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Description of the System Concept

Cooperative ITS Corridor System (ICS)

Date 4 juli 2016
Status Final

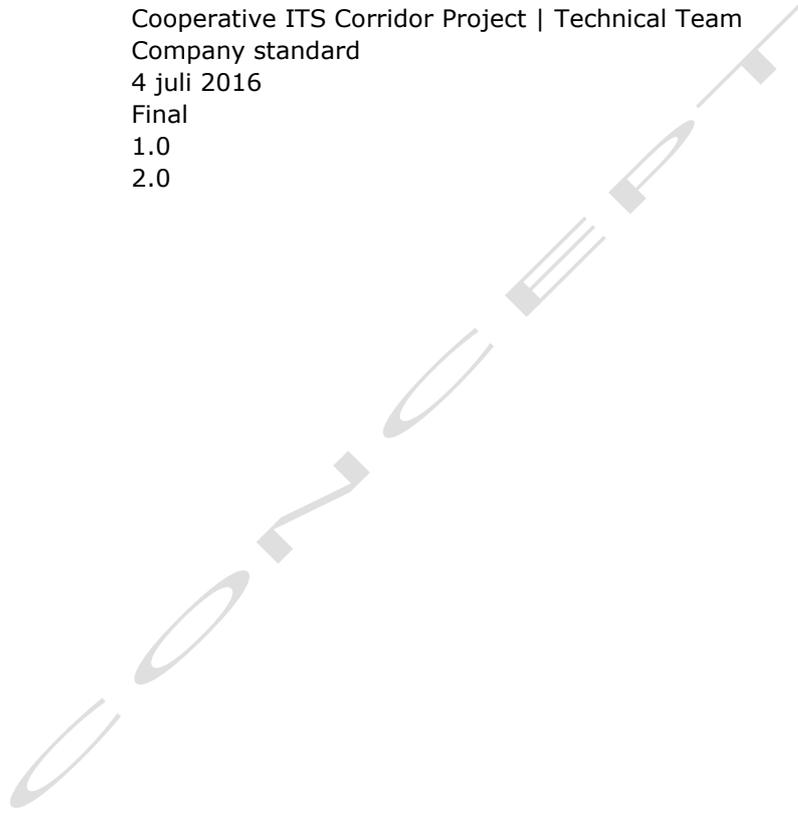
Cooperative ITS Corridor

Joint deployment



Colofon

Issued by	Ministry of Infrastructure and the Environment, the Netherlands Rijkswaterstaat Programma's, Projecten en Onderhoud (PPO) Realisatiebureau ITS (RITS)
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Layout	Company standard
Date	4 juli 2016
Status	Final
Version	1.0
Release	2.0



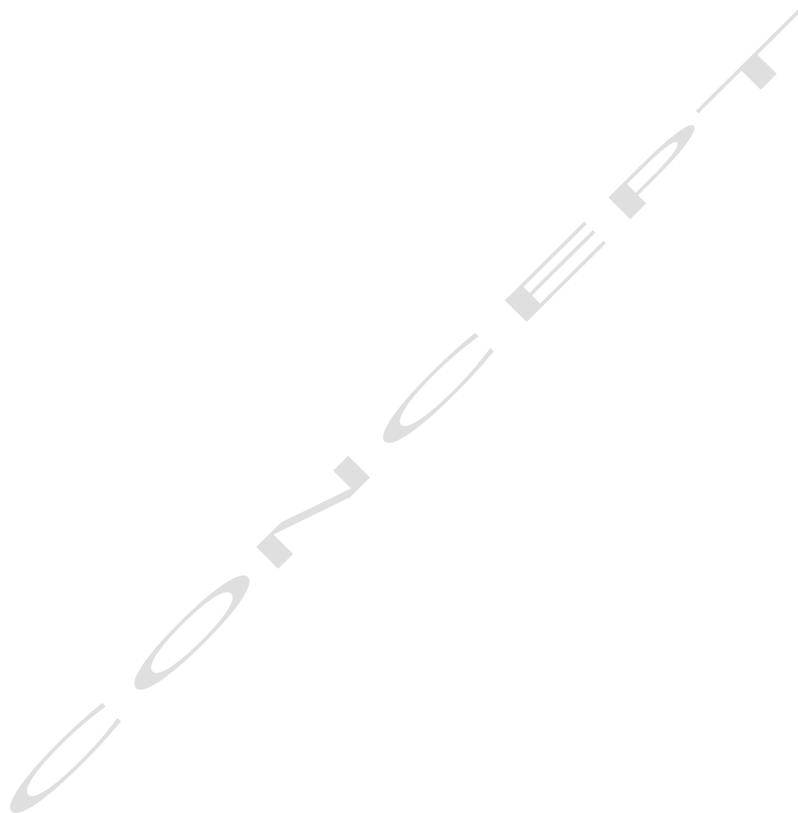
Contents

1	Introduction—5
2	Project scope—7
2.1	Background—7
2.2	Memorandum of Understanding [MoU]—7
2.3	Collision Risk Warning—9
2.4	Cellular stream—9
2.5	First deployment—10
3	System context—12
3.1	Starting point—12
3.1.1	Rulebook CROW 96a—12
3.1.2	Signalling system MTM2—12
3.1.3	Mobile signalling systems MRS—13
3.1.4	Trailers—13
3.1.5	Road works planning system SPIN—13
3.1.6	Rush hour lanes—14
3.1.7	Measuring systems—14
3.1.8	Data communication—14
3.1.9	Traffic control centres—14
3.1.10	Data management—14
3.1.11	Traffic inspectors—14
3.2	Future state—15
4	Use cases—17
4.1	ITS framework—17
4.2	Road Works Warning (RWW)—19
4.2.1	Road works process—19
4.2.2	Sending and receiving RWW information—20
4.2.3	Use of DENM and IVI—21
4.2.4	RWW information and data elements—22
4.2.5	Operational scenario's—24
4.2.6	Road works types—25
4.3	basic Probe Vehicle Data (bPVD)—25
4.3.1	Use of CAM and/or DENM messages—26
4.3.2	Extended PVD—26
4.3.3	Basic PVD—26
4.3.4	PVD information and data elements—27
4.3.5	Processing—28
4.4	Collision Risk Warning (CRW)—28
4.4.1	CRW information and data elements—30
5	System overview—31
5.1	Subsystems and system context—31
5.2	Principles and constraints—32
5.2.1	Interoperability—32
5.2.2	Non-proprietary RSU-CU interface—32

- 5.2.3 Use of NNV/VICnet—33
- 5.2.4 Generic wifi-P (G5) infrastructure—33
- 5.2.5 Central control—34
- 5.2.6 Cooperative and cellular stream in parallel—35
- 5.2.7 Information input and triggers—35
- 5.2.8 Privacy and security—35
- 5.3 RSU variants—36
- 5.3.1 RSU variants per scenario—37

Appendix A. References and Abbreviations—39

- A.1 References—39
- A.2 Abbreviations—40



1 Introduction

The Cooperative ITS Corridor project is a cooperation of Austria, Germany and the Netherlands in realising a first deployment of ITS on the corridor Vienna - Frankfurt – Rotterdam, based on the Memorandum of Understanding [MoU] as drawn up by the Ministers of Transport. This document, the Description of the System Concept [CON], is a deliverable of Rijkswaterstaat, the Dutch partner in the Cooperative ITS Corridor project.

The Customer Requirements Specification version 1.0 (in Dutch 'Klant Eisen Specificatie', [KES]) was the first step in the process of specifying the Cooperative ITS Corridor System in the Netherlands. Subsequently the project has drawn up a Functional Description version 1.2 [FD-NL] as well as a System Specification version 0.9 [SYS], together forming the so-called 'Release 1'.

For the subsequent Release 2.0 it has been decided to merge the Functional Description and the introductory chapters of the System Specification into one new document, the Description of the System Concept, this document.

The Description of the System Concept provides an overview of the envisaged system. The Description of the System Concept is intended for a broader audience than the System Specification. It provides background information on choices which are specified in the System Specification and subsequent documents. In other words: the Description of the System Concept *describes* the system whereas the System Specification *specifies* the system.

Release 2.0 further contains additional documents such as the (Dutch) Corridor Profile, the Security Architecture, etc. Release 2.0 will in future be replaced by Release 3.0. Releases 2.1 and 3.1 will also contain Tender Specifications.

Figure 1 gives an overview of these documents and their interrelations. See the Cover Note for more details.

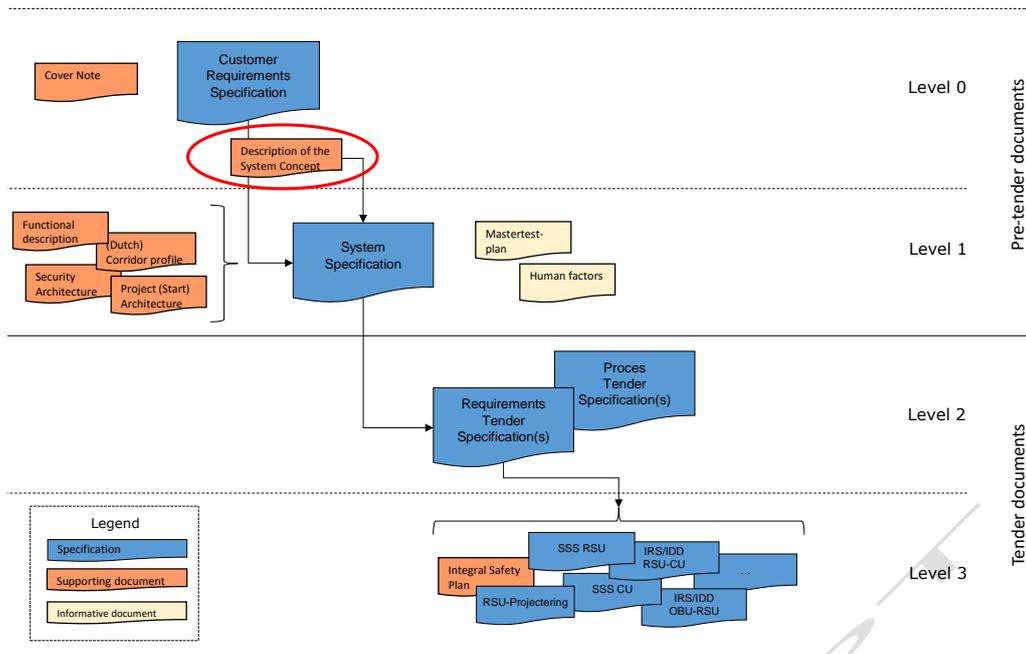


Figure 1 Specifications diagram

The document is structured as follows. Chapter 2 explains the specific scope of the Dutch Cooperative ITS Corridor project. Chapter 3 gives an overall description of the context of the envisaged system. Chapter 4 describes the use cases within scope. Chapter 5 provides a more technical overview of the envisaged system, its context and its subsystems.

