DUTCH C-ITS CORRIDOR PROFILE

Cooperative ITS Corridor
Joint deployment

Colophon

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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, as described in the Memorandum of Understanding (MoU) on Cooperative ITS Corridor Joint deployment [1]. On June 10th 2013, the Ministers of the three mentioned countries agreed to start the deployment of initial Cooperative ITS (C-ITS) services on the corridor Rotterdam – Frankfurt – 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.

The MoU focusses on two specific Cooperative ITS use cases to be deployed on the corridor. These are: Road Works Warning (RWW), roadside beacons warning road users for road works, and (basic) Probe Vehicle Data (bPVD), vehicles transmitting data on the current situation on the road to the roadside infrastructure. Additionally the Dutch Ministry of Transport has decided to extend the scope of the project with a third use case called Collision Risk Warning (CRW), alerting road users for a traffic inspectors vehicle protecting an incident.

This document gives an overview of standardisation needs for these C-ITS use cases for first deployment (‘day 1’) in the Netherlands [7]. The standards allow a wide range of implementation possibilities. The objective of this report is to limit the possibilities to those required and feasible for the Cooperative ITS Corridor project in the Netherlands (known as *profiling*).

This document was preceded by the document Use Cases C-ITS Corridor (NL) | Parts A and B. Part A (Functional Description) of this earlier document is replaced by a new document called Description of the System Concept [13]. The document now before you, this document, is the successor of Part B (Dutch C-ITS Corridor Profile) of the earlier document.

Profiling within the C-ITS field is a continuous process. As a result, documents are frequently changed and updated. Therefore, references within this document explicitly contain version numbers (or dates).

1.2 Assumptions

Some issues or ‘attention points’ are still open. Underneath the main issues are listed, together with the assumptions made.

1. Additional to the Facility layer other layers (Management, Application, Network&Transport, Access, Security) need to be profiled as well.
2. Multiple traces are only useful when the road works area is directly behind a junction. Rules are needed when to use multiple traces.
3. The profile assumes that the ‘location container’ is always used and, within this container, traces are always used (at least a start and end point).
4. Traces and eventHistory points are assumed to be carriageway based. This approach differs from the approach taken in other countries and may have to be harmonised.

5. The profile assumes that the 'situation container' is always used. Within this container the DE informationQuality is optional, the DE eventType is always used but eventHistory is optional.
6. The profile assumes that the 'alacarte container' (including DEs lanePosition, closedLanes, trafficFlowRule) is optional.
7. The profile assumes that propagation will not be used in 'day 1'.
8. The Amsterdam Group defines that the value for repetitionInterval shall be set in accordance with the applicable Decentralized Congestion Control (DCC) algorithm [5], implying that the value shall be in the range between 0.1 and 0.5 sec. Simultaneously the repetition interval (TTX) for Traffic Class (TC) 1 has been defined to be between 95ms and 250ms, depending on the channel load. It is assumed that both rules together imply that the value for repetitionInterval shall be between 0.1 and 0.25 sec.
9. There appear to be two valid possibilities for the road sign library to be used in the IVI profile: Vienna Convention and ISO14823. For now the Vienna Convention is chosen.

1.3 Legend

The chapters containing the actual profiles describe how the data frames (DFs), data elements (DEs) and containers in the DENM and IVI standards are used within the Dutch use cases and present examples for specific road works situations.

The description of the DFs and DEs can be found in [2], [4] and [6]. The description of the DEs and DFs in this document makes use of the descriptions in these standards.

The descriptions are accompanied by Excel files, shown in the annexes. The Excel files show the full DENM, IVI and CAM structures and profiled DF and DE with explanations per DF/DE. The Excel files show the different statuses of the DFs and DEs as follows:

- *Italic*: these are optional in the standard;
- Underlined: 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 this profile.

The tables use the following references with respect to the 'status' within the profile. Note that the use of 'status' may differ for RWW, CRW or bPVD. For RWW and CRW information the profile choices are made by the road operator, for bPVD the information the choices are made by others:

- Mandatory. This DF, DE or container is mandatory in the standard and is thus always provided.
- Profiled. This DF, DE or container is mandatory in the (RWW or CRW) profile although optional in the standard. The DF, DE or container has been made mandatory by this profile. It is therefore assumed that this DF, DE or container will always be provided.
- Fixed. Mandatory in the (RWW or CRW) profile and the profile uses a fixed predefined value for this DF or DE.
- Optional. This DF, DE or container is optional in the standard as well as in the profile.

- Used. This DF, DE or container is used within the (bPVD) profile. The profile makes a distinction between DFs, DEs and containers that will be actively used and those that will not be. Although they may be mandatory these DEs do not always contain an actual value. The standard allows that they may be set at 'unknown' or 'not available'. When labelled as 'used' in the (bPVD) profile, the profile assumes that these DEs do contain actual values. These DEs, in other words, are on the Dutch 'wishlist'.
- Not used. This DF, DE or container is optional in the standard but not used in the profile. The response to the use of this DF, DE or container is therefore not guaranteed.

1.4 Abbreviations

Abbreviation	Meaning
AG	Amsterdam Group
bPVD	basic Probe Vehicle Data
CAM	Cooperative Awareness Message
C-ITS	Cooperative ITS
C-ITS-S	Central ITS Station (equivalent to Central Unit (CU))
CRW	Collision Risk Warning
DE	Data Element
DENM	Decentralized Environmental Notification Message
DF	Data Frame
DZ	Detection Zone
ePVD	extended Probe Vehicle Data
GNSS	Global Navigation Satellite System
HMI	Human Machine Interface
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITS	Intelligent Transport System
IVI	In-Vehicle Information
MoU	Memorandum of Understanding
MTM	Motorway Traffic Management(system)
NDW	National Datawarehouse for traffic information
OBU	Onboard Unit (equivalent to V-ITS-S)
PVD	Probe Vehicle Data
R-ITS-S	Roadside ITS Station (equivalent to Roadside Unit)
RSU	Roadside Unit (equivalent to R-ITS-S)
RWS	Rijkswaterstaat
RWW	Road Works Warning
RZ	Relevance Zone
TCC	Traffic Control Centre
TMA	Truck Mounted Attenuator
V-ITS-S	Vehicle ITS Station (equivalent to Onboard Unit)

1.5 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	ETSI TS 102 687 (2011-07). Decentralized Congestion Control Mechanisms for ITS-G5 (DCC)
6	ISO TS 19321:2015 (2015-04-15). Dictionary of in-vehicle information (IVI) data structures.
7	Overview of Standards for First Deployment of C-ITS link
8	Amsterdam Group, Road Works Warning Functional Description, Version 1.0
9	CROW, Maatregelen op autosnelwegen | Werk in uitvoering 96a (CROW 96a)
10	Amsterdam Group, Message Set and Triggering Conditions for Road Works Warning Service
11	Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band
12	RWS, System Specification, Cooperative ITS Corridor System (ICS), September 2015
13	RWS, Description of the System Concept, June 2016

2 Scope

This document has a limited scope, it does not cover the complete C-ITS field nor does it cover the views of all parties. This chapter describes the specific scope of this document.

2.1 Use cases RWW, CRW and bPVD

The profiling of the standards for the use cases within the Cooperative ITS Corridor project is done with practical applications and the specific task of the Dutch Cooperative ITS Corridor project in mind. The focus is therefore on the RWW, CRW and bPVD use cases only.

2.2 Dutch situation

The standards are profiled from the Dutch point of view, which is formed by Rijkswaterstaat (RWS). This document for the moment expresses the point of view of the Netherlands only.

The document 'Description of the System Concept' [13] describes the specific constraints and pre-conditions in the Netherlands. The most relevant, and included in scope, are:

- The focus is on highways only. Provincial motorways and city roads are not included.
- National guidelines are leading. In the Netherlands, CROW 96a provides guidelines on how to set up road works safety measures. Road works layouts are depicted in the CROW publication 'Werk in uitvoering 96a' [9]. These layouts are the primary input for profiling the message standards.
- Dutch highways include very specific dynamic lanes, on the right (hard shoulder running) as well as on the left side (narrow extra lane). These lanes are usually available for driving during rush hour, but closed when traffic volume is low.

As a next step this document will be aligned with the German and Austrian partners. In parallel it may also be extended to cover a broader Dutch context (e.g. include more use cases).

2.3 Scenarios Basic, Plus and Luxe

The Dutch Cooperative ITS Corridor project has defined three so called 'operational scenarios':

- 'Basic', use of a portable R-ITS-S for transmitting DENM message(s) only.
- 'Plus', use of fixed R-ITS-S(s) for transmitting DENM as well as IVI messages.
- 'Luxe', use of a portable R-ITS-S for transmitting the DENM message(s) and fixed R-ITS-S(s) for transmitting the IVI and DENM message(s).

The scope of this document includes all scenarios.

2.4 Road works types

The DENM and IVI standards are profiled for the road works types 'Short Term Static', 'Short Term Mobile' and 'Unplanned (ad-hoc)' of Road Works Warning. The road works type 'Long Term Road Works' is not part of this document.

2.5 basic Probe Vehicle Data

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, like speed, but also status of the vehicle lights and vehicle length.

The Dutch Cooperative ITS Corridor project has defined a basic Probe Vehicle Data (bPVD) as well as an extended Probe Vehicle Data (ePVD) use case [7, 13]. The first use case makes use of CAM messages that are standard emitted by vehicles. This latter entails data collection (buffering) while the vehicle is out of range of an R-ITS-S. When in range, the data is transmitted for a more detailed picture of the status on the road.

Note that both use cases strongly depend on the automotive industry. They are based on data that needs to be provided by the vehicle manufacturers. Without their involvement and willingness to act, these use cases will not be feasible. For first deployment ('day 1') it is expected that only CAM messages and no DENM messages will be broadcasted by the vehicles and that buffering is not feasible.

