted on the trailer with no connection to the C-ITS-S; only a basic RWW message will be generated autonomously based on ego data available in the R-ITS-S or from the trailer control units via a local interface.
- RWW is distributed from a safety trailer via a portable R-ITS-S mounted on the trailer and connected to the C-ITS-S via cellular network (master functionalities are covered by C-ITS-S, Slave is R-ITS-S).
- RWW information is distributed from a fixed installed R-ITS-S which is directly connected to the Central-ITS-Station (C-ITS-S) via fixed or cellular network.

This document focusses on the third option: fixed installed R-ITS-Ss. Other options will have to be worked out in a later stage.

3.2 Dutch Situation

Part A provides a background of the Dutch environment in which the Corridor will be implemented. For RWW, existing guidelines (CROW) need to be respected. Guidelines on which layout to use for certain types of road works are depicted in "Handboek wegafzettingen Autosnelwegen 96a" [7]. More than 25 different layouts for different road configurations and road works types are defined in this guideline. Not all those layouts completely fit within a DENM message [2]. The main two reasons for that are (1) DENM was not created for road works and (2) the dynamic/complex Dutch motorways enable some very specific road works measures that are unique to the Netherlands. For example, there are many dynamic lanes (see Figure 1), on the right (hard shoulder) and left side (narrow extra lane). These lanes are usually available for driving during rush hour, but closed when traffic volume is low. In the table in Annex A an overview is given on which configurations are possible and which are limited.

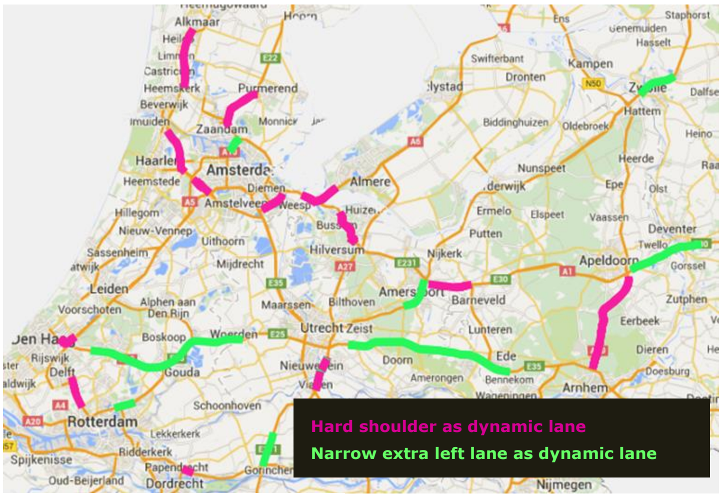


FIGURE 1: DYNAMIC LANES

3.3 Required Standards

Below the set of required standards for the RWW use case is given (Table 1). Note that the Cooperative Awareness Basic Service (ETSI EN 302 637-2; which includes the CAM) is included. For the PVD use case this standard is explicitly profiled.

Nr	Name	Latest version
	Management Layer (and architecture)	
ETSI EN 302 665	Communications Architecture	1.1.1
ETSI TS 102 965	Application Object Identifier: Registration list	1.1.1
	Application Layer	
ETSI TS 102 638	Basic Set of applications (BSA): Definitions	1.1.1
ETSI TS 101 539-1	V2X Applications; Part 1; Road Hazard Signaling (RHS) app. req. spec.	1.1.1
	Facility Layer	
ETSI TS 102 894-1	Facility layer structure; functional requirements and specifications	1.1.1
ETSI TS 102 637-1	Basic Set of Applications (BSA); Part 1: Functional Requirements	1.1.1
ETSI EN 302 637-2	Cooperative Awareness Basic Service (CAM)	1.3.2
ETSI EN 302 637-3	Decentralized Enviromental Notification Message (DENM)	1.2.2
ETSI TS 102 894-2	Common Data Dictionary (CDD)	1.2.1
ISO TR 20025	Probe Data Application and System requirements	?
ETSI EN 302 895	Vehicular Communications; BSA: Local Dynamic Map (LDM)	1.1.1
ISO TS 17419	ITS-AID (Application ID)	?
ISO TS 18750	Extended Infrastructure oriented Local Dynamic Map (LDM)	?
ETSI TS 102 890-2	Service Anouncement Message (SAM)	Draft (approval 2015-11)
	Network&Transport Layer	
ETSI EN 302 636-1	GeoNetworking: Requirements	1.2.1
ETSI EN 302 636-2	GeoNetworking: Scenarios	1.2.1
ETSI EN 302 636-3	GeoNetworking: Network Architecture	1.2.1
ETSI EN 302 636-4-1	GeoNetworking: Media-Independent Functionality	1.2.1
ETSI TS 102 636-4-2	GeoNetworking: Media-Independent Functionality for ITS-G5	1.1.1
ETSI EN 302 636-5-1	GeoNetworking: Basic Transport Protocol	1.2.1
ETSI EN 302 931	Geographical Area Definition	1.1.1
	Access Layer	
ETSI EN 202 663	Access layer spec. for ITS operating in the 5 GHz frequency band (ITS-G5)	1.2.1
ETSI TS 102 687	Decentralized Congestion Control Mechanisms for ITS-G5 (DCC)	1.1.1
ETSI TS 102 724	Harmonized Channel Specifications for ITS-G5	1.1.1
ETSI EN 302 571	Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band	1.2.1
ETSI TS 102 792	Mitigation techniques to avoid interference between CEN DSRC and ITS-G5	1.1.1
IEEE 802.11	Lower Layer specifications (ensuring ITS in 5.9 GHz)	?
	Security Layer	
ETSI TS 102 867	Stage 3 mapping for IEEE 1609.2	1.1.1
ETSI TS 102 940	ITS communications security architecture and security management	1.1.1
ETSI TS 102 941	Trust and Privacy Management	1.1.1
ETSI TS 102 942	Access control	1.1.1
ETSI TS 102 943	Confidentiality services	1.1.1
ETSI TS 103 097	Security header and certificate formats for ITS G5	1.1.1

TABLE 1: REQUIRED STANDARDS

3.4 DENM Profile

In "Annex B: DENM Profile" a screenshot (more or less readable) is shown of an Excel file that accompanies this document. The Excel file shows the full DENM structure and profiled data fields (DF) and elements (DE) with explanations per DE. The legend shows the different status of the data fields/elements:

- *Italic*: these are optional in the standard;
- <u>Underlined</u>: one of these can be chosen (OR);
- **Bold**: required by the standard;
- The label 'spec': values can be set according to the standard / specification;
- Orange: required for the Dutch RWW Corridor profile.

The description of the data elements / fields can all be found in [2] or [4]. Most of the text describing the DEs and DFs from these standards is also included in the Excel file as comments attached to the cells.

