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MAP TRAFFIC MANAGEMENT

C-ITS DEPLOYMENT IN THE NETHERLANDS

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C-ITS DEPLOYMENT IN THE NETHERLANDS

Architecture & Interoperability Table for Dutch C-ITS initiatives

VERSION 1.0

Commissioning	DITCM, Rijkswaterstaat
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Summary

This report is an update of the report, “C-ITS DEPLOYMENT IN THE NETHERLANDS” realized by TNO and MAPtm, commissioned by Rijkswaterstaat WVL in 2014. All parts have been updated but not all at full extend. They are only updated when this could have influence on any decision related to European cooperation. It includes an updated roadmap and additional element which are of relevance to decision making about to what European activities and organisations how to be connected to with the objective of realizing conformity and interoperability for ITS and Automation services envisioned to be deployed in the Netherlands.

The focus of this report is to support ITS including C-ITS and Automation use cases generically with an Hybrid Communication objective in mind. As the basis of this document is formed by the driving use case roadmap, aspects related to automation use cases are touched only lightly. The roadmap does not include aspects such as Tunnel Safety, Smart-Tachograph and Urban-Rail, items as ITS related could be considered in further discussions as they are considered as part of the ITS domain.

This report provides an overview of the use cases, the functional relevant interfaces and other aspects of interest (security) of interest to align with others in Europe. It also provides an overview of the European projects and relevant standardisation activities and those Dutch organisations active at them. Discussions with relevant Dutch stakeholders have led to the recognition of interfaces for which it maybe relevant to realize interoperability. It has not yet been possible to agree which protocols, beside ITS-G5 and related specifications, to bring to the European playing field and further align with other organisations and projects in Europe. It is proposed to discuss further what and how to align at the DITCM table and directly to the main Dutch Projects.

This report provides a comprehensive overview of the Dutch use cases and roadmap; the main European projects (we have excluded the Dutch projects as they have been assumed being known and reported by other DITCM reports); an overview of the European forums; relevant ITS standards; the identified Interfaces of interest in the ITS architecture and related aspects and the participation of Dutch organisations within ITS standardisation.

It describes the aspects and reasoning behind conformity and interoperability and provides a general view on European alignment aspects with the purpose of reaching European interoperability or business opportunities.

This report is a result of the cooperation and information sharing at the DITCM Architecture and Interoperability table and is realized by the related writing team.

Abbreviations

Abbreviation	Definition
BO	Back Office
C2C-CC	Car-2-Car Communication Consortium
CACC	Cooperative Adaptive Cruise Control
CAM	Cooperative Awareness Message
CEN	European Committee for Standardization
CIS	Central Intelligent Transport Sub-system
C-ITS	Cooperative Intelligent Transport System
CP	Communication Provider
DAB	Digital Audio Broadcasting
DATEX-II	Data Exchange – release 2
DENM	Decentralized Environmental Notification Message
DITCM	Dutch ITS Test site for Cooperative Mobility
DP	Data Provider
DVM	*Dynamisch Verkeers Management (Dutch)*
ETSI	European Telecommunication Standards Institute
ISO	International Organization for Standardization
ITS	Intelligent Transport System
ITS-S	Intelligent Transport System-Station
ITS-G5	ITS at 5 GHz frequency band
IVERA	IVER ASTRIN
IVI or IVS	In Vehicle Information or Signage
LDM	Local Dynamic Map
LTE	Long-Term Evolution (also called 4G mobile networks)
NDW	*Nationale Databank Weggegevens (Dutch)*
OBU	On-Board Unit
PID	Personal Information Device (e.g. smart phone)
PTW	Powered Two Wheel vehicle
RDS	Radio Data System
RDS-TMC	Radio Data System – Traffic Message Channel
RHW	Road Hazard Warning
RIS	Roadside Intelligent transport Sub-system
RLVW	Red Light Violation Warning
RSU	Roadside Unit
RWS	Rijkswaterstaat
SD	Service Directory
SP	Service Provider
SPES	Service Provider Exchange System
SPAT	Signal Phase and Timing
TIS	Traffic Information System
TLC	Traffic Light Controller
TMS	Traffic Management System
TPEG	Transport Protocol Experts Group
UMTS	Universal Mobile Telecommunications System (also called 3G mobile networks
VEE	Vehicle Electrical and Electronic system
VMS	Variable Message Sign
V2X/X2V	Vehicle-to-X, where X can be Vehicle (V), Roadside I or Infrastructure (I)
VIS	Vehicle Intelligent transport Sub-system

Abbreviation	Definition
VRU	Vulnerable Road Users
VRUITS	improving the safety and mobility of Vulnerable Road Users by ITS applications

1 Introduction

This report identifies important European activities and European ITS organisations, which are relevant for the deployment of C-ITS services in the Netherlands and provides an overview of Dutch representatives active at the European Standardisation organisations.