The scope will therefore for the moment be limited to the basic Probe Vehicle Data (bPVD) use case, based on standard CAM messages emitted by vehicles and not on DENM messages nor on CAM messages based on data stored in vehicles. The extended Probe Vehicle Data (bPVD) use case is thus for the moment out of scope.

2.6 Facility layer

Standards range from data standards, management standards, security standards to standards of a very technical nature. The table below gives an overview of the relevant standards.

Nr	Name	Latest version
Management Entity (and architecture)		
ETSI EN 302 665	Communications Architecture	1.1.1
ETSI TS 102 965	Application Object Identifier: Registration	1.2.1
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)	

ISO TS 19321:2015	Dictionary of in-vehicle information (IVI) data structures	2015-04-15
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	2.0.0
ETSI TS 102 792	Mitigation techniques to avoid interference between CEN DSRC and ITS-G5	1.2.1
IEEE 802.11	Lower Layer specifications (ensuring ITS in 5.9 GHz)	
Security Entity		
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	1.2.1

TABLE: STANDARDS OVERVIEW

All standards, not only on the Facility layer but on all other layers as well, need profiling. Facility layer choices for instance made on distances, areas and message forwarding also impact choices made in the Network and Transport Layer (GeoNetworking). The profile for GeoNetworking therefore needs to be harmonized with the Facility layer profile. For layers other than the Facility layer profiling may be less extensive and may be more generic but it is needed all the same.

This document focusses on the DENM [2], IVI [6] and CAM [3] standards which are used to carry the functional information of the RWW, bPVD and CRW use cases. The RWW and CRW use cases focus on the DENM [2] and IVI [6] standards whereas the bPVD use case focusses on the CAM [3] standard. All three standards are used to broadcast information: DENM and IVI from the road side and CAM from the vehicle. These standards provide the framework for the functional content of the use cases. All three standards are part of the Facility layer.

Profiles for standards other than DENM, IVI and CAM and for layers other than the Facility layer are for the moment not included and will have to be added later.

2.7 DENM, IVI and MAP

It is envisaged that in future C-ITS use cases will make use of a layered structure consisting of DENM (and CAM), IVI as well as MAP messages. This layered approach will ensure that any vehicle can receive the basic safety related information and that in parallel more advanced ITS-stations can perform more advanced tasks (e.g. autonomous driving).

DENM will provide the ground floor of the layered approach. That is, for example, the position of road works related obstacles, the availability of lanes (from a physical perspective) and possibly the speed limit at the location of the obstacle. The primary goal of the DENM is to convey information about physical obstacles in order to avoid collisions.

The IVI layer will enhance the DENM information with additional regulatory information, which in the case of road works exists primarily of extended

geographical information (e.g. closed zones, merging zones) and additional speed limits. IVI focusses on rules and regulations and conveys signage information. As a result, the V-ITS-S informs the road user on where additional speed limits begin and end and where one is allowed to drive or not (in contrast to where one can or cannot drive which is encoded in the DENM).

The MAP layer will complete the information on the road works zone. MAP is provided as the third layer. It will contain all the topological information around the road works zone, including changes due to the road works (i.e. where one could drive). This information is seen to be crucial for future autonomous driving.

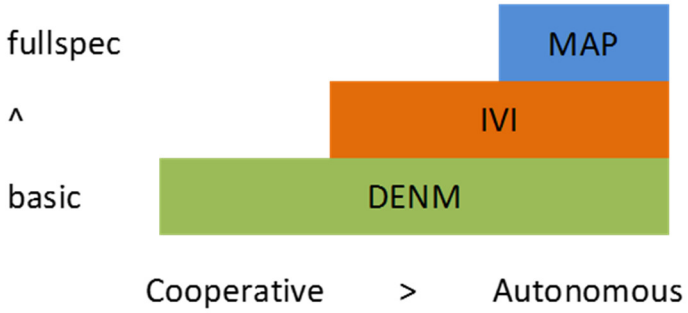


Figure 1: three-layered RWW approach

The approach described above can be summarized as follows:

- DENM provides safety related information to prevent accidents (i.e. where one can and cannot drive).
- IVI provides regulatory information to ensure conformance to traffic laws and to prevent traffic violations (i.e. where one is allowed to drive).
- MAP provides topological information to give the complete picture around the road works (i.e. where one could drive best depending on one's goal).

It is important to note that each layer can be used independently of the others. This is important since not all V-ITS-Ss will support all layers. It is expected that the DENM message, as a minimum, will be understood by all future C-ITS equipped vehicles. As a result, the risk of accidents involving road works obstacles is minimized, which is the primary purpose of the RWW use case. More sophisticated V-ITS-Ss will in future also be able to understand the 'nice to have' IVI and MAP messages.

The layered approach enables sending and receiving of all three messages in parallel. The Dutch Cooperative ITS Corridor project for the moment only includes DENM and IVI. MAP is not yet included and will have to be added in a later stage.

3 Road Works Warning (RWW)

This chapter describes the profile for the Road Works Warning (RWW) use case. The profile is divided into two sections: one for DENM and one for IVI. Together these profiles form the RWW profile. See §1.3 Legend for the meaning of the references.

3.1 RWW DENM Profile

DENM standard		Profile		
Field	Meaning	Status	Content	Value
Header		Mandatory		
protocol-Version	Version of the protocol.	Fixed	Current version is 1.	Set to 1
messageID	Indicates the type of message.	Fixed	Examples are denm(1), cam(2), ivi(6), etc.	Set to 1.
stationID	This is the ID of the station broadcasting the message.	Mandatory		Set by application.
management container		Mandatory		
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.	Mandatory	The actionID will not change for DENMs relating to the same event. I.e. the actionID will remain the same, even if there are updates for the event / DENM.	Set by application.
detection-Time	This is set to the time the road work starts at a functional level (i.e. the event is detected). Usually this is the time when the trailer or truck mounted attenuator is in position. This time can be updated to extend the time the message is valid.	Mandatory	The detectionTime shall be set to the time that the application that creates the DENM receives the information on the road works. The DENM message shall be updated as soon as the functional configuration of the road works layout	detectionTime set by application. repetitionDuration equal to validityDuration.

DENM standard		Profile		
Field	Meaning	Status	Content	Value
			changes (i.e. number of closed lanes, speed limits, position of the trailer, etc.). To ensure the validity of the message and thus to prevent expiration of the message, the DENM shall be updated when its age is greater than or equal to half of the validity duration. The value for repetitionDuration shall be set to the same value as validityDuration. This ensures that the DENM is repeated by the originating ITS station as long as the message is valid. The value for the repetitionInterval shall be set in accordance with the applicable Decentralized Congestion Control (DCC) algorithm.	repetitionInterval between 0.1 and 0.25 sec.
reference-Time	This is the time the DENM is encoded / updated by the application. The time can be updated as part of the DENM update mechanism.	Mandatory	Following the DENM standard, the referenceTime shall be set to the time the DENM message is encoded by the application.	Set by application.
termination	This DF is used to cancel the DENM from the originating ITS-S (cancellation) or another ITS-S (negation).	Profiled	In order to end the communication a termination message will be sent. If the originating stationID is the same as the ID of the station that terminates the message, a cancellation message shall be sent. If it is another station, the negation option shall be used.	Set by application.
event-Position	This DF is of type ReferencePosition (DF A.124 from ETSI TS 102 894-2). It contains the coordinates (WGS 84) of the position of the event.	Mandatory	DENM messages focus on the safety related aspects. DENMs thus primarily communicate the position of obstacles. Within this RWW profile it has therefore been decided to define the event position as the point where a lane is physically closed. This will generally be the position of the trailer or rumble strips and guidance markers (e.g. in case of road works on the hard shoulder). The accuracy shall be on the level of a lane (not carriageway).	Set by application.

DENM standard		Profile		
Field	Meaning	Status	Content	Value
	Altitude and confidence DEs.	Fixed	Altitude and confidence DEs are not used and thus set to the values corresponding with 'unavailable'.	Unavailable.
relevance-Distance	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. The DE relevanceDistance together with relevanceTrafficDirection is used to indicate the area within which the message is of relevance. This therefore corresponds with the redistribution zone (i.e. the area in which messages are (re)broadcasted).	Fixed	It is unclear how an ITS-S receiving the message could, without traces, determine whether it is in this area. As a result, the usefulness of these DEs is, for day 1, unclear. Just to be sure this DE is, in line with AG, included in the profile.	Set to 'lessThan5km(5)'.
relevance-Traffic-Direction	This DF indicates for which traffic direction the message is relevant (from the perspective of the sender).	Fixed	Unclear how this DF would be used in practice. Also see relevanceDistance.	Set to 1 (upStreamTraffic).
validity-Duration	The time at which the message should be deleted with an offset since detectionTime.	Fixed	The DE validityDuration is set at a fixed value. The DENM message is stopped by means of a direct termination message.	Set to 720 (seconds).
transmission-Interval	This DE informs the receiving ITS-Ss about the intended transmission interval of two consecutive DENM transmissions. It is used for the forwarding ITS-S operation.	Not used	For first deployment ('day 1') forwarding will not be used.	-
station-Type	This defines the type of the station broadcasting the DENM.	Fixed	This is set to 15 (roadSideUnit). This is true for both fixed R-ITS-S and portable R-ITS-S.	Set to 15.

situation container		Profiled		
information-Quality	This can be set to one of eight different values (0..7). ETSI does not specify what the different values mean.	Optional	AG has defined a method to use the DE informationQuality. This method focusses on the way the coordinates in the message are obtained. It however gives limited information about the accuracy of the location(s). Potential recipients of the message might decide to trust the coordinates	The DE information-Quality shall be set as follows (as proposed by AG): 0. (Not defined) 1. (a AND e /

DENM standard		Profile		
Field	Meaning	Status	Content	Value
			or not based on the method they are obtained. AG specifies the possible values for informationQuality depending on the way the event is detected and validated. This might be different for each RWW type depending on the actual situation on the field. 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 (map-matched position) e) traces: planned position (by road operator) f) traces: simple GNSS g) traces: differential GNSS h) traces: validated positions (map-matched traces) i) event automatically approved by traffic / road works management system j) event manually approved by a traffic / road works management system The quality levels of eventPosition and traces are in ascending order, so that the list of indicators above fulfils relations a < b < c < d (for eventPosition) and e < f < g < h (for traces).	planned by road operator) 2. (b AND f / simple GNSS) 3. (c AND g / differential GNSS) 4. (d AND h / validated positions) 5. (d AND h AND i / system approved) 6. (d AND h AND j / operator approved) 7. (Not defined).
event-Type	This DF consists of a DE causeCode and subCauseCode.	Fixed	The causeCode is set to 3 (road works). The subCauseCode is set to either 3 (slowMovingRoadMaintenance) or 4 (shortTermStationaryRoadworks) which correspond	causecode set to 3. subCauseCode set to 3 or 4.