Below is described how each DF / DE from the DENM standard is used within the Dutch RWW use case. In addition, examples with explicit road works are shown in par. 3.4.3.

header	
protocolVersion	Version of the protocol. Current version is 1, thus field is set to 1.
messageID	Indicates the type of message. Examples are denm(1), cam(2), ivi(6), etc. Here 1 is used.
stationID	This is the ID of the station broadcasting the message.
management container	
actionID	The actionID consists of DEs originatingStationID (stationID) and sequenceNumber. The first is set to the ID of the station first encountered by a vehicle. The sequenceNumber starts at the first unused value and is increased for each additional DENM message. Together the elements form a unique identifier for each DENM message.
detectionTime	This is set to the time the road work starts at a functional level. Usually this is the time a corresponding red cross and/or speed limit appears on a MTM display. Basically this is the time from which the content of the DENM becomes valid. Depending on the exact specification of message management this time can be updated / changed. See par. 3.4.1.
referenceTime	This is the timestamp of the first time a DENM with a certain actionID is generated (i.e. the time the message was first broadcasted). Depending on the exact specification of message management this time can be updated / changed. See par. 3.4.1.
termination	Depending on the exact specification of message management this DE can be used to update or cancel a DENM. See par. 3.4.1.
eventPosition	This DF is of type ReferencePosition (DF A.124 from ETSI TS 102 894-2). It contains the coordinates (WGS 84) of the position from where a lane is closed. Usually it is the first encountered MTM with a red cross. However, it is also possible that the lane closure is realized using a trailer. In case of the hard shoulder it is even possible only some rumble strips and guidance markers are used. Altitude and confidence DEs are not used and thus set to the values corresponding with 'unavailable'.
relevanceDistance	Together with relevanceTrafficDirection, this DE forms the relevance area. The relevance area is a geographic area in which information concerning the event is identified as relevant for use or for further distribution. This is set to lessThan1000m(4).

relevanceTrafficDirection	This DF indicates for which traffic direction the message is relevant (from the perspective of the sender). It is set to 1 (upStreamTraffic).
validityDuration	The time at which the message should be deleted with an offset since detectionTime. The value depends on the exact specification of message management. See par. 3.4.1.
stationType	This defines the type of the station broadcasting the DENM. This is set to 15 (roadSideUnit). This is true for both fixed R-ITS-S (MTM) and portable R-ITS-S.
situation container	
informationQuality	This can be set to one of eight different values (0 .. 7). It is not specified by ETSI what the different values mean. The Amsteram Group has made a proposal for the meaning of the values [8, par. 6.2]. For now it is set to 1. See par. 3.4.2.
eventType	This DF exists of a DE causeCode and subCauseCode. The causeCode is set to 3 (road works) and subCauseCode to either 3 (slowMovingRoadMaintenance) or 4 (shortTermStationaryRoadworks) which correspond to 'Short Term Mobile' and 'Short Term Static' respectively. 'Unplanned (ad-hoc) Road Works' is either 3 or 4. For now, the focus is on 'Short Term Static' and thus only 4 is used.
eventHistory	This is a sequence of EventPoints which together form a trace from the eventPosition until the end of the road works or, if it exists, the eventPosition of the next related DENM (downstream). It therefore defines the (length of the) area for which the DENM is valid. Which DENMs are related is defined by referenceDenms DF (see below). Points will only be available on the accuracy level of a carriage way. (See 3.4.3 about the number of points)
location container	
eventSpeed	This DF could be used for mobile road works, but since there will be (mobile) MTM in place and moving road works will move within closed areas, it is not relevant, only the closed areas are. Those are, however, static and can be seen as Short Term Static. As a result, in the Dutch profile, this DF is not used.
eventPositionHeading	See eventSpeed above.
traces	This DF exists of up to 7 traces of type PathHistory. These traces exist of points describing the path towards the eventLocation. These are used by approaching vehicles to determine whether the DENM is relevant or not. Points will only be available on the accuracy level of a carriage way. Multiple traces are therefore only useful when the road works area is shortly after a junction.
alacarte container	
lanePosition	This DE indicates on which lane the eventPosition is positioned.
roadWorks container (container within alacarte container)	
closedLanes	The closeLanes DF exists of two DEs: hardShoulderStatus and drivingLaneStatus. The hardShoulderStatus indicates whether the hard shoulder is available for driving, stopping or is closed. The drivingLaneStatus, counting from the outside, is a sequence of bits indicating whether the lane is closed (1) or not (0).
speedLimit	This is the speed limit in km/h. This limit is valid from the startingPointSpeedLimit (see below) up to the last point in the eventHistory (see above).
incidentIndication	See eventType in the situation container. It is set to the same values.

startingPointSpeedLimit	This describes the position from which the speed limit (see speedLimit) is valid as an offset from the eventPosition (see above) as ΔLatitude, ΔLongitude, ΔAltitude in 1/10th of a microdegree. The lateral position of this point is in the middle of the carriageway.
trafficFlowRule	This DE indicates whether vehicles shall merge to the left (3) or right (2). Values 0 and 1 indicating passage rules are not used.
referenceDenms	This is a sequence of up to 8 actionIDs. As described above in the actionID DF from the managementcontainer, an actionID forms an unique ID for a given DENM. This sequence shall hold a unique set of DENMs which belong to the same road works.

Legend	
bold	required by standard
cursive	optional by standard
normal	required when parent container is used

3.4.1 *Message Handling*

When broadcasting DENMs it has to be defined how often messages will be broadcasted, how they are updated and eventually cancelled or negated. This can be done in several ways and many choices have to be made, having individual advantages disadvantages.
Within the Amsterdam Group some progress has been made in the area of message handling [8] as well in the ECo-AT project of Austria [12]. However, at the time of writing there is not yet a final set of definitions for the message handling available.

3.4.2 *informationQuality*

The Amsterdam Group has defined following the informationQuality classes [8] for RWW. The following options are determined as indicators for the quality of transmitted information:

a. eventPosition: planned position (by road operator)
b. eventPosition: simple GNSS
c. eventPosition: differential GNSS
d. eventPosition: validated position (e.g. map-matching)
e. traces: planned position (by road operator)
f. traces: simple GNSS
g. traces: differential GNSS
h. traces: validated positions (e.g. map-matching)Text

The informationQuality value shall be set according to the following criteria:

Class	Criteria
0	Not defined
1	a AND e (planned by road operator)
2	b AND f (simple GNSS)
3	c AND g (differential GNSS)
4	d AND h (validated positions)
5	Not defined
6	Not defined
7	Not defined

The options (d) and (h) (validated position (e.g. map-matching)) are not defined in detail in the Amsterdam Group document. Until there is a final definition of these values, (a) is used for eventPosition and (e) for traces (planned position).

3.4.3 *Discrepancy EventHistory - 23 or 40 Points*

A discrepancy exists between the DENM [2] and the Common Data Dictionary [4] standard. In DENM it is stated that 23 points are allowed in the EventHistory data field, but a reference is also made to the Common Data Dictionary version of the EventHistory data field where 40 points are allowed. This discrepancy needs to be solved.
Note: the SAE J2735 standard allows 23 points in a similar data field.

3.5 DENM Examples

Below, two road works layouts are shown: one with one lane closed off (and the hard shoulder) and one with two lanes closed off. These examples are also included in the attached PowerPoint file: "DENM CROW 96a Fig 210 and 310 - v1.0.pptx".