2 Project scope

This chapter describes the specific scope for the Dutch Cooperative ITS Corridor project. Here we focus on how the project will contribute to the transition from starting point to future state.

2.1 Background

The German, Austrian and Dutch partners in the Cooperative ITS Corridor project will jointly develop a number of cooperative ITS services (C-ITS). The objective of the cooperation is to implement cooperative ITS services to improve the traffic flow and safety, with the exchange of information between vehicles and the roadside infrastructure.

In the Netherlands, Rijkswaterstaat is responsible for this project and is actively involved in preparations for the introduction of this new technology. The three countries are working closely together with the car industry and service providers to realise several use cases relating to various C-ITS services and applications.

European cooperation on cooperative ITS resulted in the foundation of the Amsterdam Group (<http://www.amsterdamgroup.eu>) which provides a forum for stakeholders in order to accelerate the implementation throughout Europe. The joint German/Austrian/Dutch Cooperative ITS Corridor project closely relates to the Amsterdam Group initiative.

2.2 Memorandum of Understanding [MoU]

On 10 June 2013 the Ministers of Germany, Austria and the Netherlands signed a Memorandum of Understanding [MoU] to initiate the implementation of two specific use cases: Road Works Warning (RWW) and Probe Vehicle Data (PVD).

Based on the MoU the Dutch Cooperative ITS Corridor project aims at a first deployment of Road Works Warning (RWW) and Probe Vehicle Data (PVD) on the corridor Vienna – Frankfurt – Rotterdam in cooperation with the German and Austrian partners.

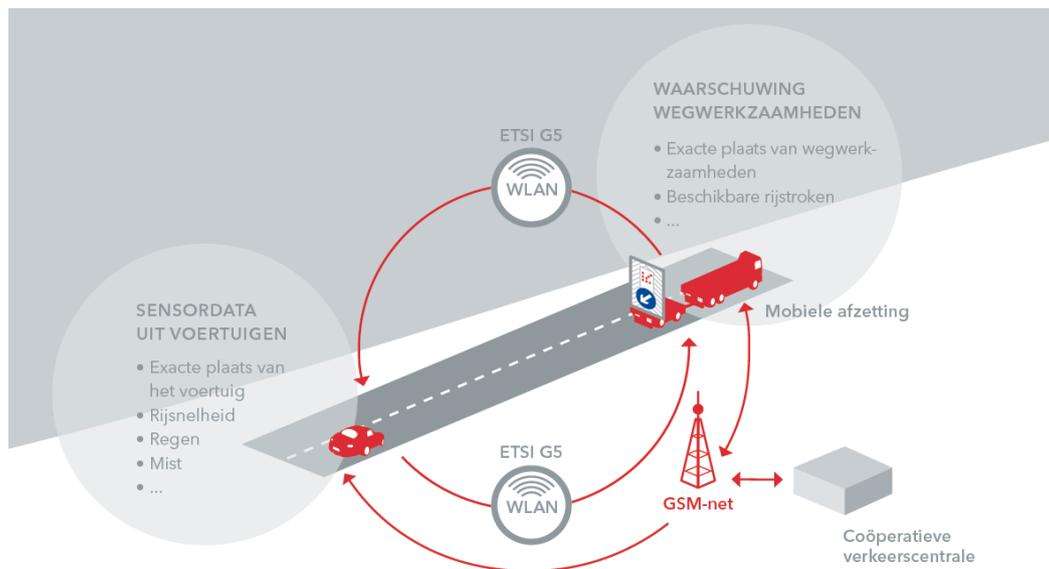


Figure 2 System overview as drafted at the offset of the Cooperative ITS Corridor project. Note that since then terminology has changed and, for the Netherlands, it is envisaged that fixed as well as portable beacons will be used. The overall logic as depicted in this figure however remains unchanged.

The MoU states:

- 'C-ITS covers all technical systems that exchange traffic-related data among vehicles and between vehicles and the roadside telematics infrastructure via wireless communication. The communication can take place using the ETSI G5 Standard within the 5.9 GHz spectrum and cellular mobile communication.
- ... The aim of this MoU is the co-operation of the Road Authorities of Germany, Austria and the Netherlands on the development of a joint strategy and road map for the deployment of C-ITS and their implementation.
- The ... participants ... will co-operate on:
 - the development of a Joint Roadmap (time table) for the introduction of the first ITS applications (namely: Roads Works Warning and Probe Vehicle Data), which they will use as a basis for the deployment of roadside based equipment along the highways in the corridor Rotterdam – Frankfurt – Wien.
 - the definition of common conventions that guarantee a harmonized interface to the vehicles across the three Countries – Functional Description of the first C-ITS applications (namely: Roads Works Warning and Probe Vehicle Data) and Technical Specifications and Standards.'

2.3 Collision Risk Warning

Additional to the use cases as agreed upon in the MoU, the Dutch Ministry of Transport decided to extend the scope of the Dutch Cooperative ITS Corridor project and to also develop the use case Collision Risk Warning (CRW) as a first expansion to new ITS services. This use case will be developed in cooperation with the Flister project in the Netherlands.

2.4 Cellular stream

The Dutch Cooperative ITS Corridor project in principle covers cooperative technologies as well as technologies using cellular communication.

Road Works Warning, Probe Vehicle Data as well as Collision Risk Warning can use cooperative as well as cellular¹ streams. In principle, these streams have the same functionality; information is transmitted from one place to another. However, the methods used are different, leading to different service levels.

Cooperative systems are systems where Onboard Units (OBUs) in vehicles communicate with each other and/or with Roadside Units (RSUs). Communication is across short distances: between 500 m and 1.5 km. Within this range an OBU can send a message to another OBU or RSU using a wifi-P connection (also known as ITS-G5). Similarly, a RSU can send a message to an OBU in a vehicle. In the Netherlands the RSU will always be connected to a remote central station.

The cooperative stream is intended for time and safety-critical systems. This means that aspects such as the transmission speed, location reliability and guaranteed reception are extremely important. Cooperative systems also allow propagation of messages. Messages will be forwarded from one ITS station to another. This mechanism broadens the range even when penetration (number of equipped vehicles) is still low.

Cellular systems communicate across longer distances. This can be based on two-way communications (3/4G) or broadcasting only (FM/DAB). These connections are handled by existing networks and therefore do not require additional investments.

Cellular systems are mostly used to inform drivers across longer distances. They can be deployed relatively quickly using apps, etc. Data communication delays, reliability, availability and dependency issues imply that cellular systems are considered less suitable for time and safety-critical applications. The ITS domain using cellular communication relies on a variety of nomadic devices like mobile phones, car radios, navigation devices, etc.

The Dutch Cooperative ITS Corridor project recognises the need for ITS systems using cellular communication but the project will not itself realise subsystems in this domain. The Dutch Cooperative ITS Corridor project will enable and stimulate service providers to actually realise the cellular stream. The project will feed the National Data Warehouse for Traffic Information (NDW) with relevant data. This will enable the NDW to supply service providers with data that is identical to the cooperative stream.

¹ This stream is also sometimes referred to as 'Connected ITS'. This term however may lead to confusion and is therefore not used here.

2.5 First deployment

The Dutch Cooperative ITS project focusses on a first deployment rather than actual full scale roll-out. The technology is still new and relatively un-proven. The project focusses on learning by doing.

The Road Works Warning, Probe Vehicle Data and Collision Risk Warning functionality will for the moment be additional to the current Traffic Management Systems. In other words: Traffic Management in the Netherlands will for the next couple of years still depend on the existing and not on the new ITS systems.

Any change to existing systems will be made in such a way that it sets a first viable step into future ITS.

Note that the scale is still limited. Only a small amount of vehicles will be equipped with OBUs and it will take some time until a substantial part of the vehicles will indeed be equipped.

The relevant road trajectory for Cooperative ITS Corridor stretches from Vienna via Frankfurt to Rotterdam. In the Netherlands the trajectory includes the highways A16, A58, A2 and A67, from Rotterdam along the cities of Breda, Tilburg, Eindhoven and Venlo. [Figure 3](#) gives an overview.

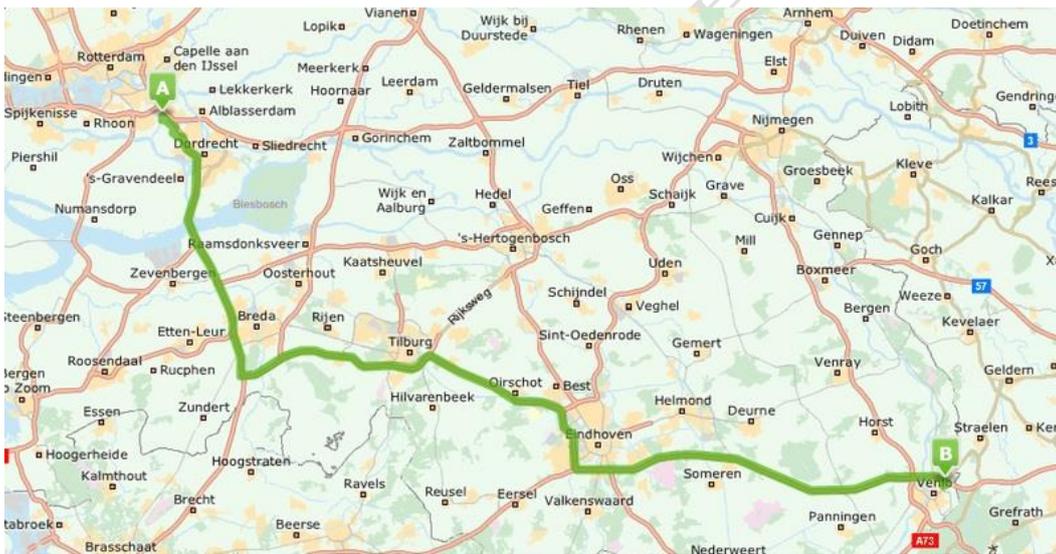


Figure 3 Overview of the Cooperative ITS Corridor trajectory in the Netherlands

The Cooperative ITS Corridor project seeks active cooperation with the industry. It is specifically essential to align the road operators perspective on vehicle-to-roadside communication to that of manufacturers of OBUs. These actors each independently provide a critical element in the overall chain. End-to-end functionality and performance will strongly depend on both. Additionally the views of RSU manufacturers and traffic information service providers will be taken into account. These actors also form a crucial part of the overall chain.