As reference an view of the expected C-ITS services is provided and this report provides a general overview of different European stakeholder groups and other European flora actively involved in the deployment and exploitation of Cooperative Intelligent Transportation Systems Services (C-ITS) Services, which have influence on the deployment of C-ITS services in Europe.

This report provides references to the European organisations and activities within Europe with focus to C-ITS. It provides an overview, which identification of the relevant European stakeholders, insight about their focus and influence with specific interest in particular to the C-ITS Services to be deployed in the Netherlands for Day 1 and beyond. Automation is limitedly included.
This document is based on the in 2014 realized report, “C-ITS DEPLOYMENT IN THE NETHERLANDS” realized by TNO and MAPtm, commissioned by Rijkswaterstaat WVL.

This document includes:

An update of Chapter 2, “Dutch C-ITS roadmap”, gives an overview of the Dutch use cases to be deployed within the Netherlands via multiple business models and communication technologies. Including updates of chapter 3, “Other Use Cases”, and an update of Chapter 5 “ Use Case Roadmaps”, gives an overview of the use cases, as expected for Dutch deployment of C-ITS, in a prioritised manner.

- New Chapter 3, on “European organisations”
- New Chapter 4, on “European projects”
- An updated Chapter 5, “Standardisation & Legislation”,.
- New Chapter 6, “Interoperability and Compliance”
- New Chapter 7, “Participation in the European context”
- Chapter 8, “Next Steps”.

This report does covers the development of both -functional as well as -technical aspects such as specifications, standards and processes to enable initial deployment of C-ITS services, with a wider view then in the original report from 2014, it takes an extended list of use cases as identified in chapter 2 into account. To facilitate such extended set of Dutch ITS use cases, in the 2014 report the “Hybrid Communication” approach was introduced, which in this update this is considered as extension to the original single communication protocol approach, but not detailed here at this time as this is assumed to be handled in other deliverables of the A@I Table and by the EU CEF project InterCor. The main communications considered here are:

- short range communication WiFi-p / ITS-G5 (5.9 GHz, IEEE 802.11p)
- mid/long range communication technologies such as 3-5G cellular
- long range communication such as DAB+ broadcasting.

2 The Dutch ITS roadmap

2.1 In General

This chapter provides an overview of the progress of an Dutch ITS roadmap. The basis for this was the roadmap realized as result of the discussions in 2015. This roadmap as provided in Figure 1 was reviewed with the current developments in the Dutch projects in mind. The use case workshop let to the creation of an extended Dutch use case roadmap representing the planned deployments in the Dutch projects (Figure 2 and Figure 3). During the workshop it became clear more discussion is needed to also clarify the importance in terms of effects and business relevance.

Within the Cooperative ITS Corridor there are 3 services based on C-ITS which will be deployed on the whole corridor. These are: Road Works Warning (RWW); Basic Probe Vehicle Data (PVD); Collission Risk Warning (CRW).
In addition to these services two extra services are planned for the Dutch part of the Cooperative ITS Corridor. These are: Extended Probe Vehicle Data; In-Vehicle Signage (IVS).