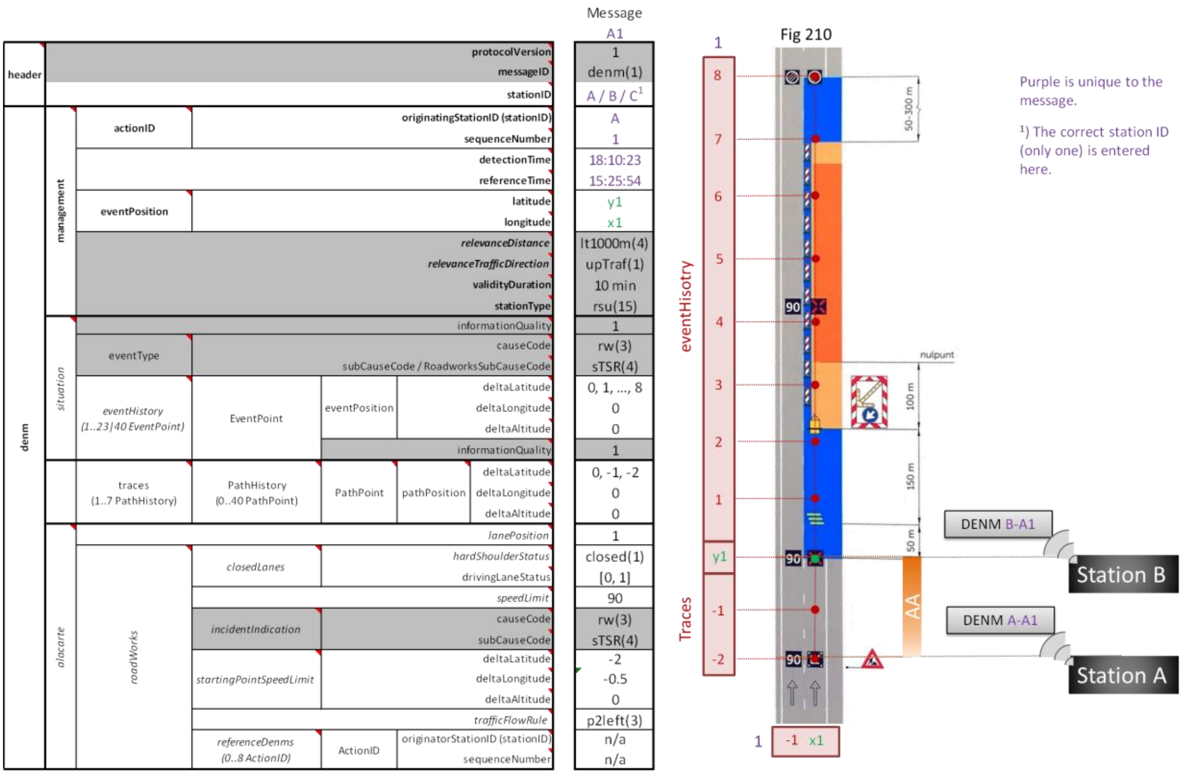
It is important to note, that the values used in these examples are fictional. Also, the type of values used for each DE may deviate from the ETSI standards for explanatory purposes. For example, the coordinates are shown as x1, 1, 2, etc., but in the standard, the WGS84 reference system is used. Another example is the time values. Here "readable" time notation is used like 18:10:23, but in the standard the number of milliseconds since 2004-01-01T00:00:00.000Z, as specified in ISO 8601, is used.

The DEs marked grey in the figures do not change from example to example and are always the same for road works of the type Short Term Static.

Additionally in Annex C a figure is included which shows the relations between the functional road works layout and several technical elements. This figure can help to understand the examples below and vice versa.

3.5.1 *CROW 96a Fig. 210*

Road works on the hard shoulder, within 1.10m from the border line.



In Figure 210 road works are shown where a single lane is closed and there is an accompanying speed limit of 90 km/h. The red boxes with numbers in them represent an imaginary coordinates system. Using those imaginary coordinates, it is shown how a DENM would be filled for these road works.

Location

The *eventPosition* indicates from where the lane is closed and thus corresponds to the red cross. It is positioned at (x1, y1) and is the reference position for all other location based elements (i.e. the zero point).

Road Works Area

The stretch of road for which the cross section (i.e. speed limit, closed lanes, etc.) remains the same is represented by the *eventHistory* which consists of 9 points [(x1, y1), …, (x1, 8)]. Those points are positioned on the closed lane. At least the first and last points are needed to mark the beginning and end of the said stretch of road. Those positions correspond to the *eventPosition* (gantry with the red cross) and the gantry that removes all restrictions (at x=8). In this example the length of the *eventHistory* equals the length of the road works (in the next example this is slightly different).

The fact that the right lane is closed is also shown by *drivingLaneStatus*. That DE has the values [0,1] indicating that the left lane is open and the right lane is closed in the road works area. In addition the hard shoulder is unavailable for stopping/closed in the road works area. This is indicated by the *hardShoulderStatus* which has the value 1 (closed).

Lastly, downstream of the eventPosition the trailer is located. On which lane the trailer is located, is indicated by the *lanePosition* DE. The lanes are counted from the outside of the road. As a result, in this case, the value is set to 1.

Awareness Area (AA)
Upstream of the closed lane (red cross) an area is marked as the Awareness Area. This is the area confined by the starting point of the speed limit, *startingPointSpeedLimit*, and the red cross. The red cross, as stated, is indicated by the eventPosition (x1, y1) and the *startingPointSpeedLimit* by the relative coordinates (-0.5, -2). The y-value -2 corresponds with the cross section where the gantry showing the speed limit is positioned. The value -0.5 refers to the middle of the carriageway. The speed limit itself, in this case, 90, is represented by the DE *speedLimit*.
The speed limit is accompanied by an arrow indicating vehicles should pass to the left. Although the arrow or its location is not *explicitly* communicated, its *message* is communicated using the *trafficFlowRule* element. It is set to 3 (*passToLeft*). That way drivers it is known vehicles should pass to the left to pass the closed lane.

In addition the DF *traces* is used to indicate the Awareness Area. It exists of a series of points starting at the *startingPointSpeedLimit* and ending at the *eventPosition*. For this example it is [(x1,-2), (x1,-1), (x1,y1)].

Relevance Area
Another area that is defined upstream of the *eventPosition* is the Relevance Area. The relevance area is a geographic area in which information concerning the event is identified as relevant for use or for further distribution. The length of the area is defined by the DE relevanceDistance and is set to 4 (lessThan1000m).
Another attribute used for the Relevance Area is the *relevanceTrafficDirection*. This DE indicates for which traffic, as seen from the *eventPosition*, the information is relevant. In case of road works it is upstream. The value is therefore set to 1 (*upstreamTraffic*).

Time
Above, all spatial aspects of DENM are covered. They specify <u>where</u> the DENM is valid. The DE *detectionTime* specifies <u>when</u> the DENM is valid. The DENM is valid from the time mentioned in *detectionTime* until time period mentioned in *validityDuration* has passed.
The remaining time DE is *referenceTime*. That DE is used to timestamp the broadcasted message. It is set to the time the DENM was broadcasted for the first time (i.e. the time the DENM was generated for the first time).
The exact values and the way the DE are eventually used will depend on the message handling specification (see par. 3.4.1).

Other
There are a few DEs, other than spatial or temporal, left. The most important are *stationID* and the DF *actionID* containing DEs *originatingStationID* and *sequenceNumber*.
The *stationID* is set to the station identity that broadcasts the message. Which/what message that is, is determined by the *actionID*. In other words, the *actionID* is the identifier for messages with the same content. The *originatingStationID* is set to the *stationID* first encountered by vehicles driving up to the road works. The *sequenceNumber* is increased with 1 for each new DENM message (having a different content and not being an update of a previous message).