DENM standard			Profile		
Field	Meaning		Status	Content	Value
				to 'Short Term Mobile' and 'Short Term Static' respectively. 'Unplanned (ad-hoc) Road Works' is either 3 or 4.	
event-History	This is a sequence of points, which together form a path from the eventPosition to 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 the DF referenceDenms. The maximum number of points is 23.	Start eventHistory point.	Optional	The first point shall be next to the *eventPosition* (traverse position) in the middle of the carriageway. .	Set by application.
		End eventHistory point.		The last point shall be in the middle of the carriage way at the end of the road works (i.e. where the sign 'end-of-restrictions' is placed).	Set by application.
		In between points.	Optional	When used, the minimum number of points is therefore 2 (start and end). Intermediate points are only needed when the road is curved. When the road is straight, no intermediate points will be needed. An intermediate point shall be added when the line between two consecutive points falls outside of the carriageway. Points will on the accuracy level of a carriageway.	Set by application.

location container			Profiled		
event-Speed	This DF can be used for mobile road works, determining the speed of the trailer.		Not used	This DF is not used, not even in case of mobile road works.	-
event-Position-Heading	See eventSpeed above.		Optional	Simple V-ITS-Ss might need the DE eventPositionHeading to determine relevance of the message. Currently the DE is optional.	Set by application.
traces	This DF consists of minimum 1, maximum 7 traces of type PathHistory. These traces consist of points describing the path towards the eventLocation. These	End trace point.	Profiled	The end trace point is defined as the point parallel to the *eventPosition* (traverse position) in the middle of the carriageway (thus equal to the start eventHistory point).	Set by application.
		Start trace point.	Profiled	The start trace point (carriage way level) is recommended to be at least 1.5 km upstream of	Set by application.

DENM standard			Profile		
Field	Meaning		Status	Content	Value
	are used by approaching vehicles to determine whether the DENM is relevant or not. The maximum number of points a trace can hold is assumed to be 40, the minimum number of points is 2 (start and end).			the event position.	
		In between trace points.	Optional	Traces and EventHistory points are defined as offset or delta positions with respect to the eventPosition. Both use de definition of DeltaReferencePosition, which in turn uses DeltaLatitude, DeltaLongitude and DeltaAltitude. Those longitude and latitude deltas are defined in tenths of micro degrees and have a range of -131071..131072 (-0.0131071..0.0131072 degrees). As a result of how the geographical degree reference system (WGS84) works, the distance 1 degree covers depends on whether it refers to latitude or longitude and the distance from the equator. For the Netherlands, this implies that the horizontal (west-east and vice versa) maximum distance between two delta points is about 880 meters. The maximum vertical (north-south and vice versa) distance is about 1450 meters. In case of a straight road, no intermediate points are needed. As for the eventHistory points, an intermediate point shall be added when the line between two consecutive points falls outside of the carriageway. Points will be defined on the accuracy level of a carriage way.	Set by application.

alacarte container		Optional		
lane-Position	This DE indicates on which lane the eventPosition is positioned.	Optional		Set by application.
roadWorks container (container within alacarte container)		Optional		
closed-Lanes	The closedLanes DF consists of two DEs: hardShoulderStatus and drivingLaneStatus. The	Optional	The Common Data Dictionary [4] holds the following definition of the drivingLaneStatus data	Set by application.

DENM standard		Profile		
Field	Meaning	Status	Content	Value
	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).		element which is used in the DENM [2] standard: "DrivingLaneStatus ::= BIT STRING { outermostLaneClosed(1), secondLaneFromOutsideClosed(2) } (SIZE (1..14))". It is assumed that the first bit (LSB, the bit on the right) is a 'don't care' (dc) bit. The value for the outermost driving lane (lane 1) is encoded by the second bit of drivingLaneStatus and so on. All lanes are encoded. The bitstring has a constant length, trailing zeros are not omitted. This is in accordance with the Request for Change (number 7296) on this issue, as delivered to ETSI. In case of a 'plusstrook', an extra narrow lane on the left side, that lane is always included with the correct status set (0=open or 1=closed) in drivingLaneStatus. In case of a 'spitsstrook', i.e. a hard shoulder is temporarily used as a normal lane (also known as 'hard shoulder running'), the hard shoulder shall be included as a regular lane in drivingLaneStatus if it is in use. If this lane is in use, hardShoulderStatus shall, since the hard shoulder as such no longer exists, not be used.	
speed-Limit	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.	Optional	If multiple speed limits exist within a collection of DENMs (via referenceDenms, see below), the speed limit belonging to the last passed startingPointSpeedLimit is valid. In case not all lanes at the eventPosition have the same speed limit, the lowest speed limit or none shall be used.	

DENM standard		Profile		
Field	Meaning	Status	Content	Value
incident-Indication	See eventType in the situation container.	Optional	Set to the same value as eventType.	Equal to eventType.
starting-Point-Speed-Limit	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 $1/10^{th}$ of a micro degree.	Optional	The default value for the speed limit starting point is the (middle of the carriageway at the) eventPosition. This point is on the accuracy level of a carriageway.	Default set at 0.
traffic-Flow-Rule	This DE indicates whether vehicles shall merge to the left (3) or right (2).	Optional	Merge to the left (3) or the right (2). Values 0 and 1 indicating passage rules are not used.	Set at 2 or 3.
reference-Denms	This is a sequence of up to 8 actionIDs. As described above in the actionID DF from the management container, an actionID forms a unique ID for a given DENM. This sequence shall hold the other DENMs which belong to the same road works (if more than 1 is used).	Optional	A DENM shall not reference to itself.	Set by application.

Other DFs / DEs	All other DFs and DEs in the DENM standard, not mentioned above.	Not used		

3.2 RWW IVI Profile

IVI standard		Profile		
Field	Meaning	Status	Content	Value
Header		Mandatory		
protocol-Version	Version of the protocol.	Mandatory	Current version is 1.	Set to 1.
messageID	Indicates the type of message..	Mandatory	Examples are denm(1), cam(2), ivi(6), etc.	Set to 6.
stationID	This is the ID of the station broadcasting the message.	Mandatory		Set by application.
Management container		Mandatory		
service-ProviderId	Identifies the organization that provided the IVI by using the DE Provider; contains a country code according to ISO 3166-1.	Mandatory	Numbers shall be assigned on national basis. See ISO 14816 for registration.	To be determined.
ivi-Identification-Number	This DE is the identifier of the IVI Structure, as assigned by the Service Provider. This component serves as the ID of the message and can be used by other related messages as a reference.	Mandatory		Set by application.
timestamp	This DE is the timestamp of the generation of the IVI message or the last change in information content. The message is valid from this time if *validFrom* is omitted.	Optional	The standard repetition rates should be used for IVI signage messages.	Set by application.
validFrom	This component may hold the Start time of the validity period of the message.	Optional	An IVI message should be sent from the moment a sign is valid until it is not valid anymore. When the validity or value of a sign changes this is seen as an update message and not a triggering condition. All signage information should always be received by a vehicle the moment the information is available. An IVI message should have a high interval frequency, similar to DENM.	Set by application.
validTo	End time of the validity period of the message duration.	Profiled	For RWW this DE shall always be used to determine the validity. An update shall be sent when the	Set by application.

IVI standard		Profile		
Field	Meaning	Status	Content	Value
			validity of a part of a sign is changed. For example, when the maximum speed limit is reduced during rush hour or when trucks are allowed to overtake during off-peak hours.	
connected-IviStructures (1..8)	This component holds a list of other iviIdentificationNumbers identifying other IVI messages.	Optional	This can be used to link various IVI messages to each other. Most RWW situations use multiple gantries with dynamic signs. Each gantry is connected to an IVI message. These IVI messages can refer to each other via this component.	Set by application.
iviStatus	This component holds the status of the IVI Structure. This can be set to; new, update, cancellation or negation. Is used for message handling.	Mandatory		Set by application.

Geographic Location Container		Profiled		
reference-Position	This component holds the starting point of the relevance zone (RZ).	Profiled	It is also used as a reference point for the detection zone (DZ). It is the main reference point for other positions within the IVI message.	Set by application.
Parts (1..16)	GlcPart (1..16). Up to 16 zones can be defined in one Geographic Location Container.	Profiled		Set by application.
zondId	Identifier of the definition of the zone, using the DE Zid. Up to 32 IDs can be defined within one IVI structure. There shall be at least 1 zone (i.e. the detection zone).	Profiled	ZoneId 1 is used to refer to the detection zone (DZ). The direction of the DZ is in the opposite direction with respect to the referencePosition. IVI does not enable the explicit definition of the direction of DZ. It is therefore required to explicitly define a zone as the DZ and to define the order of the points within. This will enable vehicles to use this zone as a trace to determine relevance.	Set by application.
zone	Definition of a zone using the DF Zone consisting of the choice DF Segment, DE PolygonalLine or DF ComputedSegment.	Profile	For RWW the DF Segment is used.	Set by application.
segment/	A sequence of delta points with respect to the previous	Profile	This sequence of points is defined on carriageway	Set by application.