Within C-ITS there are several use cases which can finally be defined into services. Figure 1 gives a schematic overview how services between Infrastructure and Vehicles can be created by using harmonised message sets. There are more than 60-70 different use cases being developed in Europe, however there is much overlap in functionality. This document only gives a limited overview of some of the most characteristic use cases based on the use cases defined by the Amsterdam Group and the experiences from European projects like DRIVEC2X and Compass4D. Within the Amsterdam Group some of the use cases have been further described in white-papers. As an example for classification these use cases can be divided into three categories: Safety, Efficiency and Information.
Use cases within the Safety group are typically very dynamic and only viable within a small range. Therefore, for communication, these use cases rely mainly on ad-hoc, short-range communication networks (ITS-G5 networks, IEEE 802.11p). The use cases within the information group are aimed at pre-trip, and/or give information to the driver well before reaching the relevance zone to which the information is related. These use cases will mainly use IP-based communication technology, usually through 3, 4 and/or 5G cellular networks. The use cases within the Efficiency group are a mix of short and longer range services and therefore use a mixture of ITS-G5 and 3/4/5G networks. The so-called Connected services are mainly located in the information spectrum and rely on a back office for their information sources and thus 3/4/5G. Co-operative services are based on communications directly with and between vehicles and thus rely on ITS-G5.

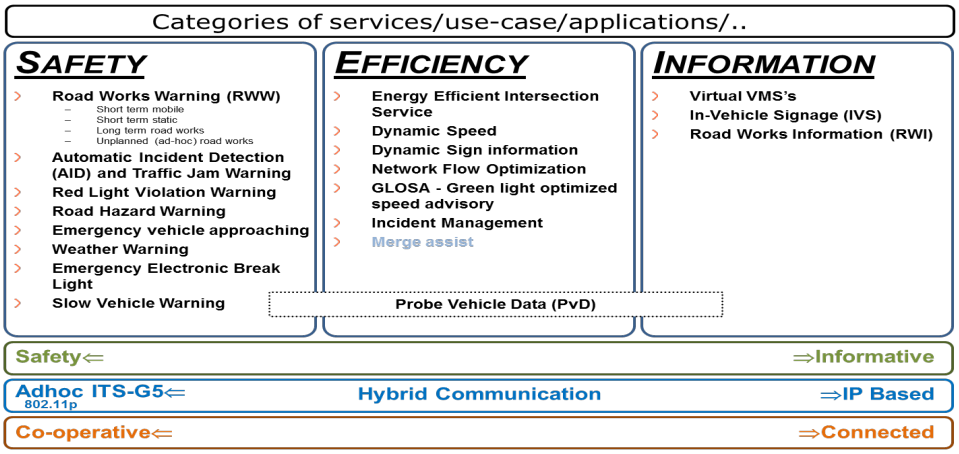

FIGURE 1: USE CASES DIVIDED INTO 3 CATEGORIES

For the Beter Benutten and PPA use cases reference to the related Beter Benutten and PPA documents must be made at the moment of this document release. Figure 2 and Figure 3 provide an overview.

Application Class	Application	Use Case	Situation	EC	BBV	Corridor	InterCor
Road safety	Driving assistance (info) – In-vehicle signage	Static signage information (descriptive/prescriptive)	Merge or diverge	Day 1	1d3, 1d4	(x)	(x)
			Change in carriageway configuration		1b5		
			Overtaking prohibition		1c1		
		Dynamic signage information (descriptive/prescriptive)	Status peak-hour lanes		1d1		
			Status tidal flow lanes		1d2		
			(Dynamic) legal speed limit		1a1		
	Driving assistance (awareness) - Road Hazard Signalling	Emergency vehicle warning		Day 1	2a6		
		Slow vehicle indication		Day 1			
		Stationary vehicle	Accident	Day 1	2a4, 2a8		
			Vehicle Problem		2a4, 2a8		
			Road Inspector		2a7		
		Emergency electronic brake lights		Day 1			
		Wrong way driving warning		Day 1.5			
		Adverse weather condition	Precipitations	Day 1	2a3		
			Road adhesion		2a3		
			Visibility		2a3		
			Wind		2a3		
		Hazardous location notification	Object on the road	Day 1	2a9		
			Spilled load		2a9		
			Pothole				
		Traffic condition warning	Traffic jam ahead warning / AID	Day 1	2a2		
		Road work warning	Short-term mobile	Day 1	2b1, 2b2	x	(x)
			Short-term static		2b1, 2b2		
			Long-term road works		2b1, 2b2		
			Unplanned (ad-hoc) road works				
		VRU safety warning		Day 1.5			
	Collision avoidance (warning) - (Longitudinal) Collission Risk Warning	Forward collision warning		Day 1.5			
		Lane change, merge and overtaking assistance			2a10	(x)	
		Motorcycle approaching		Day 1.5			
	Collision avoidance (warning) - Intersection Collision (Risk) Warning	Across traffic turn collision risk warning					
		Merging traffic turn collision risk warning					
		VRU crossing while turning					
		Signal violation warning		Day 1			
Automated driving	Driving assistance (automatic)	Cooperative Adaptive Cruise Control / Platooning					