It is important to note that each DENM (with the same *actionID*) can be transmitted from any ITS station. Only the value of the stationID would change in such a scenario. In the ether, there can be two DENMs, broadcasted by different stations (*stationID*), but with the same content (*actionID*). To illustrate this, the attributes in the example figures related to these IDs are shown in purple.

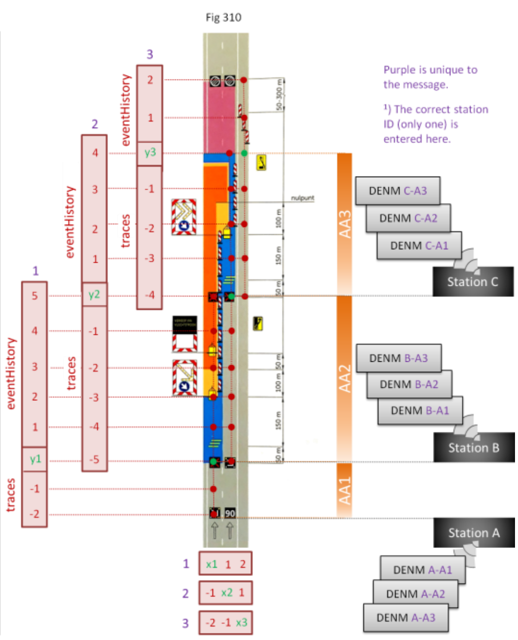
In this example just one DENM is needed. If, however, multiple DENMs are needed, they will refer to each other's *actionIDs* within the *referenceDenms* DF. This is explained in the next example (par. 3.5.2.; Fig. 310).

Three DEs remain: *informationQuality*, *causeCode* and *subCauseCode*. The *informationQuality* is used to indicate the accuracy/quality of the information. It can be set to one of eight values (0-7). What each value represents is, however, not defined by ETSI. A proposal is done by the Amsterdam Group, but it is not finalized yet (see par. 3.4.2).
The *causeCode* and *subCauseCode* indicate the type of event the DENM refers to. In this case that is 3 (*roadworks*) and 4 (*shortTermStationaryRoadworks*).

3.5.2 *CROW 96a Fig. 310*

Road works on multiple bordering lanes.

Container	Element	Field	Message A1	Message A2	Message A3
header		protocolVersion	1	1	1
header		messageID	denm(1)	denm(1)	denm(1)
header		stationID	A / B / C[1]	A / B / C[1]	A / B / C[1]
denm / management	actionID	originatingStationID (stationID)	A	A	A
denm / management	actionID	sequenceNumber	1	2	3
denm / management		detectionTime	18:10:23	18:10:25	18:10:28
denm / management		referenceTime	15:25:54	15:25:58	15:25:59
denm / management	eventPosition	latitude	y1	y2	y3
denm / management	eventPosition	longitude	x1	x2	x3
denm / management		*relevanceDistance*	lt1000m(3)	lt1000m(3)	lt1000m(3)
denm / management		*relevanceTrafficDirection*	upTraf(1)	upTraf(1)	upTraf(1)
denm / management		validityDuration	10 min	10 min	10 min
denm / management		stationType	rsu(15)	rsu(15)	rsu(15)
denm / *situation*		informationQuality	1	1	1
denm / *situation*	eventType	causeCode	rw(3)	rw(3)	rw(3)
denm / *situation*	eventType	subCauseCode / RoadworksSubCauseCode	sTSR(4)	sTSR(4)	sTSR(4)
denm / *situation*	*eventHistory (1..23|40 EventPoint)* / EventPoint / eventPosition	deltaLatitude	[0, 1, ..., 5]	[0, 1, ..., 4]	[0, 1, 2]
denm / *situation*	*eventHistory (1..23|40 EventPoint)* / EventPoint / eventPosition	deltaLongitude	0	0	0
denm / *situation*	*eventHistory (1..23|40 EventPoint)* / EventPoint / eventPosition	deltaAltitude	0	0	0
denm / *situation*	*eventHistory (1..23|40 EventPoint)* / EventPoint	informationQuality	1	1	1
denm	traces (1..7 PathHistory) / PathHistory (0..40 PathPoint) / PathPoint / pathPosition	deltaLatitude	[0, -1, -2]	[0, -1, ..., -5]	[0, -1, ..., -4]
denm	traces (1..7 PathHistory) / PathHistory (0..40 PathPoint) / PathPoint / pathPosition	deltaLongitude	0	0	0
denm	traces (1..7 PathHistory) / PathHistory (0..40 PathPoint) / PathPoint / pathPosition	deltaAltitude	0	0	0
denm / *alacarte*		*lanePosition*	2	1	0
denm / *alacarte*	*roadWorks* / *closedLanes*	*hardShoulderStatus*	aFS(0)	aFD(2)	closed(1)
denm / *alacarte*	*roadWorks* / *closedLanes*	drivingLaneStatus	[1, 0]	[0, 0]	[1, 1]
denm / *alacarte*	*roadWorks*	*speedLimit*	90	90	90
denm / *alacarte*	*roadWorks* / *incidentIndication*	causeCode	rw(3)	rw(3)	rw(3)
denm / *alacarte*	*roadWorks* / *incidentIndication*	subCauseCode	sTSR(4)	sTSR(4)	sTSR(4)
denm / *alacarte*	*roadWorks* / *startingPointSpeedLimit*	deltaLatitude	-2	-5	-4
denm / *alacarte*	*roadWorks* / *startingPointSpeedLimit*	deltaLongitude	0.5	-0.5	-1.5
denm / *alacarte*	*roadWorks* / *startingPointSpeedLimit*	deltaAltitude	0	0	0
denm / *alacarte*	*roadWorks*	*trafficFlowRule*	p2right(2)	p2right(2)	p2left(3)
denm / *alacarte*	*roadWorks* / *referenceDenms (0..8 ActionID)* / ActionID	originatorStationID (stationID)	[A, A, A]	[A, A, A]	[A, A, A]
denm / *alacarte*	*roadWorks* / *referenceDenms (0..8 ActionID)* / ActionID	sequenceNumber	[1, 2, 3]	[1, 2, 3]	[1, 2, 3]



In Figure 310 road works are shown where two lanes are consecutively closed off with an accompanying speed limit of 90 km/h. It differs from the previous example in that three DENMs are now needed to describe the road works. Below, only deviations from the first example are described.

Location

Instead of one *eventPosition*, there are now three (shown in green): one for each “closed lane” / ”red cross” / ”closed hard shoulder”. That also means there are now three coordinate systems and thus reference positions (zero points) for all other location based elements. However, the principle on how to refer to those locations, remains the same.

Road Works Area

In the previous example the *eventHistory* represented the length of the road works area. However, only one DENM was needed. In this example, the *eventHistory* of all DENMs need to be summed up to determine the length of the road works area. The *eventHistory* for each DENM is confined by its *eventPosition* and the *eventPosition* of the next DENM. As a result each DENM describes a stretch of road within which the traffic rules do not change (i.e. speed limit, closed lanes, status of the hard shoulder, etc.).

The *drivingLaneStatus* for the three DENMs is respectively [1,0], [0,0] and [1,1], meaning first the left lane is closed, than the right lane is closed and after that, both lanes are available again.