IVI standard		Profile		
Field	Meaning	Status	Content	Value
polygonal/ deltaPositions	position, with latitude and longitude, as coded by the data element DeltaPosition, the first position being the referencePosition in the locationContainer.		level and shall be in the middle of the carriageway. The string of points defined in this component defines a zone (e.g. RZ or DZ). IVI allows four choices for defining a polygonalLine with respect to a reference position. In order to be similar to the DENM profile, IVI will use deltaPositions. This allows zones in IVI to be equivalent to traces in DENM.	
segment/ laneWidth	The data element LaneWidth contains the width of the lane in centimetres measured at the reference point. Only used when a single lane is referenced within the zone.	Profiled		Set by application.

General IVI Application Container (1..16 GicParts)		Mandatory		
detection-ZoneIds (1..8)	List of Identifier(s) of the definition(s) of the Detection Zone(s), using the DE Zid.	Optional	This is the area in which an IVI message should be detected	Set by application.
revelance-ZoneIds (1..8)	List of Identifier(s) of the definition(s) of the Relevance Zone(s), to which the IVS Container applies, using the DE Zid.	Optional	This is the area in which an IVI message is applicable. It starts at the referencePosition.	Set by application.
direction	Direction of relevance within the relevance zone using the DE direction.	Fixed	Is always set to sameDirection (0).	Set to 0.
minimum-Awareness-Time	Time in tenths of seconds before the vehicle enters the relevance area, in which the IVI should be available as a minimum.	Optional	Can be optionally included as a suggestion to the receiving ITS station.	Set by application.
applicable-Lanes (1..8)	List of identifiers of the lane(s) to which the IVS Container applies using the DE LaneNumber/LanePosition.	Optional	If applicable to all lanes on a carriageway this DE may be absent. The road signs included in RSCode below apply to these lanes.	Set by application.
iviType	Priority of the Container information within the overall context of IVI. This DE is used to determine the priority of the IVI message.	Fixed	This shall be set to 1 which is regulatory information. Immediate danger would be 0. For RWW IVI is however by defintion used as supporting information, additional to DENM.	Set to 1.
iviPurpose	This informes the receiving ITS-S on how the message	Fixed	Altough IVI is used for supporting information, the	Set to 0.

IVI standard		Profile		
Field	Meaning	Status	Content	Value
	should be used. This can be, Safety, Environmental or TrafficOptimisation.		purpose is safety. The value is therefore set to Safety (0).	
laneStatus	Indicates the lane status (e.g. open, closed, mergeR) of the applicableLanes.	Optional	This field may be set at 'closed' for lanes closed with a red cross sign, at 'mergeR' for lanes with an arrow sign pointing right, etc.	Set by application.
complete-Vehicle-Characteristics	Characteristics of vehicle, for which the IVI is applicable. The applicable regulations, such as limits, are defined as part of the roadSignCode component. Can be used to communicate vehicle restrictions within the relevance zone.	Optional		Set by application.
roadSign-Codes (1..4)	This component specifies which road signs are applicable for a Relevance Zone. Road sign codes are dependent on the referenced classification scheme. A sending ITS-S should select the road sign from a catalogue which is known to be supported by a receiving ITS-S. Additional attributes to the road sign code can be added as provided by the options in the Data Frame RSCode.	Mandatory	In order to link a roadSigncode to the correct roadsign, a common library should be used. Within IVI the DF RSCode can be used to set the library. Prechosen libraries are; Vienna Convention, ISO14823, SAE J2540. For RWW the choice is between Vienna Convention and ISO14823.	Set to Vienna Convention
RSCode	The data frame RSCode shall contain the definition of the road sign code. It allows different options pointing to different pictogram catalogues.	Mandatory	The component RSCode refers to several other Data Frames via the Vienna Convention. For RWW the following signs will be included: red cross, arrow pointing right, arrow pointing left, arrow pointing down, speed limit 50, speed limit 70, speed limit 90, end of restrictions.	Set by application.
extraText (1..4)	List of text lines associated to the ordered list of road sign codes. Each piece contains language code plus extra, limited-size text in the selected language using the DF text.	Optional	Can be used to send a message for clarification or additional information.	Set by application.

Other DFs / DEs	All other DFs and DEs in the DENM standard, not mentioned above.	Not used		

4 basic Probe Vehicle Data (bPVD)

This chapter describes the profile for CAM for the basic Probe Vehicle Data (bPVD) use case. See §1.3 Legend for the meaning of the references.

Note that DEs may, even when mandatory, not contain an actual value. The standard allows that they may be set at 'unknown' or 'not available'. When labelled as 'used', the profile however assumes that they do contain actual values.

Traffic flow data is currently 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 messages in the use case basic Probe Vehicle Data (bPVD) contains: vehicle position, vehicle speed, vehicle direction, vehicle lights status and vehicle length. The extended version (ePVD), where data is temporarily stored in the vehicle until the moment it passes a R-ITS-S, is not in the current scope.

4.1 bPVD CAM Profile

CAM standard				
Field		Meaning	Standard	Profile
header			**Mandatory**	**Mandatory**
protocol-Version		Version of the protocol. Current version is 1, thus field is set to 1.	Mandatory	Mandatory
messageID		Indicates the type of message. Examples are denm(1), cam(2), ivi(6), etc. Here 2 is used.	Mandatory	Mandatory
stationID		This is the ID of the station (vehicle) broadcasting the message.	Mandatory	Mandatory
cam			**Mandatory**	**Mandatory**
generation-Delta-Time		Timestamp belonging to the referencePosition.	Mandatory	Mandatory

CAM standard				
Field		Meaning	Standard	Profile
basic container			**Mandatory**	**Used**
station-Type		This DE can be 0 or 4 – 10. Other values indicate vehicles that are not allowed on the highway.	Mandatory	Used
reference-Position	Latitude	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).	Mandatory	Used
	Longitude			
	positionConfidenceElipse			Not used
	Altitude			Not used

highFrequencyContainer			**Mandatory**	**Used**
heading	headingValue	The (compass) direction of the vehicle, in 1/10th of a degree.	Mandatory	Used
	headingConfidence		Mandatory	Not used
speed	speedValue	Speed of the vehicle in cm/s.	Mandatory	Used
	speedConfidence		Mandatory	Not used
driveDirection		The direction the vehicle is travelling in: forward(0), backward(1) or unavailable(2).	Mandatory	Used
vehicleLenght	vehicleLenghtValue	Length of the vehicle in steps of 10 cm. 1 == 10cm.	Mandatory	Used
	vehicleLenghtConfidenceIndication		Mandatory	Not used
vehicleWidth		The vehicle width in 10 cm steps. 1 == 10cm. Required by the standard but not part of the wish list.	Mandatory	Not used
longitudinal-Acceleration	longitudinalAccelerationValue	The longitudinal (forward / backward) acceleration of the vehicle in steps of 0.1 m/s^2.	Mandatory	Used
	longitudinalAccelerationConfidence		Mandatory	Not used
curvature		The curvature of the vehicle trajectory. Required by the standard but not part of the wish list.	Mandatory	Not used
curvatureCalculationMode		The calculation mode for the curvature. Required by the standard but not part of the wish list.	Mandatory	Not used
yawRate		The rate the vehicle is spinning around its centre of mass. Required by the standard but not part of the wish list.	Mandatory	Not used
accelerationControl			Optional	Not used

CAM standard				
Field		Meaning	Standard	Profile
lanePosition			Optional	Not used
steeringWheelAngle			Optional	Not used
lateralAcceleration			Optional	Not used
verticalAcceleration			Optional	Not used
performanceClass			Optional	Not used
cenDsrcTollingZone			Optional	Not used
rsuContainerHighFrequency			Optional	Not used

lowFrequencyContainer			*Optional*	*Used*
basicVehicleContainer-LowFrequency	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.	Optional	Not used
	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.).	Optional	Used
	pathHistory	This DF can hold up to 40 points (pathPoints) 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.	Optional	Not used

specialVehicleContainer			*Optional*	*Not used*

5 Collision Risk Warning (CRW)

The Dutch Ministry of Transport has decided to add a third use case called Collision Risk Warning (CRW) to the scope of the Cooperative ITS Corridor project. This chapter describes the profile for this Collision Risk Warning (CRW) use case. See §1.3 Legend for the meaning of the references.

This use case entails that a traffic inspector when standing still on the road (including the hard shoulder) will trigger a DENM warning message. This message will alert approaching road users. In the message the traffic inspectors vehicle protecting the incident is considered to be the obstacle.

The message will be derived from a broader system (called 'Flister') that in parallel alerts the road user via cellular (connected) streams.

5.1 CRW DENM Profile

DENM standard		Profile		
Field	Meaning	Status	Content	Value
Header		Mandatory		
protocol-Version	Version of the protocol.	Fixed	Current version is 1.	Set to 1
messageID	Indicates the type of message.	Fixed	Examples are denm(1), cam(2), ivi(6), etc.	Set to 1.
stationID	This is the ID of the station broadcasting the message.	Mandatory		Set by application.
management container		Mandatory		
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.	Mandatory	The actionID will not change for DENMs relating to the same event. I.e. the actionID will remain the same, even if there are updates for the event / DENM.	Set by application.