The required RSU density for ITS in the Netherlands is not yet known. This will depend on the requirements which all applications, services and use cases pose together. It is expected that although at the beginning this will be determined by the use cases within scope, it will gradually evolve into a generic infrastructure with a density sufficient for all use cases, combined with logical geonetworking facilities. The Dutch Cooperative ITS Corridor project will for the moment make assumptions which will later on have to be verified and enhanced.

The Dutch Cooperative ITS Corridor project for the moment assumes that Probe Vehicle Data messages will be gathered at the same locations where Road Works Warning is transmitted. For Collision Risk Warning it is assumed that the vehicle of the road inspector is equipped with a Roadside Unit (RSU).

3 System context

This chapter describes the current Traffic Management situation in the Netherlands that provides the starting point for ITS. Subsequently this chapter describes the envisaged ITS future situation, the long term scope.

3.1 Starting point

Rijkswaterstaat, the Dutch road operator for the National highways, has a long history in traffic management. The Dutch road network is highly dense and is equivalently equipped with a sensor and actuator network of high density.

Within the context of Intelligent Transport Systems the following characteristics are specifically relevant for the situation in the Netherlands.

Note that the approach taken to road works in the partner countries may significantly differ from that in the Netherlands. Gantry based signalling systems (permanent or mobile) are rarely used in other countries. Other countries largely rely on trailers and temporary signs. These different approaches imply different (RSU) deployment strategies and scenarios.

3.1.1 *Rulebook CROW 96a*

The road works are standardized in a (mandatory) rulebook called CROW 96a [CROW96a]. This book contains a predefined set of road works configurations and deployment scenarios (called 'CROW figures'). The definitions include the variable signs on the gantries (arrows, red crosses, speed limits) as well as the positioning of the trailer.

3.1.2 *Signalling system MTM2*

A large portion of the Dutch highways is equipped with a fixed, gantry-based, signalling system (nationwide 40%). This system, called MTM2, operates with centrally controlled variable message signs (MSIs) on gantries. The gantries are spaced at approximately 800 meters. The system uses loop detectors in every lane every 400 meters (average).

The system is actively used to facilitate road works. Red crosses, preceded by an arrow on the upstream gantry, denote the unavailability of a lane. Over 75% of the route of the Dutch Cooperative ITS Corridor project has MTM2 signals (see [Figure 4](#)).

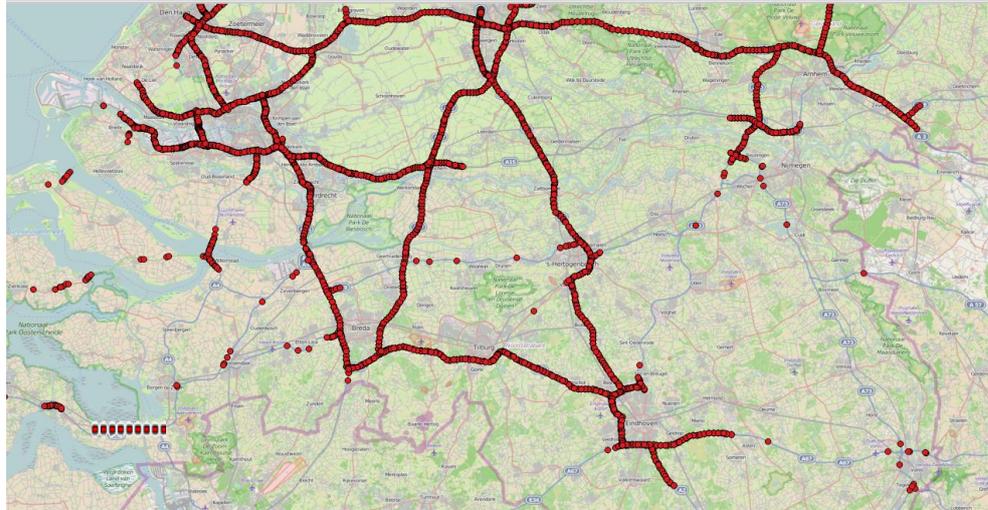


Figure 4 MTM2 coverage in the Netherlands.

3.1.3 *Mobile signalling systems MRS*

If there is no MTM2 signalling then road works are normally indicated by temporary signalling gantries (MRS). These mobile systems are for road works functionally equivalent to the MTM2 system and are used to implement the CROW96a figures in an equivalent way. These MRSs however have no connection to a central control system of Rijkswaterstaat.

3.1.4 *Trailers*

In cases where neither MTM2 nor MRSs are available, road works are implemented with regular trailers only.

In the Netherlands most trailers are owned by private parties rather than the road operator. These private parties include contractors (building and maintaining the roads), road workers (specialised in roadblocks) and rental companies (renting roadside equipment). There is no overall system which monitors and manages this equipment. Some trailer manufacturers do provide management systems but these are private and proprietary.

3.1.5 *Road works planning system SPIN*

SPIN is the central logging, acceptance and registration system for road works in the Netherlands (planning tool). It provides detailed information (CROW96a figures) for practically all planned road works, such as time, location, impact on the traffic flow and the diversions in operation. This system contains all planned road works and is mandatory for all contractors to use. Unplanned (for instance emergency repairs) road works are not registered (but could be).

Consequently, information on planned road works in SPIN in the Netherlands is centrally available. Note however that SPIN is a planning system and does not by definition represent the actual situation on the road side (this could be updated).

3.1.6 *Rush hour lanes*

The number of hard shoulder rush hour lanes and additional narrow rush hour lanes on the left edge of the carriageway has increased significantly in the Netherlands in recent years. These lanes are much less common in surrounding countries and are never located on the left of the carriageway, as is common in the Netherlands. Since these lane configurations are not standard and very specific for the Netherlands it may be difficult to handle them with ITS.

3.1.7 *Measuring systems*

There is a variety of measuring systems in and around the Dutch road infrastructure (e.g. inductive loops and radar) to measure traffic data (primarily speed and intensity). On the main road network traffic flow is mostly measured using inductive loops.

3.1.8 *Data communication*

Rijkswaterstaat has an extensive data communication network (called VICnet, part of NNV) along most of its highways. This network connects the roadside systems to the central traffic management systems. The network includes fixed, mostly glass fiber based, as well as wireless communication and by means of a private APN.

3.1.9 *Traffic control centres*

Traffic on highways in the Netherlands is monitored and managed from 5 regional traffic control centres, divided over the country, and one nationwide control centre. These centres not only manage the MTM2 system but other systems like cameras and additional VMSs as well. The centres are operational 24/7.

3.1.10 *Data management*

Dutch traffic data is collected, combined and distributed via a dedicated organization called the National Data Warehouse for Traffic Information (NDW). The NDW is the (main) single-point-of-access for traffic data. Speed, travel time and intensity are the primary traffic parameters. At present, the data flow measured by the vehicle or a mobile device (floating car data) is not included in the NDW dataset.

3.1.11 *Traffic inspectors*

In the Netherlands traffic inspectors perform a crucial role in managing traffic safety. Currently some traffic inspectors vehicles are, as a pilot, equipped with a button allowing the traffic inspector to warn road users via an app on their mobile for incidents at that location. It is intended that this pilot will be extended to all traffic inspectors vehicles.

3.2 Future state

The Traffic management policy of Rijkswaterstaat states:

'Traffic management changes rapidly. Maybe not in one year but step wise change is inevitable. The future consists of 'connected systems' and 'connected people': automated transport systems and increased personal traffic management, therefore aimed at the individual road user. This is, more than ever, enabled by joint public and private services. These systems are glued together by the data collected from all vehicles and spread out for services to individual road users. The result is one integrated transport system with smart infrastructure as well as smart vehicles.'

In the Netherlands partners in the ITS field have united their efforts in a platform called 'Connecting Mobility'. The Cooperative ITS Corridor project is denoted as one of the leading projects. Concrete ITS activities are in the Netherlands coordinated by the Dutch ITS Test site for Cooperative Mobility (DITCM).

Rijkswaterstaat actively participates in the Amsterdam Group. The Amsterdam Group states in its Roadmap:

'The implementation of Cooperative ITS (C-ITS) will provide communication and share real-time information between vehicles, between vehicles and the infrastructure and infrastructure to vehicles. This will enable the exchange of information to support road safety, traffic efficiency and sustainable travel beyond the scope of stand-alone systems. The implementation of cooperative systems will bring innovative services to road users and that will support road authorities and road operators in their roles as traffic managers and network operators. It will also change the behaviour of road users as well as influence the road authorities' and the road operators' investments in cooperative systems.'

Figure 5 sketches the envisaged future infrastructure, including roadside, data communication and central systems. The Cooperative ITS Corridor project will be one of the main projects contributing in building this future.

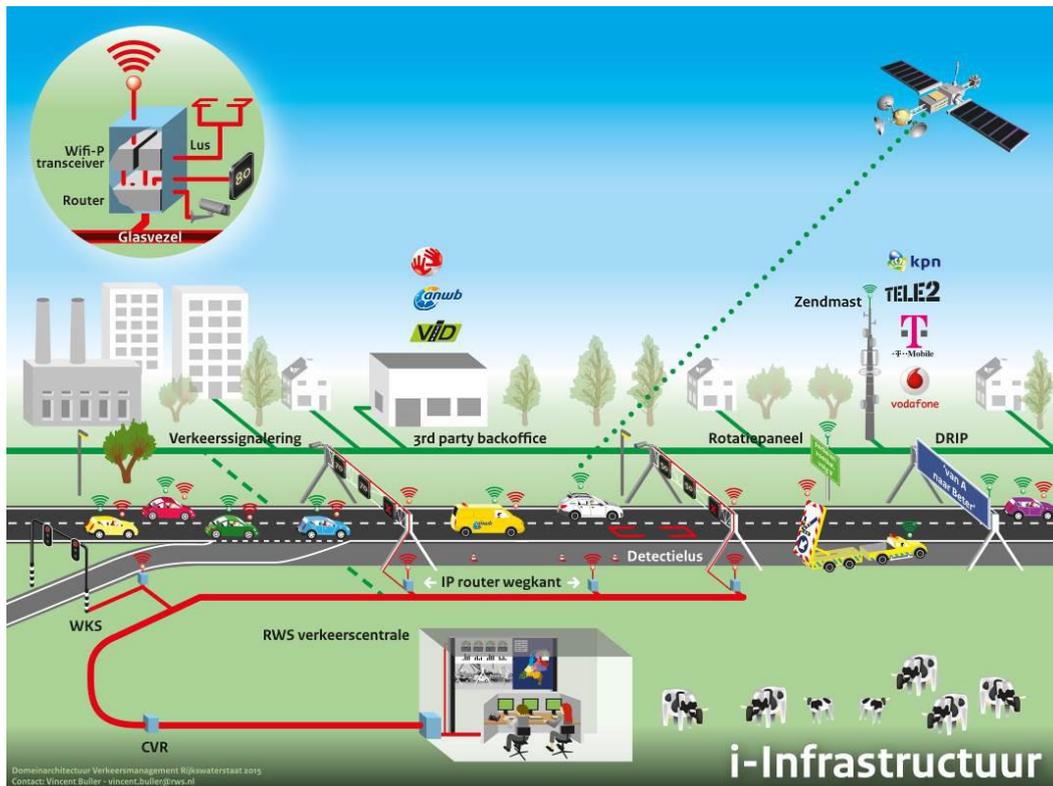


Figure 5 Future i-Infrastructure

Cooperative ITS is completely new. Cooperative ITS will be primarily based on cooperative technologies (wifi-P) but will also include streams using cellular communication. Like the cellular communication the wifi-P network can be used for multiple service providers for different use cases.