FIGURE 2: TRAFFIC SAFETY USE CASES OVERVIEW

Application Class	Application	Use Case	Situation	EC	BBV	Corridor	InterCor
Traffic efficiency	Speed management	Regulatory / contextual speed limits notification	Shockwave damping	Day 1	1b1, 1b2		
			Weather condition		1b3		
			Hazardous location		1b4		
			Emergency vehicle		1b6		
		Traffic light optimal speed advisory	Time-to-green information and speed advice	Day 1	4.1, 4.3		x
			Time-to-red information and speed advice		4.2, 4.3		
	Probe data	Basic probe vehicle data		Day 1		x	(x)
		Extended probe vehicle data				(x)	
	Traffic management	Flexible lane allocation					
		Traffic signal priority request	Priority public transport	Day 1	3a1		
			Priority trucks		3a2		
			Priority vehicle platoon		3a3		
			Priority group of cyclists		3a4		
			Preemption for emergency vehicle		3b1		
		Zone access control for urban areas		Day 1.5			
	Cooperative navigation	Traffic information and route guidance	Bridge open	Day 1.5	2a1		
			Reduced speed due to event		2a5		
			Parking routes		6.3		
			Eco-routes				
			Limited access				
			Tunnel information				x
		Parking management	Off street parking information	Day 1.5	6.1, 6.2		
			On street parking information	Day 1.5	6.1, 6.2		
			Parking facilities at events		6.4		
			Bicycle parking facilities		6.5		
			Truck parking				x
Smart mobility	Location based services	Point of interest notification					
		Automatic access control and parking access		Day 1.5			
		ITS local electronic commerce					
		Media downloading					
	Urban mobility	Multimodality support		Day 1.5			
	Communities services	Insurance and financial services					
		Fleet management (goods delivery)					x
		Loading zone management (goods delivery)		Day 1.5			x
		Information on AFV fuelling & charging stat.		Day 1.5			
Operational management	ITS station life cycle management	Veh. software / data provisioning and update					
		Vehicle and RSU data calibration					

FIGURE 3: TRAFFIC EFFICIENCY AND SMART MOBILITY

The mentioned services related to the Cooperative ITS Corridor are described shortly in the next chapters. Because C-ITS is a fast moving domain this document will also give an insight into use cases which are of broader interest for the Netherlands but are not covered within the Cooperative ITS

Corridor. This is done to ensure a joint focus across several C-ITS projects which are currently on-going.

2.2 Road Works Service (RWS)

The Road Works Service can be split into three sub-services according to the following segmenting:

1. Providing information; distance to road works more than 5 kilometres (min. before last exit-ramp) – Road Works Information to re-rout traffic;
2. Providing information; distance to road works less than 1000 Meters – Road Works Warning to increase urgency and warn for immediate danger;
3. Collecting information: distance to road works less than 1000 Meters and in road works zone – Road Works Data.

These services are described in the next paragraphs.

2.2.1 Road Works Information

This service informs traffic at longer distances about the existence of road works along their route, on- and pre-trip. This service enables traffic rerouting via alternative routes with less congestion, thereby reducing congestion caused by the road works. This service is mostly handled as part of Traffic Information Services.

This service relies primarily on 3-4-5G cellular networks.

2.2.2 Road Works Warning (RWW)

To reduce the risk of collision around road work areas (e.g. crashing into safety trailers), oncoming traffic will receive warnings and restrictions concerning the road works area and installed safety vehicle(s) such as the location of a Truck Mounted Attenuator (TMA).
For all situations, the information transmitted contains at least the following:

- Reduced maximum speed
- Status of the hard shoulder
- Position of works area
    - Length of works area
    - Closed lane information
    - Position of trailer

This service will use short-range ITS-G5 because of the ad-hoc and dynamic nature of the transmitted information.
Within the Cooperative ITS Corridor this use case is further described and specified. At this stage the use case only covers Motorway use. However, standards need to facilitate RWW on (inter-)Urban roads as well.
This service can be spilt into 4 sub-services based on the type of road works the service is related to. These subservices are described in the following paragraphs. A full description can be found in the Whitepaper “Message Set and Triggering Conditions for Road Works Warning Service” of the Amsterdam Group.