DENM standard		Profile		
Field	Meaning	Status	Content	Value
detection-Time	This is set to the time the event starts at a functional level (i.e. the event is detected). Usually this is the time the traffic inspectors vehicle is in position. This time can be updated to extend the time the message is valid.	Mandatory	The detectionTime shall be set to the time that the application that creates the DENM receives the information on the incident. To ensure the validity of the message and thus to prevent expiration of the message, the DENM shall be updated when its age is greater than or equal to half of the validity duration. The value for repetitionDuration shall be set to the same value as validityDuration. This ensures that the DENM is repeated by the originating ITS station as long as the message is valid. The value for the repetitionInterval shall be set in accordance with the applicable Decentralized Congestion Control (DCC) algorithm.	detectionTime set by application. repetitionDuration equal to validityDuration. repetitionInterval between 0.1 and 0.25 sec.
reference-Time	This is the time the DENM is encoded / updated by the application. The time can be updated as part of the DENM update mechanism.	Mandatory	Following the DENM standard, the referenceTime shall be set to the time the DENM message is encoded by the application.	Set by application.
termination	This DF is used to cancel the DENM from the originating ITS-S (cancellation) or another ITS-S (negation).	Profiled	In order to end the communication a termination message will be sent.	Set by application.
event-Position	This DF is of type ReferencePosition (DF A.124 from ETSI TS 102 894-2). It contains the coordinates (WGS 84) of the position of the event.	Mandatory	DENM messages focus on the safety related aspects. DENMs thus primarily communicate the position of obstacles. Similar to RWW, this will for this use case be the point where a lane is physically closed and thus the position of the traffic inspectors vehicle. The accuracy shall be on the level of a lane (not carriageway). For this use case this will generally be the hard shoulder.	Set by application.
	Altitude and confidence DEs.	Fixed	Altitude and confidence DEs are not used and thus set to the values corresponding with 'unavailable'.	Unavailable.
relevance-Distance	Together with relevanceTrafficDirection, this DE forms the relevance area.	Fixed	This DE is for pragmatic reasons included in the profile as a fixed value. See also the RWW profile.	Set to 'lessThan5km(5)'.

DENM standard		Profile		
Field	Meaning	Status	Content	Value
relevance-Traffic-Direction	This DF indicates for which traffic direction the message is relevant (from the perspective of the sender).	Fixed	This DF is for pragmatic reasons included in the profile as a fixed value. See also the RWW profile.	Set to 1 (upStreamTraffic).
validity-Duration	The time at which the message should be deleted with an offset since detectionTime.	Fixed	The DE validityDuration is set at a fixed value. The DENM message is stopped by means of a direct termination message.	Set to 720 (seconds).
transmission-Interval	This DE informs the receiving ITS-Ss about the intended transmission interval of two consecutive DENM transmissions. It is used for the forwarding ITS-S operation.	Not used	For first deployment ('day 1') forwarding will not be used.	-
station-Type	This defines the type of the station broadcasting the DENM.	Fixed	This is set to 15 (roadSideUnit). This is true for both fixed R-ITS-S and portable R-ITS-S.	Set to 15.

situation container		Profiled		
information-Quality	This can be set to one of eight different values (0..7). ETSI does not specify what the different values mean.	Optional	AG has defined a method to use the DE informationQuality. See also the RWW profile.	The DE information-Quality shall be set as follows: 0. (Not defined) 1. - 2. (b AND f / simple GNSS) 3. (c AND g / differential GNSS) 4. - 5. - 6. - 7. (Not defined).
event-Type	This DF consists of a DE causeCode and subCauseCode.	Fixed	The causeCode is set to 97 (Collision Risk). The subCauseCode is set to 1 (Longitudinal Collision Risk),	causecode set to 97. subCauseCode set to 1.

DENM standard		Profile		
Field	Meaning	Status	Content	Value
event-History	This is a sequence of EventPoints, which together form a path from the eventPosition to 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 the DF referenceDenms. The maximum number of points is 23.	Not used	This DF is not used since this use case warns for a dangerous point rather than a dangerous stretch.	-

location container			Profiled		
event-Speed	This DF can be used for to define the speed of the traffic inspectors vehicle.		Not used	The Flister application currently does not provide this information. This DF is therefore not used.	-
event-Position-Heading	The heading direction of the event and the confidence of the heading information, if applicable.		Optional	The Flister application uses the 'driving direction' as an information element. This information element may be conveyed in DENM as eventPositionHeading. This is however not mandatory since the DENM message, contrary to the Flister application, also includes traces.	Set by application.
traces	This DF consists of minimum 1, maximum 7 traces of type PathHistory. These traces consist of points describing the path towards the eventLocation. These are used by approaching vehicles to determine whether the DENM is relevant or not. The maximum number of points a trace can hold is assumed to be 40, the minimum number of points is 2 (start and end).	End trace point.	Profiled	The end trace point is, equivalent to traces for RWW, defined as the point parallel to the *eventPosition* (traverse position) in the middle of the carriageway.	Set by application.
		Start trace point.	Profiled	The start trace point (carriage way level) is recommended to be at least 1.5 km upstream of the event position.	Set by application.
		In between trace points.	Optional	Points will be defined on the accuracy level of a carriage way. See also the RWW profile.	Set by application.

DENM standard		Profile		
Field	Meaning	Status	Content	Value
Other DFs / DEs	All other DFs and DEs in the DENM standard, not mentioned above.	Not used		

Annex A: RWW DENM Profile

The picture below provides a screenshot of Excel file of the DENM [2] profile: "Road Works Warning (RWW) DENM profile – v1.1.xlsx".

Road Works Warning

v1.1

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	lessThan5km(5)
							relevanceTrafficDirection	1
							validityDuration	720 | spec
							transmissionInterval	
							stationType	15
		situation					informationQuality	2-6
			eventType				causeCode	3
							subCauseCode / RoadworksSubCauseCode	4
			linkedCause				causeCode	
							subCauseCode	
			eventHistory (1..23|40 EventPoint)	EventPoint	eventPosition		deltaLatitude	spec
							deltaLongitude	spec
							deltaAltitude	spec
							eventDeltaTime	
							informationQuality	2-6
		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	
							exteriorTemperature	
			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 B: RWW IVI Profile

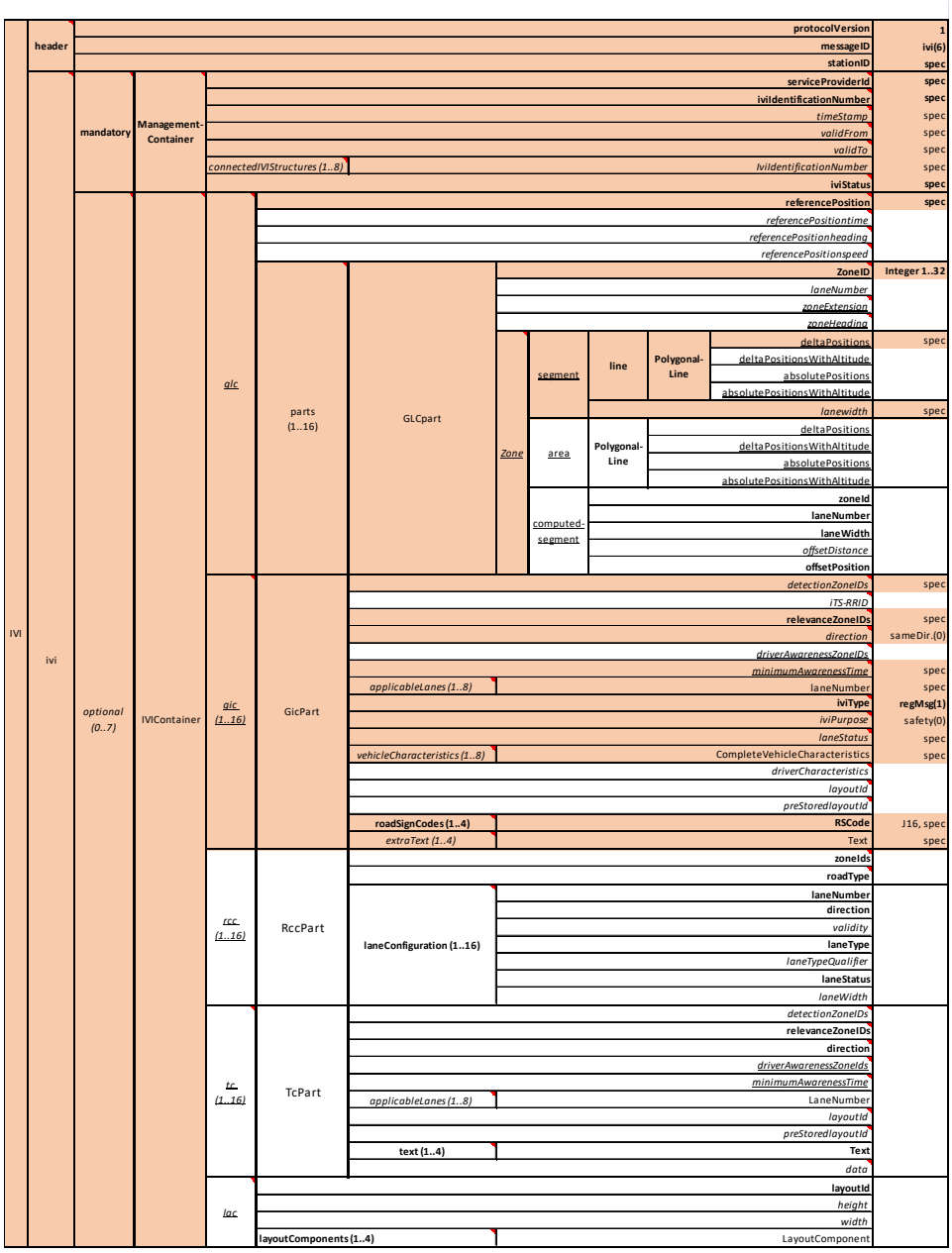
The picture below gives a screenshot of the Excel file of the IVI [6] profile: “Road Works Warning (RWW) IVI profile - v1.0.xlsx”.