Cooperative ITS provides opportunities for services in several areas, such as safety, traffic management and the provision of information. Which of those services are provided by the public and which by the private sector is subject of extensive discussion, both nationally and internationally.

4 Use cases

This chapter describes the specific use cases in scope of the Dutch Cooperative ITS Corridor project. The following use cases are considered:

- Road Works Warning (RWW)
- basic Probe Vehicle Data (bPVD)
- Collision Risk Warning (CRW)

4.1 ITS framework

The Cooperative ITS framework distinguishes a wide range of Services, Applications and Use cases. The ETSI standards Basic Set of Applications/Definitions [ETSI-BSA] and Basic Set of Applications/Functional Requirements [ETSI-FR] give an overview.

Different actors in the field each use different definitions of the terms Services, Applications and Use cases and each apply different structures. The standards mentioned above appear to be the only common basis for all. The Dutch Cooperative ITS Corridor project has therefore chosen to base its definitions and structure on the above ETSI standards.

The scope of the Dutch project was initially limited to Road Works Warning and Probe Vehicle Data as agreed upon in the [MoU]. Additionally the Dutch Ministry of Transport has decided to also include the functionality of warning road users by means of cooperative communication for a stationary traffic inspectors vehicle marking an incident as a means for traffic inspectors in improving traffic safety.

This functionality by definition falls within the application 'Road Hazard Warning' (RHW). Within RHW the Dutch Cooperative ITS Corridor has chosen that this functionality falls within the use case 'Collision Risk Warning' (CRW). The CRW use case focusses on preventing collisions on dangerous points.

The ETSI standards [ETSI-BSA] and [ETSI-FR] do not yet include 'Probe Vehicle Data' (PVD), neither as a service, application or use case. The Dutch Cooperative ITS Corridor project has therefore added PVD to the structure given in the ETSI standards.

Probe Vehicle Data (PVD) is added as a new application under the service 'Cooperative Traffic Efficiency'. The application PVD is further divided into 2 use cases:

- 'basic Probe Vehicle Data' (bPVD, based on vehicle messages sent continuously) and
- 'extended Probe Vehicle Data' (ePVD, based on vehicle messages which are stored and sent periodically).

For the moment the Dutch Cooperative ITS Corridor project only includes basic Probe Vehicle Data (bPVD) and does not include extended Probe Vehicle Data (ePVD).

The table below gives an overall overview of the services, applications and use cases in the C-ITS field based on ETSI-BSA] and [ETSI-FR]. The use cases added are listed in **white**, the use cases in scope are listed in **bold**.

Field	Service	Application	Use case
Cooperative Intelligent Transport Systems (C-ITS)	Active Road Safety	Cooperative awareness	Emergency vehicle warning
			Slow vehicle indication
			Intersection collision warning
			Motorcycle approaching indication
		Road Hazard Warning (RHW)	Emergency electronic brake lights
			Wrong way driving warning
			Stationary vehicle - accident
			Stationary vehicle - vehicle problem
			Traffic condition warning
			Signal violation warning
			Road Works Warning (RWW)
			Collision Risk Warning (CRW)
			Decentralized floating car data - Hazardous location
			Decentralized floating car data - Precipitations
	Decentralized floating car data - Road adhesion		
	Decentralized floating car data - Visibility		
	Decentralized floating car data - Wind		
	Cooperative Traffic Efficiency	Speed management	Regulatory / contextual speed limits notification
			Traffic light optimal speed advisory
		Cooperative navigation	Traffic information and recommended itinerary
			Enhanced route guidance and navigation
			Limited access warning and detour notification
			In-vehicle signage
	Probe Vehicle Data (PVD)	basic Probe Vehicle Data (bPVD)	
		extended Probe Vehicle Data (ePVD)	
	Cooperative local services	Location based services	Point of interest notification
			Automatic access control and parking management
ITS local electronic commerce			
Media downloading			
Global internet services	Communities services	Insurance and financial services	
		Fleet management	
		Loading zone management	
	ITS station life cycle management	Vehicle-software / data provision and update	
		Vehicle and RSU data calibration	

Table 1 Overview of services, applications and use cases based on [ETSI-BSA] and [ETSI-FR].

In summary, the Dutch Cooperative ITS Corridor project therefore focusses on:

- Use case '**Road Works Warning**' (RWW), part of the Application 'Road Hazard Warning' (RHW), part of the Service 'Active Road Safety'.
- Use case '**Collision Risk Warning**' (CRW), part of the Application 'Road Hazard Warning', part of the Service 'Active Road Safety'.
- Use case '**basic Probe Vehicle Data**' (bPVD), part of the Application 'Probe Vehicle Data' (PVD), part of the Service 'Cooperative Traffic Efficiency'.

4.2 Road Works Warning (RWW)

The main aim of Road Works Warning RWW is to improve road safety. RWW aims at reducing the number of collisions with safety-objects near road works. RWW will alert the road user when approaching a dangerous zone and will simultaneously provide information on the changes in the road layout.

Within the cooperative ITS framework, the Road Works Warning (RWW) use case is part of the Road Hazard Warning application (RHW).

CROW 96a, the Dutch road works handbook, provides the starting point for road works in the Netherlands and is therefore the basis for RWW for the Dutch Cooperative ITS Corridor project.

4.2.1 Road works process

The process for road works as used in the Netherlands on motorways where the signalling system MTM2 is available (MRSs are used when MTM2 is not available, resulting in a similar process) can be described in an example as follows:

- It is Tuesday night, 21:05 h, and a traffic team is standing by on the A58L, upstream of the Baars intersection, waiting till they can implement a lane closure at verge marker post 34.80. Part of the surface of the left-hand lane (lane 1) has to be replaced.
- The traffic team contacts the traffic control centre and requests permission from the traffic control manager to implement the road closure (approved in advance and allocated a SPIN number).
- The traffic control manager assesses the request based on the current situation on the roads and decides that the closure will not lead to undue traffic disruption.
- The traffic control manager then indicates the measure on the traffic signals. Lane 1 is now marked with a red cross and speed restrictions are in place.
- The traffic team drives onto the A58. The truck mounted attenuator stops at 34.90. The contractor can now safely position the safety trailer and deploy it, downstream of the truck mounted attenuator.
- Once the trailer is in position the contractor places the traffic cones along the length of lane 1. Once the trailer is positioned the truck mounted attenuator can drive away.
- Once the lane is fully coned off the contractor with the heavy plant arrives at 21:15. The work can now start.

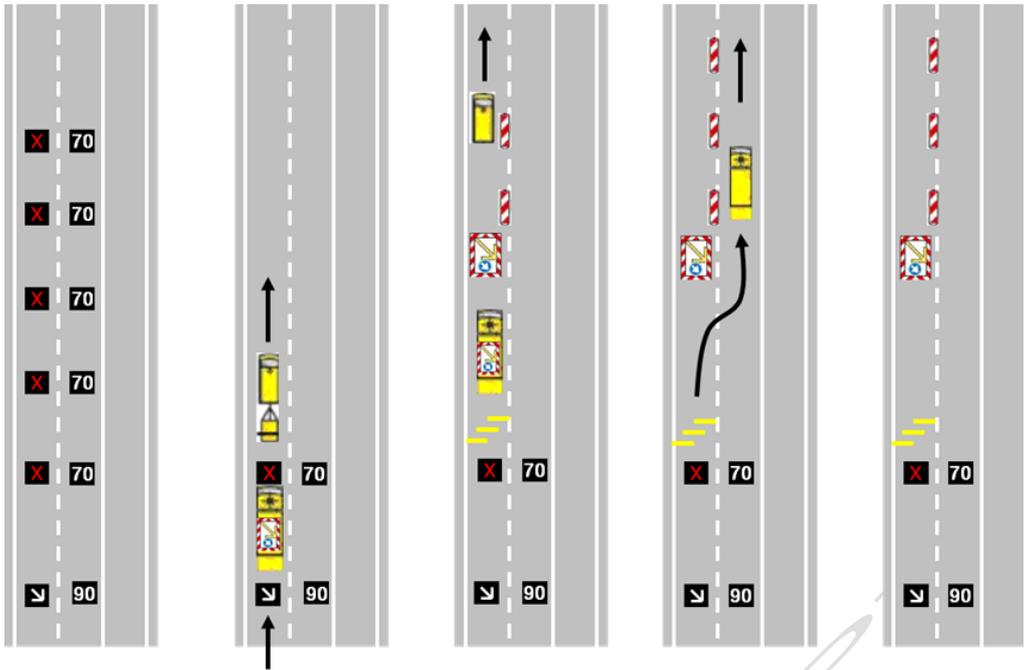


Figure 6 Setting up road works.

4.2.2 *Sending and receiving RWW information*

The RWW use case entails sending RWW information upstream from the road works, enabling the OBU to warn and inform the road user.

The RWW messages are transmitted via wifi-P ('cooperative' communication channel) by Roadside Units (RSUs) to the Onboard Units (OBUs) in vehicles. The project will make use of fixed RSUs and/or portable RSUs. The communication range of a RSU is estimated to be about 500-1500 meters. The point where the OBU first receives the messages sent by a RSU is named the Reception-point.