2.2.2.1 Short Term Mobile

These road works are typically moving along the road in the driving direction. This type of roadwork is used for environmental maintenance work (mowing, cleaning etc.) and for measurement and inspection work. The work area will displace with low speeds and is always protected from oncoming traffic with a TMA per lane. Planning information will be available on timing, location and the exact road layout and availability of lanes, per vehicle type.

2.2.2.2 Short Term Static

These are planned non-moving road works which do not take longer than a day. The road works area is typically set out with the use of safety beacons and are safeguarded with a TMA (Truck Mounted Attenuator). The impact for passing traffic is normally a speed reduction, a reduced number of lanes or narrowed lanes with the use of the hard shoulder. Planning information will be available on timing, location and the exact road layout and availability of lanes, per vehicle type.

2.2.2.3 Long Term Road Works

This type of road works takes place for an extended period and can vary over time in road layout. Typical for long term road works is the use of temporary guiderails (barriers) to protect the work area from passing traffic. In most cases the lanes are also displaced and tightened to create more room for the road works. All changed lane layouts must be marked with yellow temporary lining to indicated the lane positions. Because of the duration of the road works, the work area is not protected by TMAs (all the time). This is done primarily when setting out, changing or removing temporary road markings and guidance objects. This specific part of long term road works should be seen as short term (see §2.1.2.2). Planning information will be available on timing, location and the exact road layout and availability of lanes, per vehicle type.

2.2.2.4 Unplanned (ad-hoc) Road Works

A typical need for unplanned (ad-hoc) road works are maintenance works after incidents such as accidents or road wear due to adverse weather conditions. Same as short term static (see §2.1.1.2), but without detailed planning. The work area is protected with a TMA.

2.3 Probe Vehicle Data

In the previous paragraph an initial list of use cases is presented. Most use cases rely on the information sent out by vehicles and received by C-ITS Road Sight Units (RSU). This data is interpreted by the various services and through those services send back to the passing vehicles. Almost all services use this information, derived from CAM and DENM-messages.

2.3.1 PVD Service

Traffic flow data is collected through loops in the road surface or with cameras, radars, etc. Probe Vehicle data can extend this with data from vehicles transmitted through CAM-messages and DENM-messages.
The basic information covered by these messages contain: vehicle position, vehicle speed, vehicle direction and road hazard warnings. In the future these messages might be extended with other vehicle related data like use of headlights and windshield wipers as well as more event related data like incidents and slippery roads.
This extra data can be used by the Road Operators (ROs) to get a better understanding of the status of the traffic. Additional measures can be activated including provision of information towards other services to inform oncoming traffic about possible dangerous and hazardous situations. The data sent out through CAM- and DENM-messages will be picked up by the RSU when the vehicle is passing.

2.3.2 Extended PVD Service

This service has the basic PVD-service as described in paragraph 2.2.1 as a basis. In addition to the basic PVD-service, vehicles will buffer collected information between two RSUs and send all the data to the first RSU it passes. Vehicles driving in an opposite direction can also (re-)send the gathered information to a nearby RSU. This way the PVD-service is not only a data-service with point-probing but it can give a far more detailed view of the traffic situation between RSUs. Also available data is delivered quicker to other services and/or a back office for further use. This is illustrated in diagram Figure 4.