In-Vehicle Information (IVI)

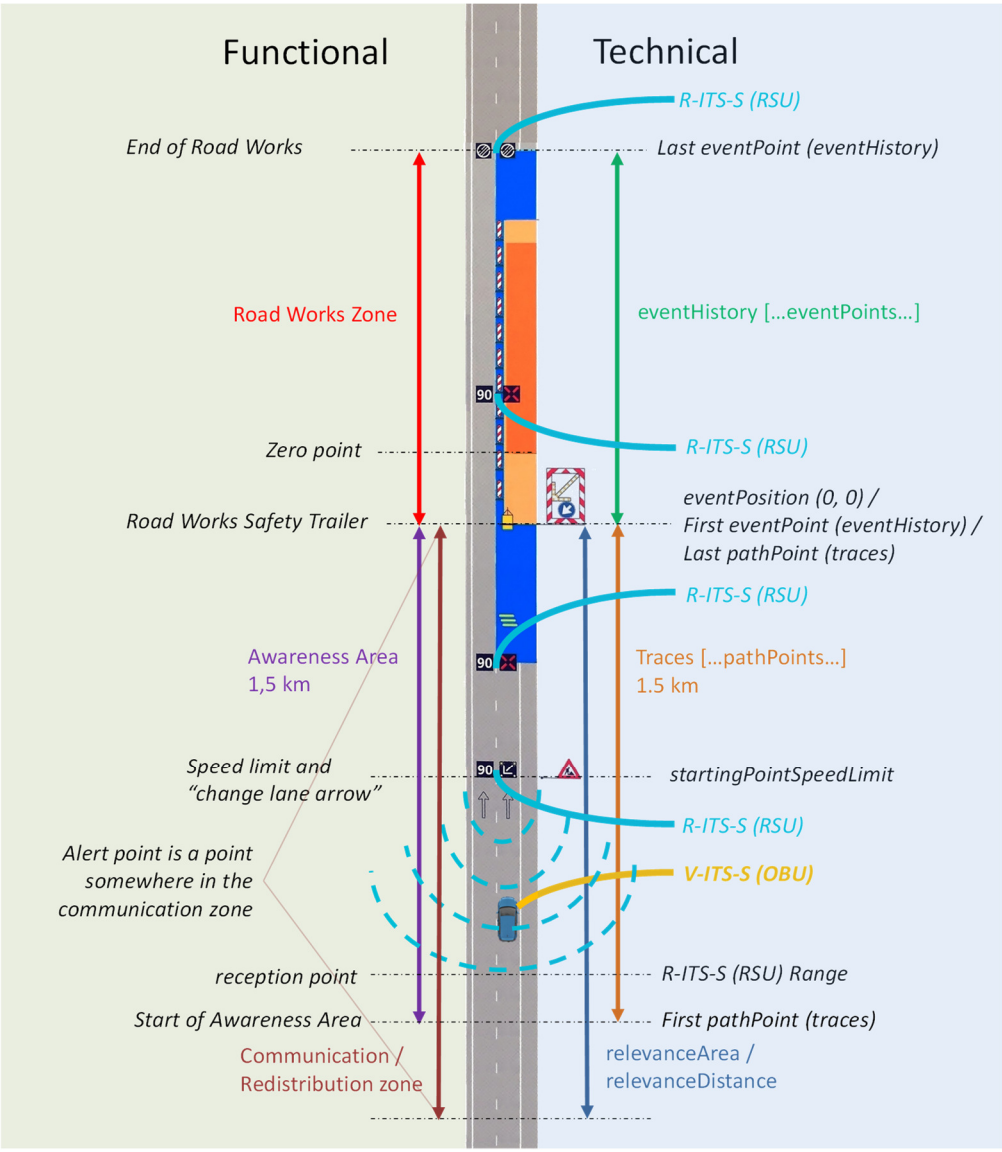
Intelligent transport systems — Cooperative ITS — Dictionary of in-vehicle information (IVI) data structures
ISO/PDTS 19321

IVI message profile
v1.0 28-06-2015 Anton Wijbenga

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



Annex C: Functional and technical locations



Annex D: RWW 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.

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.

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.
.

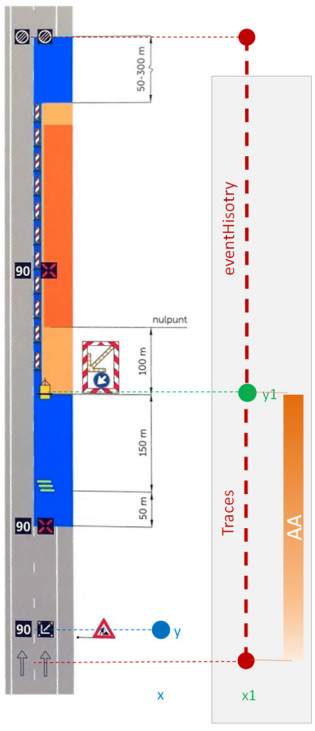
Right Lane and Hard Should Closed (CROW 96a Fig. 210)

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

DENM Example

					Message 1
header			protocolVersion		1
			messageID		denm(1)
			stationID		id-x
denm	management	actionID	originatingStationID (stationID)		id-x
			sequenceNumber		1
			detectionTime		time
			referenceTime		time
		eventPosition	latitude		y1
			longitude		x1
			relevanceDistance		lt5km(5)
			relevanceTrafficDirection		upTraf(1)
			validityDuration		10 min
			stationType		rsu(15)
	situation		informationQuality		profile
		eventType	causeCode		rw(3)
			subCauseCode / RoadworksSubCauseCode		sTSR(4)
		eventHistory (1..23|40 EventPoint)	EventPoint	eventPosition	[Δx1, Δy1]
		traces (1..7 PathHistory)	PathHistory (0..40 PathPoint)	PathPoint pathPosition	[-Δx1, -Δy1]
	alacarte		*lanePosition*		1
		roadWorks	*closedLanes*	*hardShoulderStatus*	closed(1)
				drivingLaneStatus	[0, 1, dc]
			speedLimit		90
			startingPointSpeedLimit		[x-x1, y-y1]
			trafficFlowRule		p2left(3)

Fig 210



CROW96a figure 210 shows road works where a single lane is closed and there is an accompanying speed limit of 90 km/h. The red and orange dots represent an imaginary coordinate 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 first physical obstacle is encountered and thus corresponds to the trailer. 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 road works area contains an area that is physically closed off: from the first obstacle (trailer) until the last (the last guidance marker). That area is represented by the *eventHistory* as can be seen in the figure. The points that make up the eventHistory are positioned in the middle of the carriageway. At least the first and last points are needed to mark the beginning and end of the closed off area. The first point is at the cross section with the *eventPosition* (trailer) and the last at end of the road works zone (denoted by the end-of-restrictions sign). In this example, the length of the *eventHistory* equals the length of closed-off area.
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, the DE *lanePosition* indicates on which lane the *eventPosition* (i.e. trailer) is located. For a closed lane, the value 1 is used and for an open lane the value 0.

Awareness Area (AA)
Upstream of the *eventPosition* an area is marked as the Awareness Area (AA). This area is represented by the trace(s). The traces are used by V-ITS-Ss to determine whether they are on the path towards the physical obstacle (e.g. trailer).
It is allowed to define a specific DE *startingPointSpeedLimit*. In this example this point is referenced with (x, y). This DE will be used if the point where the speed limit starts does not correspond to the *eventPosition*. If it does correspond, the DE *startingPointSpeedLimit* is omitted.
The speed limit as show on the trailer itself, in this case 90, is represented by the DE *speedLimit*.
Finally, the vehicle in the AA needs to know on which side to pass the physical obstacle (right or left). This is communicated using the DE *trafficFlowRule*. It is set to 3 (*passToLeft*).

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 where the DENM is valid. The DE *detectionTime* specifies when the DENM is valid. The DENM is valid from the time mentioned in *detectionTime* until *detectionTime+validityDuration*. The remaining time DE is *referenceTime*. That DE is used to timestamp the broadcasted message from the application that generates the DEN message.

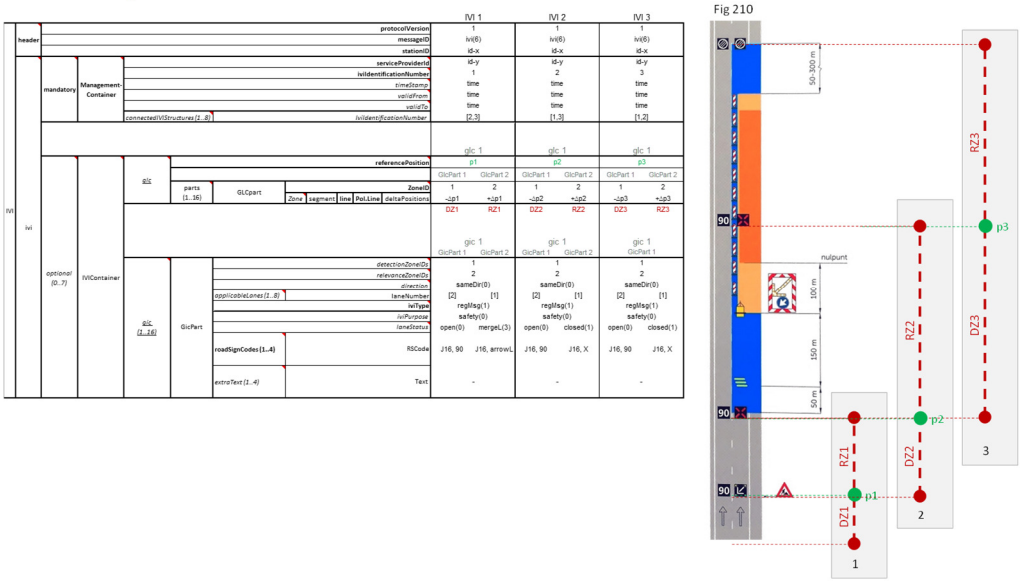
Other
There are a few DEs, other than spatial or temporal, left. The most important are *stationID* and the DF *actionID* containing DEs *originatingStationID* and *sequenceNumber*.
The *stationID* is set to the station identity that broadcasts the message. Which/what message that is, is determined by the *actionID*. In other words, the *actionID* is the identifier for messages with the same content and only changes when changes occur in the road works (e.g. different speed limit, other number of closed lanes, etc.). The *originatingStationID* is set to the *stationID* of the station that generates the DENM. The *sequenceNumber* is increased with 1 for each new DENM (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*).