The RWW information needs to be received upstream from the road works, preferably after the last exit (Reception-point). It is essential that the OBU has sufficient time to process the information and to properly warn and inform the road user. Note that the OBU may after reception choose to wait before alerting the road user. This point is named the Alert-point.

Note that the RWW information will simultaneously be sent to the NDW. This allows the cellular and the cooperative stream to communicate identical information.

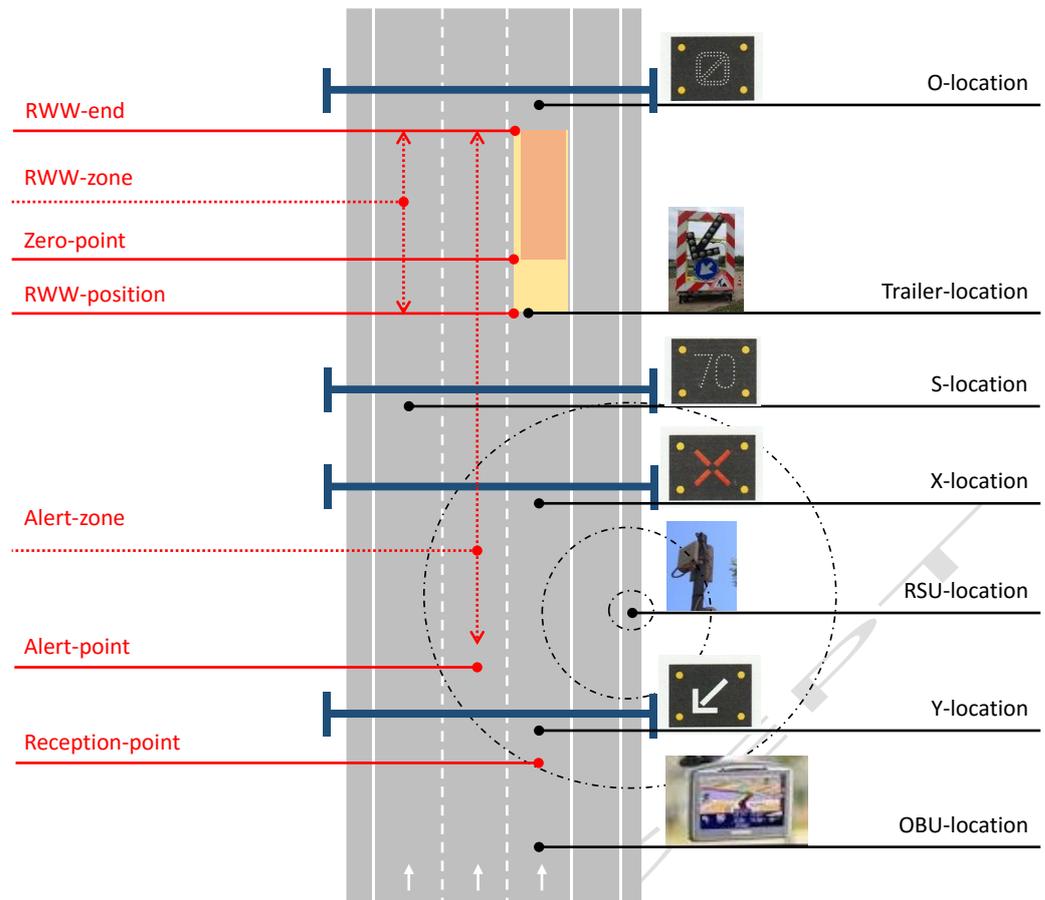


Figure 7 Overview of locations, points, zones and positions, including naming.

The way in which the driver is actually informed depends on how the OBU processes and presents the information. This implementation is determined by the parties supplying the OBUs. Whether or not the OBU will indeed use the information supplied is unknown. It should be noted that although it is uncertain if and how the OBU processes and presents the information, it is still in the interest of the road operator to provide all relevant information timely and completely. Although this will not guarantee the correct and complete operation of RWW, it is an essential prerequisite for it.

4.2.3 Use of DENM and IVI

The Amsterdam Group has originally selected DENM as the basis for RWW. DENM was originally intended for vehicle-to-vehicle (V2V) communication on events observed in the vehicles environment. Some modifications were needed to make DENM suitable for infrastructure-to-vehicle (I2V) based use cases such as RWW. The DENM standard [ETSI-DENM], including these modifications, is widely accepted by car industry as well as road operators.

Additionally other message sets such as IVI (In-Vehicle Information) have been drawn up. The IVI standard [CEN-IVI] provides better and more extensive options. The IVI standard has now been officially released and is considered to be stable.

Car manufacturers have expressed that they prefer a clear distinction between information on actual lane closures, road works and obstructions in general and supplementary information on for instance speed information.

The Dutch Cooperative ITS Corridor project has therefore decided to make use of the DENM as well as the IVI standard and to divide the RWW information over these two message sets.

The RWW information is transmitted by means of DENM as well as IVI messages. The core of the RWW information is transmitted by means of DENM messages, the supporting information (e.g. on signs) is transmitted by means of IVI messages.

The Dutch Cooperative ITS Corridor project has thus chosen to use DENM for the bare essence of the information needed for RWW (need-to-have-information) and to use IVI for all additional and supplementary information (nice-to-have-information).

4.2.4 RWW information and data elements

The Dutch Cooperative ITSD Corridor project distinguishes the following RWW information elements:

- Position of road works
- End of road works
- Path to road works
- Path from road works
- Closed lane
- Open lanes
- Availability of the hard shoulder
- Pass right or left
- Speed limit at road works
- Position of the sign
- Value of the sign

The RWW information elements are divided over DENM and IVI as follows.

RWW information element	Meaning	Typical value	DENM data element
Position of road works	Location of the physical object blocking the lane (the trailer or truck mounted attenuator), defined on lane-level.	Trailer-location	eventPosition
End of road works	Point at carriageway-level where the road works end.	RWW-end	eventHistory
Path to road works	Points at carriageway-level leading towards the road works, including the point next to the event itself.		traces
Path from road works	Points at carriageway-level leading away from the road		eventHistory

	works, including the point next to the event itself.		
Closed lane	The specific lane that is blocked.		lanePosition
Open lanes	Available open lanes.		drivingLaneStatus
Availability of the hard shoulder	Hard shoulder available or not.		hardShoulderStatus
Pass right or left	Pass the road works at the left or right side.		trafficFlowRule
Speed limit at road works	Applicable maximum speed, related to the road works (e.g. as displayed on the trailer). Default starting at the event position.	50, 70, 90, ...	speedLimit

RWW information element	Meaning	Typical value	IVI data element
Position of the sign	Location of the sign, defined on lane level.	X-location S-location Y-location	referencePosition
Value of the sign	Speed limit, red cross, arrow, ... displayed on the sign.	[50], [70], [90], [X], [\], [/], etc.	roadSignCode

The Dutch Cooperative ITS Corridor project chooses the physical location of the trailer as starting point of the road works (RWW-position). This choice is preferred over the location of the red cross since generally in DENM messages the *eventPosition* refers to a physical (blocking) object. Choosing the location of the red cross as *eventPosition* would therefore be an exception to this rule.

The DENM and IVI messages will start and stop based on centrally controlled triggers. These triggers will be derived from the existing Traffic Management Systems of Rijkswaterstaat (such as SPIN and MTM2) and/or external triggers from other sources (such as NDW, road workers, contractor, etc.).

It should be noted that although basically all road works are planned in SPIN en all measures are known in MTM2, in real life this may differ. There are exceptions such as emergency repairs. The systems are not always fully updated. Information supplied by road workers or contractors may for various reasons also not be fully accurate. Other exceptions include situations where only part of the road section is equipped with MTM2 or situations where MTM2 is available but where there are no fixed RSUs. These exceptions need to be elaborated further.

4.2.5 *Operational scenario's*

The situation on Dutch motorways differs. Not all Dutch highways are equipped with the signalling system (MTM2). Road works on non-equipped highways will in many cases make use of mobile road signalling systems (MRS). When neither MTM2 nor MRSs are available, road works are managed solely by means of trailers. Note that this situation will also be the predominant situation on provincial and city roads.

Given these different situations, the following so-called 'operational scenarios' (or 'deployment scenarios' or in short 'scenarios') are foreseen:

- Operational scenario 'Basic'. This scenario assumes use of a portable RSU for transmitting DENM message(s) only.
- Operational scenario 'Plus'. This scenario assumes use of fixed RSU(s) for transmitting DENM as well as IVI messages.
- Operational scenario 'Luxe'. This scenario assumes use of a portable RSU for transmitting the DENM message(s) and fixed RSU(s) for transmitting the IVI and DENM message(s).

Scenario Basic

This scenario is the basic and most elementary version of RWW. This scenario assumes that there are no fixed RSUs and that therefore a portable RSU has to be used. This scenario therefore only includes use of DENM and does not include IVI messages.

In this scenario the DENM messages are transmitted from a RSU which will be mounted on the trailer, on a post/object, on a vehicle, in the soft shoulder, etc. The portable RSU will have to be placed at the event position or upstream.

Scenario Plus

This scenario assumes the availability of one or more fixed RSUs and the availability of MTM2. In this scenario the DENM messages (containing the basic RWW information) as well as the IVI messages are used. The IVI message(s) will be sent additional to the DENM message(s) to enable the RWW information to be consistent with the signs on the MSIs. The IVI messages will contain the information about the 'red-crosses', the arrows, the maximum speeds, etc. as displayed by the signalling system.

The Dutch Cooperative ITS Corridor project for the moment assumes that DENM and IVI messages will preferably be sent from RSUs upstream (e.g. 1000 meters) from the event/sign itself. This will allow a substantially early reception point, allowing OBUs to choose an appropriate alert point. This will be elaborated further in the [RSU-Projectering].

Note that in case of MRSs scenario Basic applies. No IVI message is used since there is no connection between the MRS and the backoffice for the information that is displayed. If and when, in future, MRSs are connected to the MTM2 central they can be treated as regular MTM2 and will subsequently adhere to scenario Plus or Luxe.

Scenario Luxe

This scenario combines the use of fixed RSUs with the use of a portable RSU on a trailer. The DENM messages are transmitted from a RSU on the trailer whereas simultaneously the IVI messages are transmitted from the fixed RSUs on gantries.

Note that the DENM messages may additionally also be transmitted from upstream fixed RSUs, allowing them to be received earlier by the OBUs.