The *hardShoulderStatus* is 0 (*availableForStopping*), 2 (*availableForDriving*) and 1 (*closed*), meaning the first part is the normal situation, the second part makes the hard shoulder available for driving and, lastly, the hard shoulder is shortly unavailable because of the markers forcing the road users back onto the road.

Finally, the *lanePosition* DE is used to indicate which lane has a red cross, trailer or is otherwise closed. The values for the three DENMs (counting from the outside of the road) are respectively, 2, 1 and 0.

Awareness Area (AA)
The traces DF translates the same way to this example as the *eventHistory* DF does. It is interesting to note that for the first two DENMs the *trafficFlowRule* is set to 2 (*passToRight*) and for the third DENM to 3 (*passToLeft*). This corresponds with the required flow of traffic around the road works.

Relevance Area
This is the same as in the first example, except the area is shifted with each eventPosition.

Time
Each DENM has its own timestamps, but other than that, there is no further difference with the first example.

Other
Since there are now three DENMs, the *sequenceNumber* has to be updated. For the purpose of the example, these are set to 1, 2 and 3 for the three DENMs respectively. The *originatingStationID* is A for all DENMs, since A is the first station encountered by traffic driving up to the road works.

Most interesting about this example is, however, the use of the DF *referenceDenms*. That container now holds the *actionIDs* of all DENMS: [(A,1), (A,2), (A,3)]. That way, the recipient of the broadcasted DENMs "knows" that these messages belong together and as a whole describe the road works.

Other DFs and DEs are used similarly as in the first example.

4 Probe Vehicle Data

4.1 Service Summary

Traffic flow data is collected by means of inductive loops in the road surface or with cameras, radars, etc. Probe Vehicle data can extend or (partially) replace this with data from vehicles transmitted through CAM-messages.
The basic information covered by these messages contains: vehicle position, vehicle speed, vehicle direction, vehicle lights statuses and vehicle length.
This data can be aggregated at R-ITS-S's and then be sent to a central system. There it can be further processed and presented to Road Operators (ROs). As a result, they can get a better understanding of the status of traffic.
At this stage only the basic Probe Vehicle Data use case will be profiled, based on standard CAM transmission.
The extended version, where data is temporarily stored in the vehicle until the moment it passes a R-ITS-S, is not in the current scope.

4.2 Dutch Motorway Data Collection

Currently, in the Netherlands traffic data is mainly collected through (double) induction loops. Additionally, as part of the National Data Warehouse for Traffic Information (NDW), systems based on Passive Infrared Detectors (PID) have been deployed. What these systems have in common is that they provide: vehicle speed, volume and class of vehicle (based on (magnetic/thermal) length). The data is aggregated in roadside equipment and sent to central systems.
The density of above mentioned detectors is approximately one each 500 meters on roads with heavy traffic. On road with less heavy traffic the distance between loops can be much larger.

4.3 Required Standards

Table 1 (Par. 3.3) gives an overview of the required standards. This list also contains the DENM standard [ETSI EN 302 637-3]. The Amsterdam Group has decided not to make use of DENM for PVD since it is not known yet whether and when vehicle manufacturers will implement DENM for broadcasting data.

4.4 CAM Aggregation

Vehicles can periodically broadcast information about their position, speed, heading, etc. with an interval between once and ten times per second (1Hz – 10Hz) according to [3]. The data is not always transmitted from the same position.
To be able to map the traffic data to certain points or road segments the Austrian concept as described in their profile, is used. Around an R-ITS-S virtual zones are defined as depicted in Figure 1. These zones are configured in the R-ITS-S, so that the information from a vehicle can be placed in one of the zones based on heading and position. Since the heading can vary slightly with respect to the absolute heading/orientation of the road, a small deviation is accepted.
By default a deviation of +/- 5 degrees[2] can be accepted, however the exact value is location dependent. For example, around junctions a more strict value might be needed.
The length of the detection zones is also location dependent. In some cases it can be useful to configure relatively small segments of 100 meters, and in others a

[2] The exact amount of deviation is yet to be determined. It might well be possible that the deviation will be infrastructure dependent. For example, around intersections where the direction of lanes vary greatly, different settings may be required than along a clean straight.

kilometre is sufficient. The length also depends on the actual (usable) range of the R-ITS-S ITS-G5 antenna.

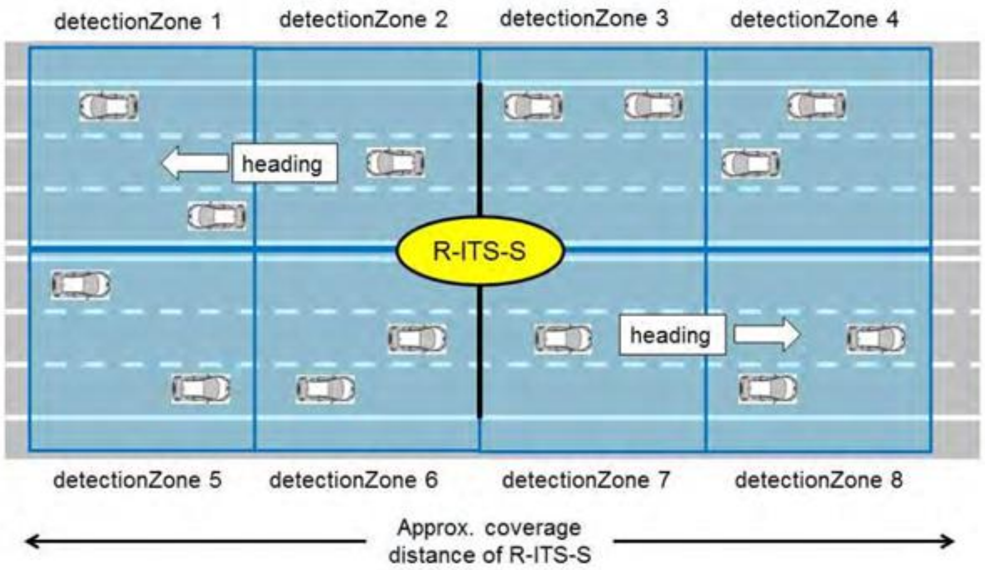


FIGURE 1: DETECTION ZONES AROUND R-ITS-S

At the R-ITS-S the collected CAM data has to be aggregated and sent to a central back-office. This process has to be defined in future work.

4.5 CAM Profile

In 'Annex D: CAM Profile' a screenshot is shown of an Excel file that accompanies this document. The Excel file shows the full CAM structure and profiled data fields (DF) and elements (DE) with explanations per DE. The legend shows the different status of the data fields/elements:

- *Italic*: these are optional in the standard;
- <u>Underlined</u>: one of these can be chosen (OR);
- **Bold**: required by the standard;
- Orange: wish list for the Dutch RWW Corridor profile.

It is called "wish list" since it is dependent on the interest and willingness of the industry to implement these data elements.

The description of the data elements / fields can all be found in [2] or [4]. Most of the text describing the DEs and DFs from these standards is also included in the Excel file as comment attached to the cells.