In this example, just one DENM is needed. If, however, multiple DENMs are needed, they will refer to the *actionIDs* of the other DENMs within the DF *referenceDenms*. This is explained in the next example.

Three DEs remain: *informationQuality*, *causeCode* and *subCauseCode*. The *informationQuality* is used to indicate the accuracy/quality of the positioning information. The DE informationQuality is set to 1 (‘planned’) assuming the information is derived from SPIN.
The *causeCode* and *subCauseCode* indicate the type of event the DENM refers to. In this case that is 3 (*roadworks*) and 4 (*shortTermStationaryRoadworks*).

IVI Example



CROW96a figure 210 shows road works where a single lane is closed and there is an accompanying speed limit of 90 km/h. The red and green dots represent an imaginary coordinates system. Using those imaginary coordinates, it is shown how IVI messages would be related to zones for the use as road works warning.

Location
Road works are realized using MTM or mobile MTM. The position of the trailers and other road works related obstacles on the road are referred to by DENM. The IVI message will inform the receiving ITS station about the dynamic signs from the MTM.

Geographic Location Container
For each gantry a separate IVI message is constructed. Since the gantries in this figure are linked to the same road works, the separate IVI messages will refer to each other via the connectedIVIStructure component. The position of a gantry is indicated by the referencePosition.

Each gantry has a detection zone (DZ). This zone is used to determine relevance for the approaching vehicle. It is similar to traces from DENM. A second zone, the relevance zone (RZ), determines the segment for which the signs and lane attributes are valid. This is similar to the eventHistory in DENM.
To describe the zones, a series of points (segment) is used which are referred to by deltaPositions. These are delta points with respect to the referencePosition. The reference position and delta points are all in the middle of the carriage way. As a result, the zones are also on a carriageway level.

Information
Which signs apply in the relevance zone is described in the generalIVIContainer. All lanes that have a sign or signs in common are included within one GicPart. In this example, each dynamic sign always refers to one lane, therefore the applicableLanes component always refers to one lane. The status of that lane is

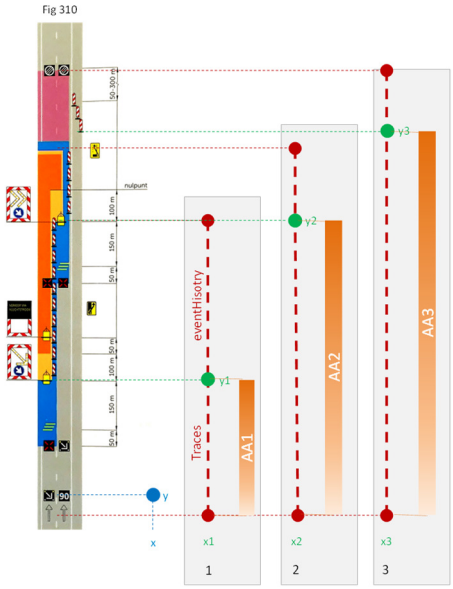
indicated by the laneStatus component. That component holds the value closed(0) in the event of a red cross or the value mergeL(3) in case of an arrow pointing to the left. The red cross and arrow are encoded in the RSCode component list. That list also, always, holds the code J16 which is the road works sign code.

<u>Two (both) lanes closed (CROW 96a Fig. 310)</u>

Road works on multiple bordering lanes.

DENM Example

				Message 1	Message 2	Message 3
header			protocolVersion	1	1	1
			messageID	denm(1)	denm(1)	denm(1)
			stationID	id-x	id-x	id-x
denm	management	actionID	originatingStationID (stationID)	id-x	id-x	id-x
			sequenceNumber	1	2	3
			detectionTime	time	time	time
			referenceTime	time	time	time
		eventPosition	latitude	y1	y2	y3
			longitude	x1	x2	x3
			relevanceDistance	lt5km(5)	lt5km(5)	lt5km(5)
			relevanceTrafficDirection	upTraf(1)	upTraf(1)	upTraf(1)
			validityDuration	10 min	10 min	10 min
			stationType	rsu(15)	rsu(15)	rsu(15)
	situation		informationQuality	profile	profile	profile
		eventType	causeCode	rw(3)	rw(3)	rw(3)
			subCauseCode / RoadworksSubCauseCode	sTSR(4)	sTSR(4)	sTSR(4)
		eventHistory (1..23|40 EventPoint) EventPoint	eventPosition	[Δx1, Δy1]	[Δx2, Δy2]	[Δx3, Δy3]
		traces (1..7 PathHistory) PathHistory (0..40 PathPoint) PathPoint	pathPosition	[-Δx1, -Δy1]	[-Δx2, -Δy2]	[-Δx3, -Δy3]
	allocate		*lanePosition*	2	1	0
		roadWorks *closedLanes*	*hardShoulderStatus*	aFD(2)	aFD(2)	closed(1)
			drivingLaneStatus	[1, 0, dc]	[1, 1, dc]	[0, 0, dc]
			speedLimit	90	90	90
			startingPointSpeedLimit	[x-x1, y-y1]	[x-x2, y-y2]	[x-x2, y-y2]
			trafficFlowRule	p2right(2)	p2right(2)	p2left(3)
		referenceDenms (0..8 ActionID) ActionID	originatorStationID (stationID)	[id-x, id-x]	[id-x, id-x]	[id-x, id-x]
			sequenceNumber	[2, 3]	[1, 3]	[1, 2]



In CROW96a 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 physical object: two times a trailer and one time a set of guidance markers. 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 there was one closed off area. Now there are three. Each DENM describes an area that is has the same lanes closed off. The first DENM only refers to the leftmost lane, the second to both lanes and the third to a section of the hard shoulder being closed off. Therefore, 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], [1,1] and [0,0], meaning first the left lane is closed, then both lanes are closed and after that, both lanes are available again.

The *hardShoulderStatus* is 2 (*availableForDriving*), 2 (*availableForDriving*) and 1 (*closed*), meaning that from the first *eventPosition* the vehicle is allowed to drive on the hard shoulder and the vehicle should move back to the right lane before the last *eventPosition,* because of the markers forcing the road users back onto the road.
Finally, the *lanePosition* DE is used to indicate on which lane the *eventPosition* is located (i.e. the two trailers and guidance markers. The values for the three DENMs (counting from the outside of the road) are respectively: 2, 1 and 0.

Awareness Area (AA)
The traces are used for the same purpose as in the previous example. However, each DENM has its own set of traces. They all start at the same point(s), since the whole of the road works can be seen as one situation and the DENMs refer to each other via the DF *referenceDenms*. If the vehicle is on one trace, it is also on the trace of the other DENMs. Therefore, it 'knows' that all DENMs are relevant.

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 obstacles.

Relevance Area
This is the same as in the first example, except the end of 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 the same for all DENMs.

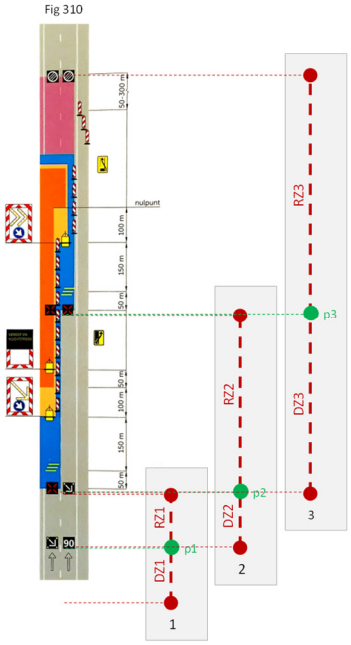
Most interesting about this example is, however, the use of the DF *referenceDenms*. That container now holds the *actionIDs* of all DENMs except the DENM itself (e.g. [(A,2), (A,3)] for the first DENM). That way, the recipient of the broadcasted DENMs "knows" that these messages belong together and as a whole describe all obstacles within the same road works.

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

IVI Example

				IVI 1	IVI 2	IVI 3
IVI	header		protocolVersion	1	1	1
			messageID	ivi(6)	ivi(6)	ivi(6)
			stationID	id-x	id-x	id-x
	ivi	mandatory	Management-Container	serviceProviderId	id-y	id-y	id-y
				iviIdentificationNumber	1	2	3
				timeStamp	time	time	time
				validFrom	time	time	time
				validTo	time	time	time
			connectedIVIStructures (1..8)	iviIdentificationNumber	[2,3]	[1,3]	[1,2]
					glc 1	glc 1	glc 1
		optional (0..7)	IVIContainer	referencePosition	p1	p2	p3
				glc		GicPart 1 GicPart 2	GicPart 1 GicPart 2	GicPart 1 GicPart 2
				parts (1..16)	GLCpart	ZoneID	1 2	1 2	1 2
						Zone segment line Pol.Line deltaPositions	-Δp1 +Δp1	-Δp2 +Δp2	-Δp3 +Δp3
							DZ1 RZ1	DZ2 RZ2	DZ3 RZ3
							glc 1 GicPart 1 GicPart 2	glc 1 GicPart 1 GicPart 2	glc 1 GicPart 1
				glc (1..16)	GicPart	detectionZoneIDs	1 2	1 2	1 2
						relevanceZoneIDs			
						direction	sameDir(0)	sameDir(0)	sameDir(0)
						applicableLanes (1..8)	laneNumber	[2] [1]	[2] [1]	[1,2]
							IviType	regMsg(1)	regMsg(1)	regMsg(1)
							iviPurpose	safety (0)	safety (0)	safety (0)
							laneStatus	mergeR(2) open(0)	closed(1) mergeR(2)	closed(1)
						roadSignCodes (1..4)	RSCode	J16, arrowR J16, 90	J16, X J16, arrowR	J16, X
						extraText (1..4)	Text	-	- Verkeer via vluchtstrook (nl)	Verkeer via vluchtstrook (nl)

Fig 310



This example is very similar to the previous IVI example. Technically, the difference is that in the third IVI message, only one GicPart is needed. The third gantry has two red crosses on them. Thus the message "lane is closed" refers to both lanes and therefore one GicPart is sufficient.