This scenario therefore assumes that the trailer is equipped with a portable RSU and that the gantries are equipped with fixed RSUs.

4.2.6 *Road works types*

The Amsterdam Group identified three types of road works relevant to RWW:

1. Short term mobile
2. Short term stationary
3. Long term stationary

For the time being, the emphasis in the Netherlands will be on short term stationary.

Short term mobile will make use of the same or similar portable solution which is needed for situations where no signalling system (MTM2) is available. For this type all scenarios (Basic, Plus and Luxe) apply, with the specific addition that the RWW-location is the (moving and changing) position of the mobile road works (the IVI messages are always stationary).

Long term stationary will be similar to short term stationary if safety trailers and MTM2 are used. If trailers and MTM are not used there will often be a new road configuration. In that case the question arises whether RWW messages should be transmitted at all.

4.3 basic Probe Vehicle Data (bPVD)

The main aim of Probe Vehicle Data (PVD) is to improve insight on the traffic situation by collecting sensor-data (such as speed and direction) transmitted by passing vehicles. PVD will improve information on actual traffic behavior and status, enabling the road operator to improve traffic management.

RSUs will collect relevant messages sent from OBUs from passing vehicles, in both directions, within the communication range of the RSU.

The application PVD is less mature than Road Works Warning (RWW). The PVD application has great potential but needs further research. How to actually use PVD data is not yet clear and there are privacy issues.

The Dutch Cooperative ITS corridor project has divided the PVD application into two use cases:

- basic Probe Vehicle Data (bPVD): based on messages continuously transmitted by vehicles
- extended Probe Vehicle Data (ePVD): based on data stored in vehicles transmitted when passing a RSU.

4.3.1 *Use of CAM and/or DENM messages*

Vehicles fitted with C-ITS systems can transmit two message types: CAM (Cooperative Awareness Message) and DENM (Decentralized Environmental Notification Message). CAM messages relate to the status and position of the vehicle and are transmitted continuously. In contrast, DENM provides information about the environment, as observed by the vehicle, and is only transmitted occasionally.

Car manufacturers have indicated that they will in the near future equip new cars with equipment sending CAM messages. When DENM will be introduced is unclear. The Dutch Cooperative ITS Corridor project has therefore decided to base PVD on CAM messages only.

4.3.2 *Extended PVD*

The main difference between extended and basic PVD is that with extended PVD the data is buffered by a vehicle when it is not within range of a RSU. As soon as a vehicle comes within range of a RSU the buffered data is transmitted. This means that data about areas without RSU coverage can still be accessed, however with a delay. The size of the delay depends of the vehicle speed and the density of the RSUs.

The information provided by extended PVD is the same as for basic PVD. The added value of this use case is that information is stored in the vehicle and therefore available to the next RSU. For example, if RSUs are installed every 5 km, then basic PVD will only include information about the speed and lights status of vehicles within range of a RSU. If extended PVD is used, vehicles store the information between RSUs and it is accessed when a vehicle comes within range of a RSU. This data is valuable as the data storage standard includes the locations.

Extended PVD poses additional requirements on the in-vehicle equipment. Data has to be stored and may have to be aggregated. Extended PVD furthermore introduces additional privacy issues. The data required for extended PVD is not expected to be available in the foreseeable future.

4.3.3 *Basic PVD*

PVD will be completely dependent on the data that the automotive industry chooses to provide from vehicles to the roadside. In view of the above the Dutch Cooperative ITS Corridor project assumes that basic CAM messages are the only solid basis for PVD for the short term. The Dutch Cooperative ITS Corridor project therefore limits the application to the use case 'basic Probe Vehicle Data' (bPVD) only.

The use case basic PVD (bPVD) is thus limited to only CAM messages, from only those vehicles that are within range of the RSU and to information related to the moment the vehicle passes. There is no historic information on the road upstream of the point of reception.

4.3.4 PVD information and data elements

For the basic PVD use case the Dutch Cooperative ITS Corridor project aims to access at least the following vehicle parameters:

- Vehicle position
- Vehicle speed
- Vehicle direction
- Vehicle heading
- Vehicle lights status
- Vehicle length
- Deceleration and acceleration

Vehicles do not always provide all data. Some fields within the standard CAM messages may be left blank (optional fields) while other fields may have value 'not available'. It is therefore conceivable that vehicles do transmit correct CAM messages but do not provide all information.

The related CAM data elements are:

PVD information element	Meaning	CAM data element
Date and time	Date and time at which the data was generated.	generationDeltaTime
Vehicle position	Position of the vehicle.	referencePosition
Vehicle speed	Speed of the vehicle.	speed
Vehicle direction	Direction of the vehicle (0-360 deg).	heading
	Driving direction of the vehicle (forward/backward).	driveDirection
Vehicle lights status	Status of the vehicles lights (fogLights, headLights, etc.).	exteriorLights
Vehicle length	Length of the vehicle.	vehicleLength
De-/acceleration	De- or acceleration of the vehicle.	longitudinalAcceleration

4.3.5 Processing

The possibilities provided by PVD are similar but also different to those provided by conventional systems such as inductive loops. In both cases data is gathered from point locations.

For the moment however, with only a limited number of vehicles transmitting CAM, it will not be possible to measure traffic intensity using PVD. On the other hand PVD however offers new possibilities such as origin-destination, acceleration, deceleration and direction of vehicles. At present it is unknown which opportunities the new PVD data will provide.

For the time being the Dutch Cooperative ITS Corridor project has therefore decided only to collect and not process the data. PVD data will be treated as raw data, the data will not be interpreted or formatted. The RSU will forward the raw PVD data to the Central Unit. Where possible and permitted the centrally collected data will be made available to third parties for research purposes.

This data can be combined with data from other sources. This will allow further research in determining how PVD data needs to be enhanced and merged with the data obtained from existing Roadside Systems.

4.4 Collision Risk Warning (CRW)

In the Netherlands the traffic inspector (in Dutch: 'weginspecteur') plays an important role in managing traffic safety. Unfortunately however they are often themselves subject to hazardous situations. It (too) frequently happens that traffic inspector vehicles are hit by others.



Figure 8 Traffic inspectors vehicle.

Rijkswaterstaat has started several projects and initiatives in order to reduce this risk and to improve the safety of the traffic inspectors. One of these initiatives, the so called 'Flister' project, installs transmitters on the traffic inspectors vehicles. When positioned at a dangerous location, the traffic inspector sends a signal to a central system which then, by means of conventional media, sends alerts to passing vehicles.

The Dutch Ministry of Transport has decided to extend the scope of the project with this traffic inspector based hazardous warning functionality and for the Dutch Cooperative ITS Corridor project to cooperate with the Flister project. The required functionality can be described as: warning road users by means of cooperative communication for a stationary traffic inspectors vehicle marking an incident.

The traffic inspector activates the signal when protecting an incident that renders one or more lanes unavailable. The signal is activated directly after reaching 'fend-off position' by pressing a button. The signal includes information on the position and heading of the vehicle. The traffic inspector is notified by means of a light that the system is active.

Note that the traffic inspectors vehicle is considered to be the obstacle instead of the incident itself.

The Dutch Cooperative ITS Corridor has chosen that this functionality falls within the application Road Hazard Warning (RHW) and the use case Collision Risk Warning (CRW). CRW is incorporated in the DENM standard and specified further in the standard on Longitudinal Collision Risk Warning ([ETSI-LCRW], ETSI TS 539-1).

Use case	Scenario illustration
Safety relevant lane Change	
Emergency electronic brake light / Traffic condition	
Roadworks	
Stationary vehicle	
Stability problem	
Collision risk warning from a third party	

Figure 9 Longitudinal Collision Risk Warning according to ETSI TS 539-1.

The Dutch Cooperative ITS Corridor will implement this functionality by means of DENM messages transmitted from the traffic inspector vehicle to passing vehicles by means of wifi-P ('cooperative' communication).

The CRW information and resulting DENM messages are seen to be Infrastructure-to-Vehicle (I2V) rather than Vehicle-to-Vehicle (V2V) communication. They are messages which are generated by the road operator, not the vehicle itself and therefore fall within the I2V domain. The sending device is therefore a Roadside Unit (RSU) (and thus connected to the Central Unit (CU)) rather than an Onboard Unit (OBU) (which is not connected to the CU).

If centrally available the Central Unit will, similar to Road Works Warning (RWW), in parallel send the CRW information to the NDW. This allows the cellular and the cooperative stream to communicate identical information.

4.4.1 CRW information and data elements

The CRW information elements are:

- Vehicle position
- Path to the incident

The related DENM data elements are as follows.

CRW information element	Meaning	DENM data element
Vehicle position	The position of the traffic inspectors vehicle.	eventPosition
Path to the vehicle	Points describing the path to the traffic inspectors vehicle, including the point next to the vehicle itself.	traces

5 System overview

This chapter gives the decomposition of the system and its context as well as some main design constraints and requirements. This chapter provides the basis for more detailed requirements to be specified in the System Specification.

5.1 Subsystems and system context

The overall system is subdivided into three subsystems:

- Onboard Unit (OBU), the equipment in the vehicle.
- Roadside Unit (RSU), the equipment at the roadside.
- Central Unit (CU), the centrally placed equipment.

The environment of the ITS Corridor System (ICS) consists of the following entities (depicted below). These entities surrounding the system are also called 'context-objects'. These are the entities that the system has interaction with (interfaces to).