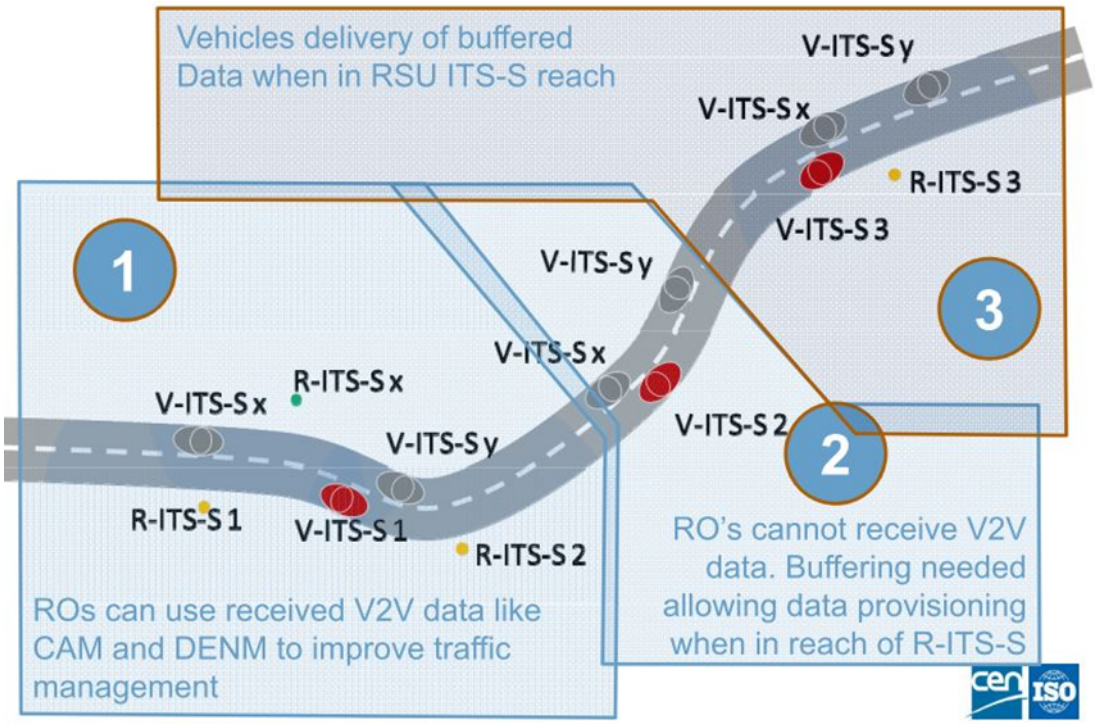

FIGURE 4: COMMUNICATION USING EXTENDED PVD SERVICE

2.4 In-Vehicle Signage (IVS)

Today, road signs are placed on a specific location and in a specific way above or alongside the road. These signs, dynamic or static, have a meaning and appearance. Regarding the appearance there are two important limitations. The signs are fixed at a specific location and are mostly general so the driver needs to verify whether the message is valid for him/her. C-ITS provides the opportunity to present the right information to the right driver at the right time. Instead of putting signs along the road, the required information can also be provided by means of a C-ITS application, directly to the In-Vehicle platform. The In-Vehicle platform needs to process the information. For instance, the information can be communicated to the driver through icons on a screen but only if the information is relevant to that specific driver (a car driver does not need to know information that is only relevant for a truck driver). A future functionality could be that the information is relayed to the driver and the vehicle itself will act on the information (for instance when the speed limit is 50km/h, the car will limit itself to avoid speeding). The way the information is provided to the vehicle can be diverse and it can be received through several communication channels depending on the specific needs and requirements. It can be done through centralized operational processes and database systems for static sign information, which is not subject to frequent change. Data can be send to the vehicle via 3/4/5G networks or even normal Wi-Fi when parked or it can be pre-loaded on a memory card. The advantage is that a large amount of data/signs can be installed in the vehicle this way. One of the disadvantages is that the information might be out-of-date when using it.
Therefore there is also an option to transmit the signs directly from road side systems or other vehicles using ITS-G5. This is primarily of interest for (semi-) dynamic signs indicating fluctuating speed limits, hazards conditions or signs, which are only valid within a certain time period (e.g. dynamic lanes).

This exchange of information is to be formatted and standardised as agreed in In-Vehicle Information (IVI, see Chapter 3).

2.5 Other Use cases

Besides the use cases described in chapter 2, which are part of the Cooperative ITS Corridor, there are many other use cases which are part of C-ITS but outside the scope of this corridor. Out of the large number of existing use cases developed by the Amsterdam Group, ETSI and other platforms and EU-projects, a selection is made, based on the characteristics (type of use-case) and matureness. This selection of use cases is described in the following paragraphs. In paragraph 6.3 a further analysis is made regarding the expected
future use and what standardisation effort is needed and by whom to establish a quality service.

2.5.1 Traffic Safety

Traffic safety use cases consist of C-ITS services with a direct impact on Road Safety. These services coincide with the traditional roadside signage indicating hazardous situations, for instance a sharp corner, a dangerous intersection or a traffic jam further down the road. Traffic safety use cases inform the road user for immediate danger.