Below is described how each DF / DE from the CAM standard is used within the Dutch PVD use case. Only values required by the standard or part of the wish list are commented on. Those which are required, but not part of the wish list, are commented on in *Italics*.

header	
protocolVersion	Version of the protocol. Current version is 1, thus field is set to 1.
messageID	Indicates the type of message. Examples are denm(1), cam(2), ivi(6), etc. Here 2 is used.
stationID	This is the ID of the station (vehicle) broadcasting the message.

cam	
generationDeltaTime	Timestamp belonging to the referencePosition.

basicContainer	
stationType	This DE can be 0 or 4 – 10. Other values indicate vehicles that are not allowed on the motorway.
referencePosition	This DF is of type ReferencePosition (DF A.124 from ETSI TS 102 894-2). It contains the coordinates (WGS 84) of the ITS station (vehicle).

highFrequencyContainer	
heading	The (compass) direction of the vehicle, in 1/10th of a degree.
speed	Speed of the vehicle in cm/s.
driveDirection	The direction the vehicle is travelling in: forward(0), backward(1) or unavailable(2).
vehicleLength	Length of the vehicle in steps of 10 cm. 1 == 10cm.
vehicleWidth	*The vehicle width in 10 cm steps. 1 == 10cm. Required by the standard but not part of the wish list.*
longitudinalAcceleration	The longitudinal (forward / backward) acceleration of the vehicle in steps of 0.1 m/s^2.
curvature	*The curvature of the vehicle trajectory. Required by the standard but not part of the wish list.*
curvatureCalculationMode	*The calculation mode for the curvature. Required by the standard but not part of the wish list.*
yawRate	*The rate the vehicle is spinning around its centre of mass. Required by the standard but not part of the wish list.*

lowFrequencyContainer	
vehicleRole	*The role of the vehicle (e.g. public transport). This is set in accordance with ETSI TS 102 894-2 (usually 0-default). Required because of the use of the lowFrequencyContainer but not part of the wish list.*
exteriorLights	This DE is a sequence of bits (BIT STRING) of size 8. Each bit holds the status of the exterior light switches of a vehicle (e.g. fogLightOn, leftTurnSignalOn, etc.).
pathHistory	*This DF can hold up to 40 points (PathPoint) of where the vehicle has been, optionally with an accompanying timestamp (pathDeltaTime). The timestamp would allow for speed calculation between the points. Required because of the use of the lowFrequencyContainer but not part of the wish list.*

Legend	
bold	required by standard
cursive	optional by standard
normal	required when parent container is used

Annex A: CROW 96a figures that fit within DENM

Overview of road works figures (layouts) from CROW 96a [7]. The table is in Dutch. See Excel file: "`Check DENM met CROW 96a v1.0.xlsx`".

CROW Figuur nummer	CROW Figuur naam	Rood Kruis (Event Posotion)	Rijstrook status (DrivingLane Status)	Vluchtstrook status (HardShoulder Status)	Snelheidslimiet (SpeedLimit)	Passeerbaarheid (TrafficFlow Rule)	Snelheid rijdende afzetting (SpeedValue)	Opmerking	Sc
Statisch kortdurend									
110	Naast de rijbaan, buiten de obstakelvrije zone (in de berm)	nvt	ja	ja	nvt	nvt	nvt		xxx
112	Naast de rijbaan, buiten de obstakelvrije zone (afzetting afrit)	nvt	ja	ja	nvt	ja	nvt		xxx
120	Naast de rijbaan, binnen de obstakelvrije zone	nvt	ja	ja	nvt	ja	nvt		xxx
130	Op de vluchtstrook, buiten de 1,10m vanaf de kantstreep	nvt	ja	ja	nvt	nvt	nvt		xxx
140	Op de vluchtstrook, buiten de 1,10m vanaf de kantstreep	nvt	ja	ja	nvt	nvt	nvt		xxx
210	Op de vluchtstrook, binnen de 1,10m vanaf de kantstreep	ja	ja	ja	ja	ja	nvt		xxx
220	Op de linkerrijstrook of links binnen 3,50m vanaf de kantstreep	ja	ja	ja	ja	ja	nvt		xxx
230	Links naast de rijbaan, buiten de 3,50m vanaf de kantstreep	nvt	ja	ja	nvt	nvt	nvt		xxx
240	Meerdere aan elkaar grenzende rijstroken	ja	ja	ja	ja	ja	nvt		xxx
250	Meerdere aan elkaar grenzende rijstroken (via vluchtstrook)	ja	ja	ja	ja	ja	nvt		xxx
310	Meerdere aan elkaar grenzende rijstroken (via vluchtstrook)	ja	ja	ja	ja	ja	nvt		xxx
311	Meerdere aan elkaar grenzende rijstroken (via vluchtstrook), zonder MTM	ja/nee	ja	ja	ja	ja	nvt	vanwege wel en geen rood kruis/TMA gebruik	xx
Rijdende afzetting									
410	Rechts naast de rijbaan	nvt	ja	ja	nvt	nvt	nvt		xxx
420	op vluchtstrook, buiten 1.10 vanaf kantstreep	nvt	ja	ja	ja	ja	ja		xxx
430	op vluchtstrook, buiten 1.10 vanaf kantstreep	nvt	ja	ja	nee	ja	ja		xxx
440	op volledige vluchtstrook of rechterrijstrook	ja	ja	ja	ja	ja	ja		xxx
441	op volledige vluchtstrook of rechterrijstrook	nvt	ja	ja	ja	ja	ja	Past binnen DENM maar niet binnen Day one	xxx
930	rijdende afzetting linkerrijstrook	nvt	ja	ja	nvt	ja	ja	Past binnen DENM maar niet binnen Day one	xxx
931	rijdende afzetting middelsterijstrook	nvt	ja	ja	ja	ja	ja		xxx
932	rijdende afzetting rechterrijstrook	nvt	ja	ja	ja	ja	ja	Past binnen DENM maar niet binnen Day one	xxx
933	rijdende afzetting spitsstrook	nvt	ja	ja	nvt	ja	ja		xxx
934	rijdende afzetting strook naast spitsstrook	nvt	ja	ja	nvt	ja	ja		xxx
944	rijdende afzetting linkerrijstrook	ja	ja	ja	ja	ja	ja		xxx
945	rijdende afzetting rechterrijstrook	ja	ja	ja	ja	ja	ja		xxx
Statisch langdurend									
510	Vluchtstrookafzetting zonder snelheidsbeperking	nvt	ja	ja	nvt	ja	nvt		xxx
520	Vluchtstrookafzetting met snelheidsbeperking	nvt	ja	ja	ja	ja	nvt		xxx
620	Rijstrookafzetting – een rijstrook	ja	ja	ja	ja	ja	nvt		xxx
630	Rijstrookafzetting – meerdere rijstroken	ja	ja	ja	ja	ja	nvt		xxx
640	Afzetting met verschoven rijstroken	nvt	ja	ja	ja	nvt	nvt	indien rijstroken zijn versmald niet aan te geven	x
650	Afzetting met verschoven rijstroken	nvt	ja	ja	ja	nvt	nvt	indien rijstroken zijn versmald niet aan te geven	x
660	Afzetting met gebruik vluchtstrook	nvt	ja	ja	ja	nvt	nvt	indien rijstroken zijn versmald niet aan te geven	x
670	Afzetting met gebruik vluchtstrook	ja	ja	ja	ja	ja	nvt		x
680	Afzetting bij werken in de middenberm	nvt	ja	ja	ja	ja	nvt	Er is niet aan te geven dat er aan de linkerzijde van de weg wordt gewerkt	xx
710a	Voorbeeld 4-0 systeem met MTM	nvt	ja	ja	ja	nvt	nvt	indien rijstroken zijn versmald niet aan te geven	x
710b	Voorbeeld 4-0 systeem met MTM	nvt	ja	ja	ja	nvt	nvt	indien rijstroken zijn versmald niet aan te geven	x
711a	Voorbeeld 4-0 systeem zonder MTM	nvt	ja	ja	ja	nvt	nvt	indien rijstroken zijn versmald niet aan te geven	x
711b	Voorbeeld 4-0 systeem zonder MTM	nvt	ja	ja	ja	nvt	nvt	indien rijstroken zijn versmald niet aan te geven	x
720a	Voorbeeld 3-1 systeem met MTM	nvt	ja	ja	ja	nee	nvt	splitsing kan niet aangegeven worden	x
720b	Voorbeeld 3-1 systeem met MTM	nvt	ja	ja	ja	nee	nvt	splitsing kan niet aangegeven worden	x
721a	Voorbeeld 3-1 systeem zonder MTM	nvt	ja	ja	ja	nee	nvt	splitsing kan niet aangegeven worden	x
721b	Voorbeeld 3-1 systeem zonder MTM	nvt	ja	ja	ja	nee	nvt	splitsing kan niet aangegeven worden	x
730a	Voorbeeld 3-0 systeem met/zonder MTM	ja	ja	ja	ja	ja	nvt		xxx
730b	Voorbeeld 3-0 systeem met/zonder MTM	nvt	ja	ja	ja	nvt	nvt		xxx
910	Rijstrook langs in- en uitvoegstrook							in-/uitvoeger werkverkeer is niet aan te geven	x
911	Rijstrook langs in- en uitvoegstrook							in-/uitvoeger werkverkeer is niet aan te geven	x
912	Rechter- en linkerrijstrook voorbij invoegstrook	ja	ja	ja	ja	ja	nvt		xxx
913	Rechter- en linkerrijstrook voorbij invoegstrook	ja	ja	ja	ja	ja	nvt		xxx
914	Rechter- en linkerrijstrook nabij splitsing of samenvoeging	ja	ja	ja	ja	ja	nvt		xxx
915	Rechter- en linkerrijstrook nabij splitsing of samenvoeging	ja	ja	ja	ja	ja	nvt		xxx
920	Werkvak rechts	nvt	ja	ja	nvt	nvt	nvt	in-/uitvoeger werkverkeer is niet aan te geven	x
921	Werkvak rechts	nvt	ja	ja	nvt	nvt	nvt	in-/uitvoeger werkverkeer is niet aan te geven	x
922	Voorbeelden ontwerp in- en uitvoegstrook, werkvak rechts	nvt	ja	ja	nvt	nvt	nvt	in-/uitvoeger werkverkeer is niet aan te geven	x
923	Voorbeelden ontwerp in- en uitvoegstrook, werkvak rechts	nvt	ja	ja	nvt	nvt	nvt	in-/uitvoeger werkverkeer is niet aan te geven	x
924	Voorbeelden ontwerp in- en uitvoegstrook: werkvak links	nvt	ja	ja	nvt	nvt	nvt	in-/uitvoeger werkverkeer is niet aan te geven	x
925	Voorbeelden ontwerp in- en uitvoegstrook: werkvak links	nvt	ja	ja	nvt	nvt	nvt	in-/uitvoeger werkverkeer is niet aan te geven	x
940	Afzetting rechterrijstrook	ja	ja	ja	ja	ja	nvt		xxx
941	Afzetting rechterrijstrook	ja	ja	ja	ja	ja	nvt		xxx
942	Afzetting linkerrijstrook	ja	ja	ja	ja	ja	nvt		xxx
943	Afzetting linkerrijstrook en beide richtingen	ja	ja	ja	ja	ja	nvt		xxx