- Road user
- Nomadic Device (e.g. smartphones)
- Operator (central operator, traffic controller, traffic inspector, etc.)
- Road Works Equipment (e.g. trailers and MRSS)
- Roadside Systems (e.g. the roadside stations of the MTM2 signalling system)
- Third Party Systems (e.g. enforcement cameras)
- Traffic Management Systems (e.g. SPIN and MTM2)
- National Data Warehouse for Traffic Information (NDW)
- Traffic Information Systems (private companies, service providers)

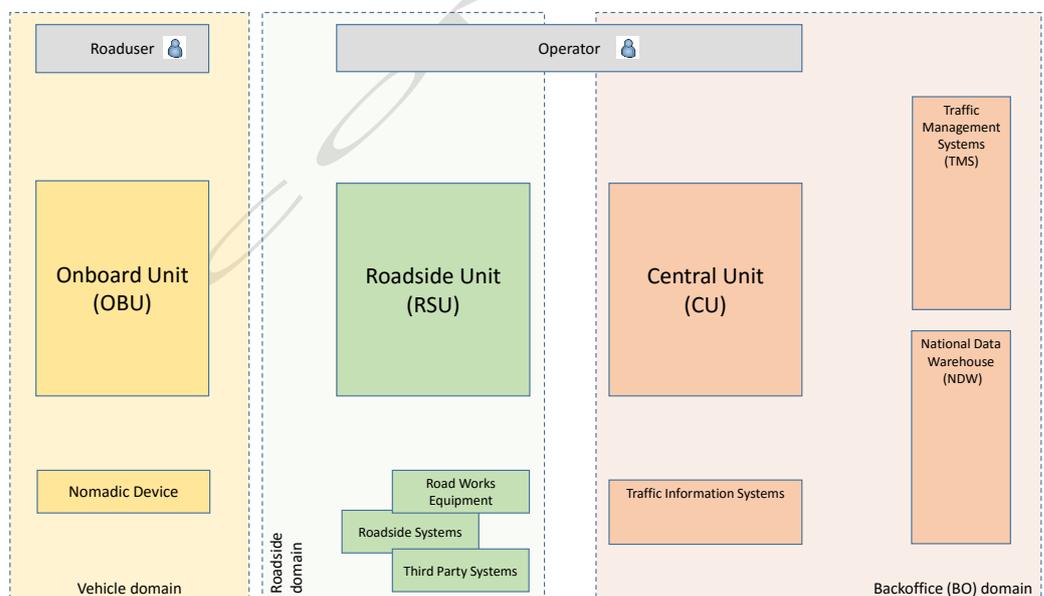


Figure 10 The system in its environment: context-objects and domains

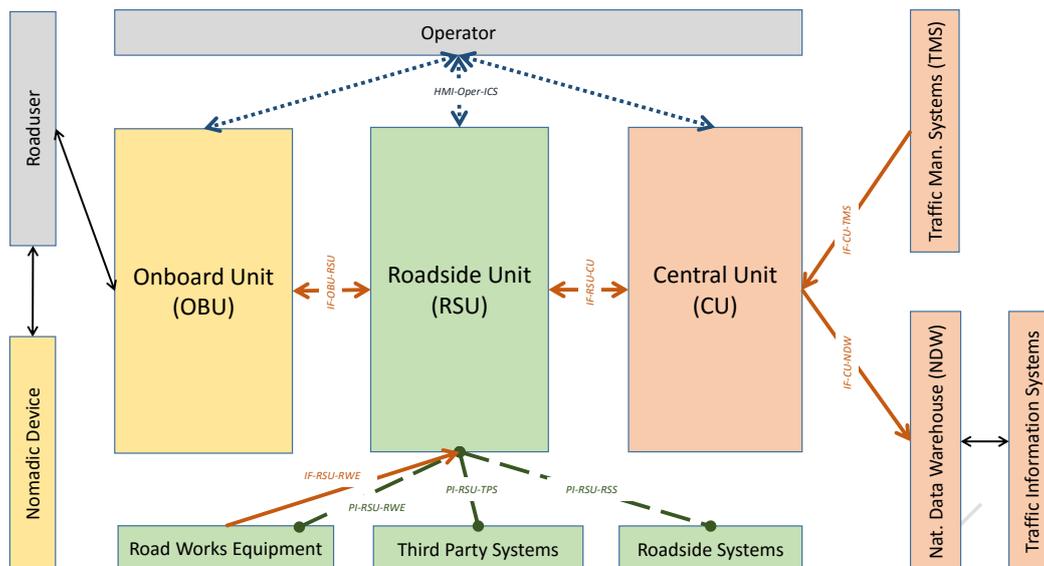


Figure 11 The subsystems and interfaces (information/datacommunication interface in orange, physical/electrotechnical in green, human/machine in blue).

5.2 Principles and constraints

5.2.1 Interoperability

The OBU-RSU interface shall guarantee RSUs and OBUs to be internationally compatible and interoperable. In view of the scope of the Cooperative ITS Corridor this shall above all apply to Germany and Austria but it shall in principle apply to all European countries as well.

Note that although the OBU is officially not in scope and will be supplied by other parties (e.g. car industry), it is essential to include the OBU in the overview of the overall system concept.

The Dutch Cooperative ITS Corridor project defines the role of the DENM and IVI messages sent from the RSU as providing actual information on the road situation to OBUs, allowing OBUs to combine this with other data sources (such as radar, cameras, etc.), to interpret the combined data and to present the outcome to the road user in an appropriate way.

Human factors and human-machine interfacing are, especially from a traffic management point of view, crucial to the overall performance of the system. The Dutch Cooperative ITS Corridor project therefore stimulates initiatives in this field (see [HF]).

5.2.2 Non-proprietary RSU-CU interface

The interface between the CU and the RSU shall be based on open standards and shall not be proprietary. The CU and RSU shall be 'plug-and-play' compatible.

5.2.3 Use of NNV/VICnet

At this moment the Dutch traffic management systems make use of a dedicated VPN (VICnet) within the Dutch NNV network. It is envisaged that for ITS a new and additional VPN will be established. All data communication, either wired or wireless, will make use of this VPN.

At this moment the Dutch Rijkswaterstaat NNV network is IPv4 based. It is envisaged that in order to allow deployment of ITS upgrading to IPv6 will be needed. Additionally in order for the network to serve as a generic infrastructure able to support multiple services, geonetworking and gateway functionality will be required.

These functionalities are not expected to be available in the short term. The system, specifically the RSU, will therefore have to be able to function under the present conditions (e.g. IPv4) as well as under the future conditions (e.g. IPv6).²

5.2.4 Generic wifi-P (G5) infrastructure

According to the ETSI architecture standard [ETSI-ARC] cooperative ITS distinguishes the following layers:

- Management layer
- Application layer
- Facilities layer
- Network & Transport layer
- Media and Access layer
- Security layer

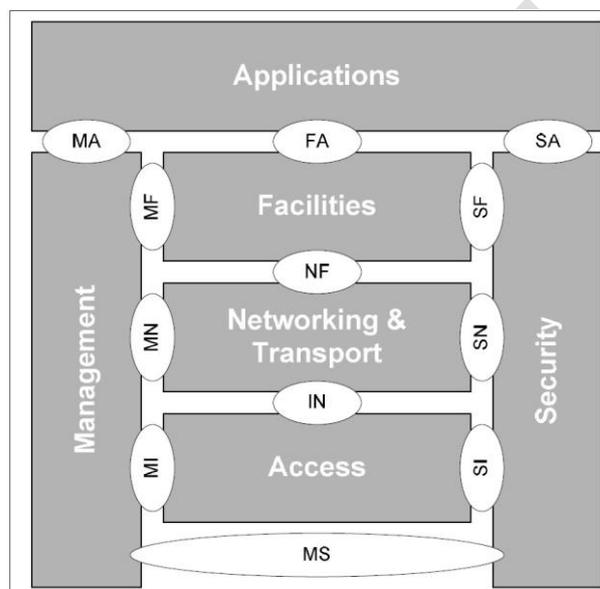


Figure 12 ITS Station Reference Architecture

² Note that upgrading the NNV network is not part of the scope of the Dutch Cooperative ITS Corridor project and will have to be achieved by Rijkswaterstaat itself. The project is merely a 'client' using services provided by the generic NNV network, not the provider of this network.

The ETSI-DENM and ETSI-CAM standards are part of the 'Facility' layer. The 'Security' layer addresses message security, the 'Network & Transport' layer defines connection standards (3/4G or wifi-P/G5).

Rijkswaterstaat wishes to establish a generic wifi-P (G5) infrastructure, enabling multiple services, applications and use cases to make use of the same (messaging) infrastructure.

This implies that there will be a demarcation between 'Facilities' and 'Network & Transport' layers. 'Access' and 'Network & Transport' layers will be provided by a generic infrastructure.

It is foreseen that within the technical infrastructure the ETSI based layers can and will be provided in different ways. The 'Facilities' layer will therefore not be required on the roadside end but will be contained in the aggregation layer in which also IPv4 to IPv6 gatewaying will or can be provided. Both scenarios will be elaborated.

The essence is that the wifi-p infrastructure will be seen as an extension of the existing roadside datacommunication infrastructure as will all network- and transport layers.

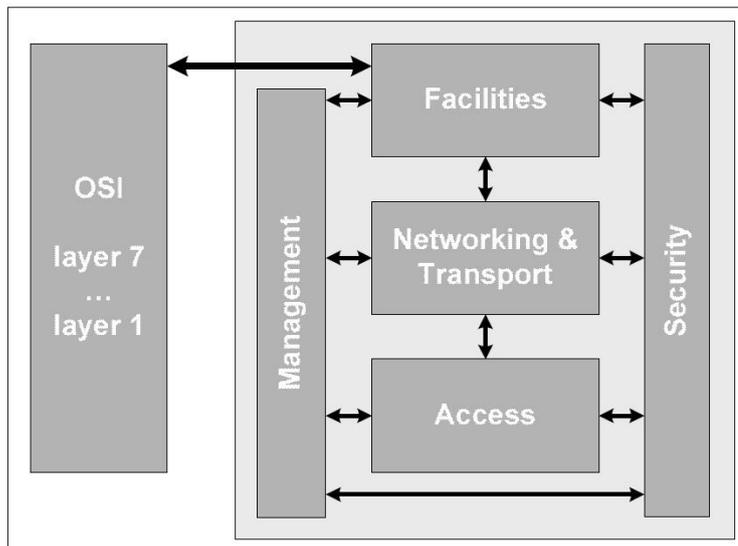


Figure 13 ITS Gateway

Note that these services, applications and use cases may be either public or private. It is envisaged that, even though the infrastructure may be (public) owned by Rijkswaterstaat, it may be open to private service providers as well.

5.2.5 Central control

RSUs are always connected to the CU, RSUs are always 'remotely operated'. There will be no standalone RSUs. Even portable RSUs will always be connected. Note that this implies that only options 2 and 3 of the Amsterdam Group are included and option 1 is not.

The Dutch Cooperative ITS Corridor project has chosen to concentrate intelligence in the Central Unit, resulting in a 'thick' Central Unit and a 'thin' Roadside Unit. Additionally the Central Unit is hierarchically the master with respect to the RSU (the slave).

DENM and IVI messages are therefore centrally generated in the CU and subsequently communicated to the relevant RSU(s). Note that even when data is supplied locally (e.g. an operator locally enters data) this data is first communicated to the central and processed centrally. DENM and IVI messages transmitted by RSUs are never generated locally.

There will be more than one RSU. There may theoretically also be more than one CU but for the moment it is assumed there will be only one.