2.5.2 Automatic Incident Detection (AID) and Traffic Jam Warning

Detailed (probe) vehicle information regarding location and vehicle speed can be used to detect sudden braking and other incidents. This information can be directly used to reduce the risk of rear-end collisions by relaying the information to connected vehicles nearby. This information will be used in-car to warn the driver of oncoming dangers. The speed of communication on potential dangers and the fact that the information is very accurate makes it highly effective.

2.5.3 Red Light Violation Warning

The Red Light Violation Warning (RLVW) service aims to increase drivers' alertness at signalized intersections in order to reduce the number and/or severity of collisions. The service provides information to the driver before a possible incident occurs and thus can prevent accidents. The service is targeted at warning drivers when they are in danger of violating a red light or when it is probable that another vehicle is going to make a red light violation. The service will also warn drivers while turning, to give way to possible traffic that are also acting on a green light but are coming from the opposite direction and to give way to crossing pedestrians and/or bicycles that are also acting on a green light. Although the focus of the service is on red light violation, the service also addresses situations involving emergency vehicles as well as the various right of way rules. This makes it possible for emergency vehicles to safely cross the intersection while (legally) running a red light.

2.5.4 Road Hazard Warning

The Road Hazard Warning (RHW) service aims to reduce incidents by sending drivers warning messages which would raise their attention level, and optionally by providing suggestions on how to react to the hazard.
The hazards can be static or dynamic. Examples of a static Hazard are a railroad crossing, or swing bridge, whereas dynamic hazards are for example slippery roads, broken down vehicles or ghost drivers.

2.5.5 Emergency Vehicle Approaching

Emergency vehicles can identify themselves and inform other vehicles in the vicinity about its position, direction, speed, etc. The aim of this service is to indicate an emergency vehicle is approaching and to timely give way to the emergency vehicles. This will avoid confusion among drivers and maintain or improve response times for the emergency vehicles.

2.5.6 Weather Warning

This service is intended to increase traffic safety with regard to weather situations. The service is aimed at informing road users on critical weather conditions that can have a direct impact on the safety of the road user. Typical situations are, slippery roads, black ice, strong side winds, heavy rain and fog.

2.5.7 Emergency Electronic Brake Light

This service is aimed at making brake-lights more visible for all drivers within dense driving environments, including drivers not directly behind the braking vehicle. The main goal is reducing accidents and rear-end collisions. The service will be activated upon (heavy) braking of a vehicle. The vehicle will send out an EEBL-message (Emergency Electronic Brake Light) and cars/drivers within range are warned of the braking vehicle even before the driver is able to react. A big benefit is that drivers are warned in situations where the braking lights of other cars are not visible.

2.5.8 Slow Vehicle Warning

This service will warn oncoming traffic for slow moving vehicles even when they are not yet in view. By warning the driver in a timely fashion the risk of collision is greatly reduced. Examples of situations in which this service proves its value are slow moving lorries moving uphill and agriculture vehicles in general.

2.6 Traffic Efficiency

This set of C-ITS use cases concentrates primarily on improving the flow of traffic. The service can provide drivers and vehicles with timely updates of the current traffic speed upstream. This information can be used to effectively adjust the advised/mandatory speed limit and thereby harmonise the speed. This way an optimal speed can be maintained with less or no differentiation in speeds resulting in a more efficient traffic flow with less traffic jams, less sudden braking, more capacity and an overall shorter journey time.
For these services “virtual signs” can be used to extend dynamic signage. These virtual signs can be “placed” anywhere, at any moment when relevant.. Because of the virtual nature, costs and manpower are saved. Traffic can be routed with the aid of virtual signs, reducing the cost for physical placement of route guidance signs. It also provides better information as the sign can display more information or even better, only the information needed for specific drivers (e.g. in case it only concerns trucks only truck drivers are informed). All this is done with the use of In-Vehicle Signage.

2.6.1 Energy Efficient Intersection Service

The Energy Efficient Intersection Service (EEIS) aims to reduce energy use and vehicle emissions at signalized intersections. This is done by communication between the intersection controller and vehicles nearby. When approaching an intersection vehicles receive information on signal timings. This information can be used to reduce lost time before a signal goes to green, drivers can optimize the use of start-stop systems in modern vehicles, and drivers can receive advise on the best approach speed. Furthermore, special vehicles can be given green with priority. This is especially relevant for heavy vehicles, public transport and emergency vehicles.
The EEIS service is possible because the ‘signal phase and timing information’ (SPaT) is communicated to the vehicle. As a result of the service, it is possible to reduce lost time at intersections and reduce CO2 emissions.