Annex B: DENM Profile

Below is a screenshot of attached Excel file of the DENM [2] profile: “`Road Works Warning (RWW) DENM profile - v1.0.xlsx`”.

Road Works Warning

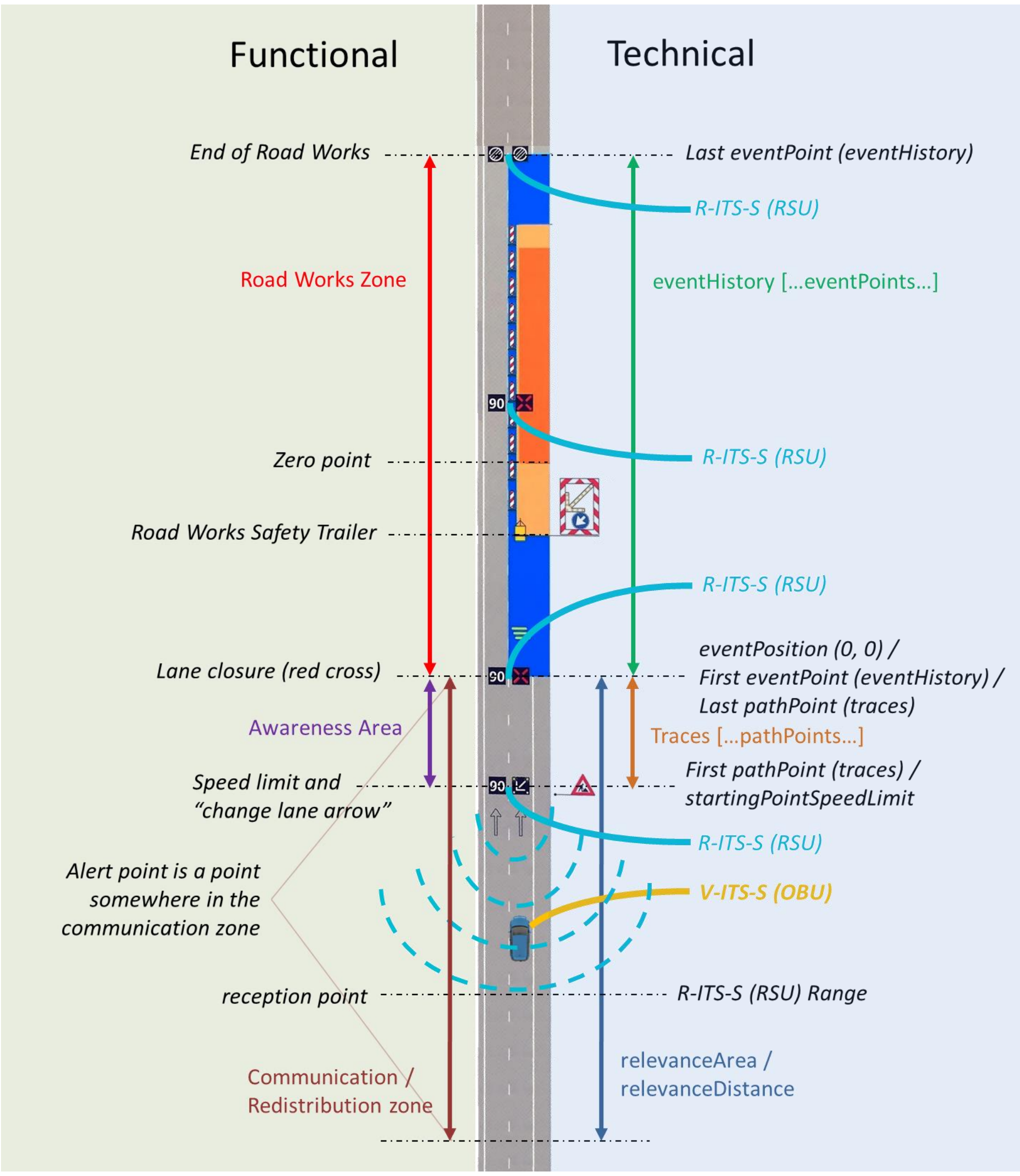
ETSI EN 302 637-3 V1.2.7 (2014-06), Decentralized Environmental Notification Basic Service
ETSI TS 102 894-2 V1.1.135 (2014-07), Common Data Dictionary