When in 'Online' mode the RSU will function under control of the CU. In case the RSU is disconnected from the CU, the RSU will change to 'Local' mode. To prevent the RSU from sending incorrect messages the RSU will stop sending messages when in Local mode. It is yet to be decided whether sending CRW information may have to be an exception to this rule.

Nevertheless, the RSU will continue receiving and storing PVD messages in Local mode. Furthermore, the mode 'Idle' is defined for the default situation after starting up or disfunctioning in case of a fatal error. The actual mode of each RSU should be known by the CU and only the CU is allowed to order a RSU to change its mode.

5.2.6 *Cooperative and cellular stream in parallel*

All information provided via the cooperative stream (wifi-P/G5) will in parallel be simultaneously provided to the cellular stream as well. The Dutch Cooperative ITS Corridor project wishes to strictly adhere to the 'single source' principle. The main and only channel in supplying the cellular stream will be the NDW. The NDW is expected to supply the service providers.

5.2.7 *Information input and triggers*

DENM and IVI messages have to be, with respect to content as well as timing, consistent with the actual situation on the road. Several sources - such as SPIN, MTM2, NDW but also triggers from operators, road workers and contractors - are available in order to achieve this. At this point in time it is not yet clear which of these sources are most suitable to be used. This will be investigated further.

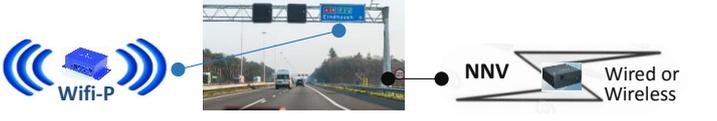
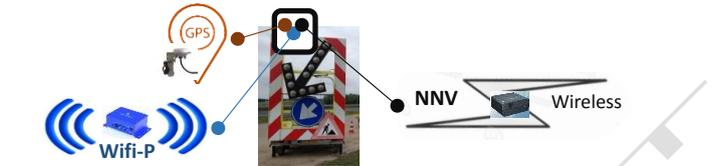
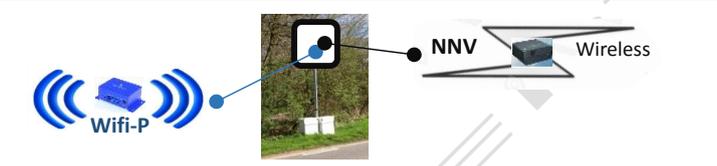
5.2.8 *Privacy and security*

The Dutch Cooperative ITS Corridor projects expects that the required security and privacy measures will be determined as a result of ongoing international developments involving road operators, authorities as well as car industry.

It is argued that Probe Vehicle Data may lead to violation of privacy. This discussion has not yet reached a conclusion. The Dutch Cooperative ITS Corridor project has therefore decided to limit PVD to merely collection of raw data that is in no way related to a vehicle or person, to be used for research.

5.3 RSU variants

For the RSU the following variants are foreseen.

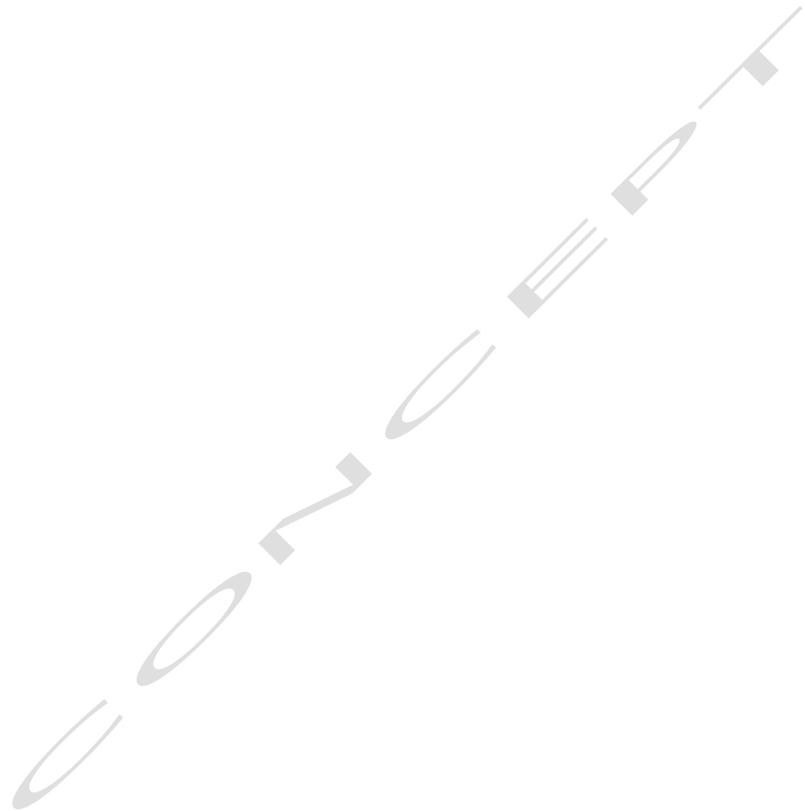
Mounted on ...	
Gantry (Ga)	
Trailer (Tr)	
Soft shoulder (SS)	
Post/object (Po)	
MRS (MRS)	
Vehicle (Ve)	
... etc.	... etc.

Note that the RSU variant 'Gantry' (Ga) does not by definition assume that the RSU is connected to the MTM2 roadside system and that it makes use of the MTM2 power supply, NNV connection to central, etc. It may well be that the RSU has its own power supply and/or NNV connection. The main assumption for this variant is that the RSU is permanently available at a fixed location.

Note that the RSU variant 'MRS' (MRS) merely assumes that the RSU is physically mounted on a MRS, not that it actually interfaces with the MRS³. In other words: scenario Basic applies. If MRS information (e.g. which signs are displayed) is centrally available, the MRS can be treated in a way similar to MTM2 (e.g. the RSU variant 'Gantry' and the scenarios Plus or Luxe apply).

5.3.1 *RSU variants per scenario*

The table below gives an overview which message formats (CAM, DENM, IVI) and which RSU variants are applicable for which use cases and scenario's.



³ Connecting MRSs to the central MTM2 system is not part of the scope of the Dutch Cooperative ITS Corridor project.

Appendix A. References and Abbreviations

A.1 References

Reference	Src	Name	Title	Version	Date
AG-FD-RWW	AG	Functional Description RWW	Functional Description of Day One Application [Road Works Warning] from the point of view of the Amsterdam Group	V1.0	
AG-MS-RWW	AG	Message Set RWW	Message Set and Triggering Conditions for Road Works Warning Service	V1.1	2014-07
CEN-IVI	CEN	CEN ISO/TS 19321	Intelligent transport systems - Cooperative ITS - Dictionary of invehicle information (IVI) data structure		2015-04
CON	RWS	Description of the System Concept	Description of the System Concept	1.0 Final	06-2016
Corridor Profile	RWS	Dutch C-ITS Corridor Profile	Dutch C-ITS Corridor Profile	1.2	2016-07
CROW96a	CROW	CROW96a	Maatregelen op autosnelwegen; Werk in Uitvoering 96a		
ETSI-ARC	ETSI	ETSI EN 302 665	Intelligent Transport Systems (ITS); Communications Architecture	1.1.1	2010-09
ETSI-BSA	ETSI	ETSI TS 102 638	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions	1.1.1	2009-06
ETSI-CAM	ETSI	ETSI EN 302 637-2	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service	1.3.2	2014-11
ETSI-DENM	ETSI	ETSI EN 302 637-3	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service	1.2.2	2014-11
ETSI-FR	ETSI	ETSI TS 102 637-1	Intelligent Transport Systems (ITS); Basic Set of Applications; Part1: Functional Requirements	1.1.1	2010-09
ETSI-LCRW	ETSI	ETSI TS 101 539-3	Intelligent Transport Systems (ITS); V2X Applications; Part 3: Longitudinal Collision Risk Warning (LCRW) application requirement specification	1.1.1	2013-11
ETSI-RHS	ETSI	ETSI TS 101	Intelligent Transport Systems	1.1.1	2013-

		539-1	(ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification		08
FD-NL	RWS	Functionele Beschrijving	Use cases C-ITS Corridor (NL); Deel A: Functionele Beschrijving	1.2 Definitief	2015-09
HF	RWS	Visie Human Factors			
IEEE-wifi-P	IEEE	IEEE 802.11	IEEE Standard for Information technology; Local and metropolitan area networks; Specific requirements; Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY)		2012
KES	RWS	Klant Eisen Specificatie	Customer Requirements Specification	1.0 Definitief	2015-11
MoU		Memorandum of Understanding	Memorandum of Understanding voor samenwerking tussen de Ministers van Verkeer van Duitsland, Oostenrijk en Nederland bij de de gezamenlijke implementatie van Coöperatieve intelligente vervoersystemen (C-ITS) op autosnelwegen op de corridor Rotterdam - Frankfurt - Wenen		2013-06
RSU-Projectering	RWS	Richtlijn RSU projectering	Richtlijn RSU projectering		
SYS	RWS	System Specification	System Specification Cooperative ITS Corridor System (ICS)	0.9 Draft	09-2015

A.2 Abbreviations

Abbreviation	Definition
bPVD	basic Probe Vehicle Data
AG	Amsterdam Group
C-ITS	Cooperative Intelligent Transport Systems
CAM	Cooperative Awareness Message
CEN	European Committee for Standardization
CRW	Collision Risk Warning
RHW	Road Hazard Warning
CU	Central Unit
IF	Interface
MSI	Matrix Signal Indicator
MRS	Mobile Road Signalling
MTM2	Motorway Traffic Management
TMS	Traffic Management Systems

NNV	Nieuwe Netwerkvoorzieningen Rijkswaterstaat
OEM	Original Equipment Manufacturers
RWE	Road Works Equipment
SPIN	Systeem Planning en Informatie Nederland
TMA	Truck Mounted Attenuator
VPN	Virtual Private Network
G5	Wifi-P
ISO	International Organization for Standardization
DENM	Decentralized Environmental Notification Message
ePVD	extended Probe Vehicle Data
ETSI	European Telecommunications Standards Institute
HMI	Human Machine Interface
I2V	Infrastructure to Vehicle
IVI	In-Vehicle Information
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transport Systems
MTM	Motorway Traffic Management system (traffic signalling)
NDW	National Data Warehouse for Traffic Information
OBU	Onboard Unit
PVD	Probe Vehicle Data
RHW	Road Hazard Warning
RSU	Roadside Unit
RWS	Rijkswaterstaat
RWW	Road Works Warning
V2V	Vehicle to Vehicle