In addition, the second and third IVI message hold the text "Verkeer via vluchtstrook" (in English: "Traffic via hard shoulder"). The text is included since there is no MTM sign explicitly indicating the hard shoulder is open, but it is implied by the mergeR and arrowR on the first lane.

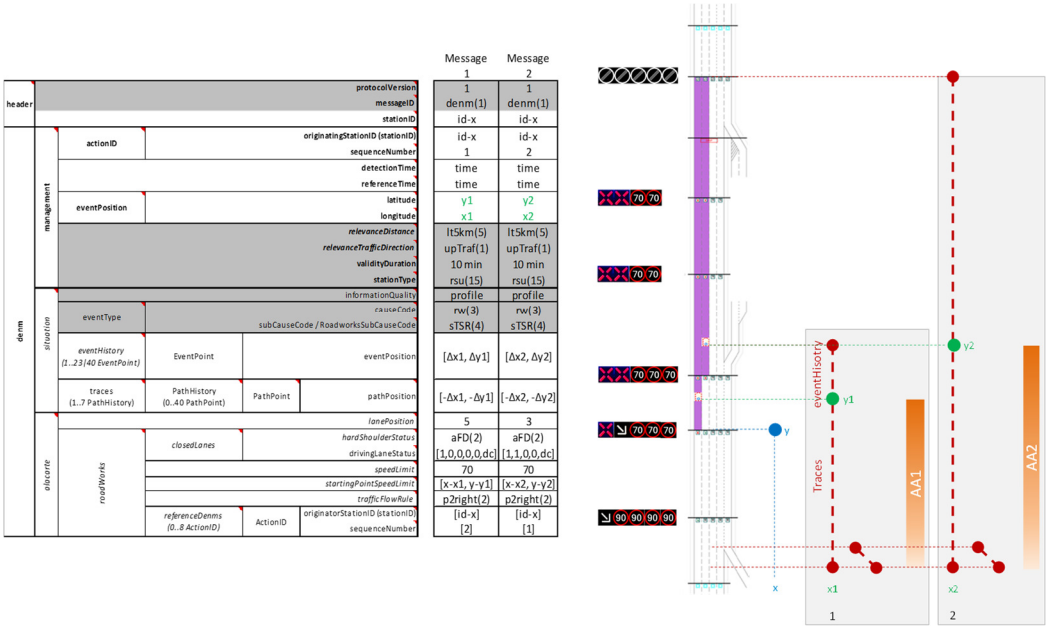
This text will be visible on the VMS in the figure. The text could also be communicated via a TextContainer. This however is currently not part of the profile.

A16 Fieldtest

Below two figures, one for DENM and one for IVI, are included as an example of another situation. This situation was used for a RWW use case fieldtest on the A16 in November 2015.

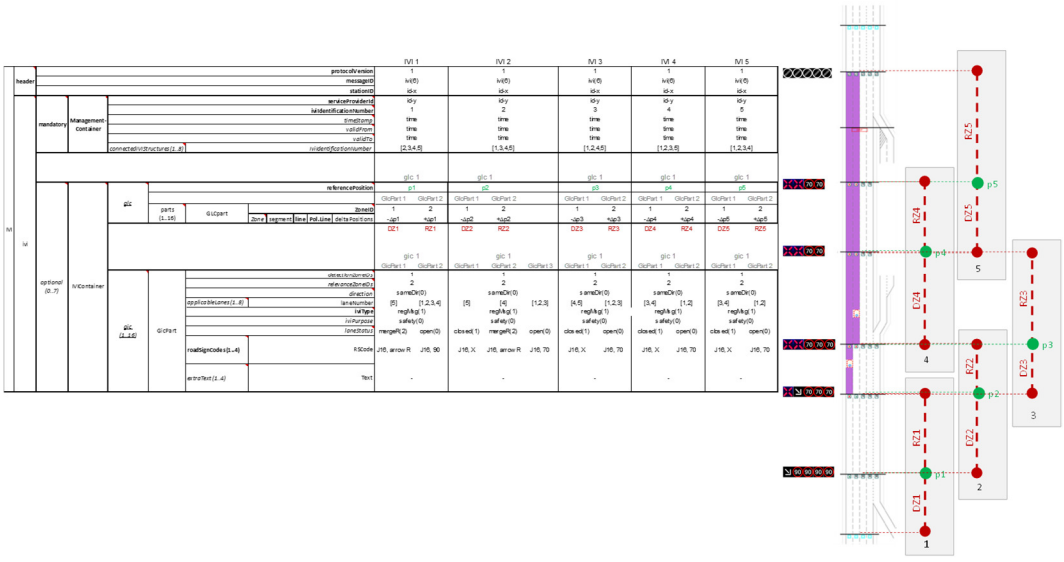
Note that DENM and IVI messages as described here differ from the messages actually used in the A16 fieldtest itself. At the A16 fieldtest only DENM messages and no IVI messages were used. The example is given here merely to clarify how DENM and IVI could theoretically be used in a particular situation.

DENM Example



					Message 1	Message 2
header				protocolVersion	1	1
				messageID	denm(1)	denm(1)
				stationID	id-x	id-x
denm	management	actionID		originatingStationID (stationID)	id-x	id-x
				sequenceNumber	1	2
				detectionTime	time	time
				referenceTime	time	time
		eventPosition		latitude	y1	y2
				longitude	x1	x2
				relevanceDistance	lt5km(5)	lt5km(5)
				relevanceTrafficDirection	upTraf(1)	upTraf(1)
				validityDuration	10 min	10 min
				stationType	rsu(15)	rsu(15)
	situation			informationQuality	profile	profile
		eventType		*causeCode*	rw(3)	rw(3)
				subCauseCode / RoadworksSubCauseCode	sTSR(4)	sTSR(4)
		eventHistory (1..23 | 40 EventPoint)	EventPoint	eventPosition	[Δx1, Δy1]	[Δx2, Δy2]
		traces (1..7 PathHistory)	PathHistory (0..40 PathPoint)	PathPoint	pathPosition	[-Δx1, -Δy1]	[-Δx2, -Δy2]
	alacarte			*lanePosition*	5	3
		roadWorks	*closedLanes*	*hardShoulderStatus*	aFD(2)	aFD(2)
				drivingLaneStatus	[1,0,0,0,0,dc]	[1,1,0,0,dc]
				speedLimit	70	70
				startingPointSpeedLimit	[x-x1, y-y1]	[x-x2, y-y2]
				trafficFlowRule	p2right(2)	p2right(2)
			referenceDenms (0..8 ActionID)	ActionID	originatorStationID (stationID)	[id-x]	[id-x]
					sequenceNumber	[2]	[1]

IVI Example



					IVI 1	IVI 2	IVI 3	IVI 4	IVI 5
header				protocolVersion	1	1	1	1	1
				messageID	ivi(6)	ivi(6)	ivi(6)	ivi(6)	ivi(6)
				stationID	id-x	id-x	id-x	id-x	id-x
ivi	mandatory	Management-Container		serviceProviderId	Ky	Ky	Ky	Ky	Ky
				iviIdentificationNumber	1	2	3	4	5
				timeStamp	time	time	time	time	time
				validFrom	time	time	time	time	time
				validTo	time	time	time	time	time
			connectedIviStructures (1..8)	*iviIdentificationNumber*	[2,3,4,5]	[1,3,4,5]	[1,2,4,5]	[1,2,3,5]	[1,2,3,4]
	optional (0..7)	IviContainer		referencePosition	gic 1 p1	gic 1 p2	gic 1 p3	gic 1 p4	gic 1 p5
			gic	parts (1..16)	GicPart	GicPart 1	GicPart 2	GicPart 1	GicPart 2	GicPart 1	GicPart 2	GicPart 1	GicPart 2	GicPart 1	GicPart 2
					ZoneID	1	2	1	2	1	2	1	2	1	2
					Zone segment line Pol.Line delta Positions	-up1 +up1	-up2 +up2	-up3 +up3	-up4 +up4	-up5 +up5
						DZ1 RZ1	DZ2 RZ2	DZ3 RZ3	DZ4 RZ4	DZ5 RZ5
			gic (1..16)	GicPart		gic 1 GicPart 1	GicPart 2	gic 1 GicPart 1	GicPart 2	GicPart 3	gic 1 GicPart 1	GicPart 2	gic 1 GicPart 1	GicPart 2	gic 1 GicPart 1	GicPart 2
					detectionZoneIDs1	1	1	1	1	1
					relevanceZoneIDs1	2	2	2	2	2
					direction	sameDir(0)	sameDir(0)	sameDir(0)	sameDir(0)	sameDir(0)
				applicableLanes (1..8)	laneNumber	[5] [1,2,3,4]	[5] [4] [1,2,3]	[4,5] [1,2,3]	[3,4] [1,2]	[3,4] [1,2]
					laneType	regAug(1)	regAug(1)	regAug(1)	regAug(1)	regAug(1)
					iviPurpose	safety(0)	safety(0)	safety(0)	safety(0)	safety(0)
					laneStatus	mergeR(2) open(0)	closed(1) mergeR(2) open(0)	closed(1) open(0)	closed(1) open(0)	closed(1) open(0)
				roadSignCodes (1..4)	RSCode	J16, arrow R J16, 90	J16, X J16, arrow R J16, 70	J16, X J16, 70	J16, X J16, 70	J16, X J16, 70
				extraText (1..4)	Text	-	-	-	-	-

Annex E: bPVD CAM Profile

The picture below gives a screenshot of 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