DENM message profile
V0.7 16-06-2015 Anton Wijbenga

Italic is optional within standard
underline is OR (only one) according to standard
bold is minimum dataset according to standard
'spec' means follow original spec/standard
Orange fields are part of the profile

DENM	**header**							**protocolVersion**	**1**
								messageID	**denm(1)**
								stationID	**spec**
	denm	**management**	**actionID**					**originatingStationID (stationID)**	**spec**
								sequenceNumber	**spec**
								detectionTime	**spec**
								referenceTime	**spec**
								termination	spec
			eventPosition					**latitude**	**spec**
								longitude	**spec**
				positionConfidenceEllipse				**semiMajorConfidence**	**4095**
								semiMinorConfidence	**4095**
								semiMajorOrientation	**3601**
				altitude				**altitudeValue**	**800001**
								altitudeConfidence	**15**
								relevanceDistance	lessThan1000m(4)
								relevanceTrafficDirection	1
								validityDuration	**600 | spec**
								transmissionInterval	
								stationType	**15**
		situation						informationQuality	1
			eventType					causeCode	3
								subCauseCode / RoadworksSubCauseCode	4
			linkedCause					causeCode	
								subCauseCode	
			eventHistory (1..23|40 EventPoint)	EventPoint	eventPosition			deltaLatitude	spec
								deltaLongitude	spec
								deltaAltitude	spec
								eventDeltaTime	
								informationQuality	1
		location	*eventSpeed*					speedValue	
								speedConfidence	
			eventPositionHeading					headingValue	
								headingConfidence	
			traces (1..7 PathHistory)	PathHistory (0..40 PathPoint)	PathPoint	pathPosition		deltaLatitude	spec
								deltaLongitude	spec
								deltaAltitude	spec
								pathDeltaTime	
								roadType	
		alacarte						*lanePosition*	spec
			impactReduction					heightLonCarrLeft	
								heightLonCarrRight	
								posLonCarrLeft	
								posLonCarrRight	
								positionOfPillars	
								posCentMass	
								wheelBaseVehicle	
								turningRadius	
								posFrontAx	
								positionOfOccupants	
								vehicleMass	
								requestResponseIndication	
								externalTemperature	
			roadWorks					*lightBarSirenInUse*	
				closedLanes				*hardShoulderStatus*	spec
								drivingLaneStatus	spec
				restriction (.. StationType)				StationType	
								speedLimit	spec
				incidentIndication				causeCode	3
								subCauseCode	4
				recommendedPath	ItineraryPath (1..40 ReferencePosition)	ReferencePosition		latitude	
								longitude	
							positionConfidenceEllipse	semiMajorConfidence	
								semiMinorConfidence	
								semiMajorOrientation	
							altitude	altitudeValue	
								altitudeConfidence	
				startingPointSpeedLimit				deltaLatitude	spec
								deltaLongitude	spec
								deltaAltitude	spec
								trafficFlowRule	spec
				referenceDenms (0..8 ActionID)	ActionID			originatorStationID (stationID)	spec
								sequenceNumber	spec
								positioningSolution	
			stationaryVehicle					*stationarySince*	
								stationaryCause	
				carryingDangerousGoods				dangerousGoodsType	
								unNumber	
								elevatedTemperature	
								tunnelsRestricted	
								limitedQuantity	
								emergencyActionCode	
								phoneNumber	
								companyName	
								numberOfOccupants	
				vehicleIdentification				*wMInumber*	
								vDS	
								energyStorageType	

Annex C: Functional RW locations mapped to technical elements (DENM)



Annex D: CAM Profile

Below is a screenshot of attached Excel file of the CAM [3] profile. "`Basic Probe Vehicle Data (bPVD) CAM profile - v1.0.xlsx`".

Probe Vehicle Data

Common Basic Awareness Service, ETSI EN 302 637-2 V1.3.2 (2014-11)
Common data dictionary (CDD), ETSI TS 102 894-2 V1.2.1 (2014-09)

CAM message profile
v0.5 16-06-2015 Anton Wijbenga

Italic is optional within standard

underline is OR (only one) according to standard

bold is minimum dataset according to standard

'spec' means follow original spec/standard

Orange fields are the wish list for the Dutch PVD use-case

CAM	**header**							**protocolVersion**
								messageID
								stationID
	cam							**generationDeltaTime**
		camParameters	**basicContainer**					**stationType**
				referencePosition				**latitude**
								longitude
					positionConfidenceEllipse			**semiMajorConfidence**
								semiMinorConfidence
								semiMajorOrientation
					altitude			**altitudeValue**
								altitudeConfidence
			highFrequencyContainer	**basicVehicleContainerHighFrequency**	**heading**			**headingValue**
								headingConfidence
					speed			**speedValue**
								speedConfidence
								driveDirection
					vehicleLength			**vehicleLengthValue**
								vehicleLengthConfidenceIndication
								vehicleWidth
					longitudinalAcceleration			**longitudinalAccelerationValue**
								longitudinalAccelerationConfidence
					curvature			**curvatureValue**
								curvatureConfidence
								curvatureCalculationMode
					yawRate			**yawRateValue**
								yawRateConfidence
								accelerationControl
								lanePosition
					steeringWheelAngle			steeringWheelAngleValue
								steeringWheelAngleConfidence
					lateralAcceleration			lateralAccelerationValue
								lateralAccelerationConfidence
					verticalAcceleration			verticalAccelerationValue
								verticalAccelerationConfidence
								performanceClass
					cenDsrcTollingZone			ProtectedZoneID
				rsuContainer-HighFrequency	*protectedCommunicationZoneRSU*			ProtectedZoneType
								expiryTime
								protectedZoneLatitude
								protectedZoneLongitude
								protectedZoneRadius
								protectedZoneID
			lowFrequency-Container	basicVehicleContainer-LowFrequency				vehicleRole
								exteriorLights
					pathHistory (0..40 PathPoint)	PathPoint	pathPosition	deltaLatitude
								deltaLongitude
								deltaAltitude
								pathDeltaTime
			specialVehicleContainer	publicTransportContainer				embarkationStatus
					ptActivation			ptActivationType
								ptActivationData
				specialTransportContainer				specialTransportType
								lightBarSirenInUse
				dangerousGoodsContainer				dangerousGoodBasic
				roadWorksContainerBasic				*roadworksSubCauseCode*
								lightBarSirenInUse
					closedLanes			*hardShoulderStatus*
								drivingLaneStatus
				rescueContainer				lightBarSirenInUse
				emergencyContainer				lightBarSirenInUse
					incidentIndication			CauseCodeType
								subCauseCode
								emergencyPriority
				safetyCarContainer				lightBarSirenInUse
					incidentIndication			CauseCodeType
								subCauseCode
								trafficRule
								speedLimit