2.6.2 Dynamic Speed

This service is a part of IVS contextual speed. Depending on the road, traffic conditions and time of day the current speed limit can change and differ between vehicle types. The service helps the driver in recognising what the speed limit is(regardless of time of day or vehicle type). It is also possible to provide temporary speed limits to the vehicle in case of for example, road works or accidents. The service could possibly be used to actively restrict the speed of the car.

2.6.3 Dynamic Sign information

Sign information can be displayed dynamically in the vehicle depending on the time, type of vehicle, vehicle load (dangerous goods), etc. This will provide the driver with accurate information directly targeted at him when needed and relevant. Examples are side wind warnings and height restrictions. This service helps the driver to focus on the information he needs to perform his driving task without additional distraction.

2.6.4 Network Flow Optimization

Detailed traffic information can be relayed to the driver to provide a real time speed advise to harmonise the traffic flow and reduce (smoothen) shockwaves. (shockwave traffic jam, in Dutch “Spookfiles”). By harmonising the traffic flow there is less risk of traffic jams, rear-end collisions resulting in a more effective use of the road infrastructure and shorter more reliable journey times.

2.6.5 GLOSA - Green Light Optimized Speed Advisory

Traffic flow data combined with data from traffic controllers at intersections can be used to create a speed advise when approaching an intersection (managed by a traffic control unit (TCU)), thereby reducing stop times at traffic lights, save fuel and reduce emissions. This effectively results in a dynamic “green wave” and optimises traffic flow and improves the impact on local environment.

2.6.6 Incident Management

In case of unforeseen incidents like accidents, traffic can be warned about the new/temporarily situation like lane closures. In practice this type of use case is identical to the RWW, unplanned (ad-hoc) and short term static, but then used for the protection of emergency services and vehicle salvage after an incident has occurred. The work area might be protected with a TMA.

2.7 Traffic Information

These use cases concentrate on providing users with relevant information on their current journey. For example, the user receives optimal route advise taking into account, travel time, max height and widths, possible traffic jams, etc. These services are typically delivered by third-parties. The required data will be transmitted to the service providers. They, in turn, will process the data and deliver accurate and unique traffic information to their customers.

2.7.1 Virtual VMSs

It is possible to display information in-vehicle, as a Virtual Message Sign (VMS) duplicating the roadside VMSs. In addition it is also possible to display VMS information in situations where there is no physical VMS available. The displayed information can be targeted at every driver specifically based on for example, destination input, time of day or the status of the car.

2.8 The Use-Case Roadmap

In this chapter an insight of a prioritised deployment of C-ITS use cases for the Netherlands is presented. This roadmap identifies the required specifications, standards, profiles, white papers and processes for the C-ITS use cases This roadmap shows on the C-ITS Services expected to be deployed in The Netherlands in the near and mid-long term, with a focus on the Cooperative ITS Corridor. Although still under development, first expectations of the Connecting Mobility program are also considered. Mainly the Cooperative use cases are being considered. For some of the earlier described use cases more detailed functional descriptions have been developed. Especially RWW has been further specified, since this is currently the main focus of the Cooperative ITS Corridor, as agreed between the Netherlands, Germany and Austria. In Annex 1 a reference use case description is presenting how the requirements and expected behaviour of Use-Cases are defined and agreed. For all the use cases this needs to be developed to define the common Road-Operator Functional, Technical and also non-functional requirements. This is also needed to qualify the applications,

standards, specifications, profiles, systems, architectures, legislations and certifications. In Annex 2 those use cases are identified which are expected to be deployed in the next steps of the deployment. The roadmap includes also use cases, which are of importance to the correct definition of the standards, specifications and system at the start. The roadmap provides a picture of the relation of the use cases with Application and Facility service standards in a prioritised way.

The roadmap as presented here is recognised at the European level by the main driving Countries and C2C-CC. Figure 5 provides a roadmap as currently envisioned at the European level for the Safety oriented applications among car and infrastructure stakeholders.

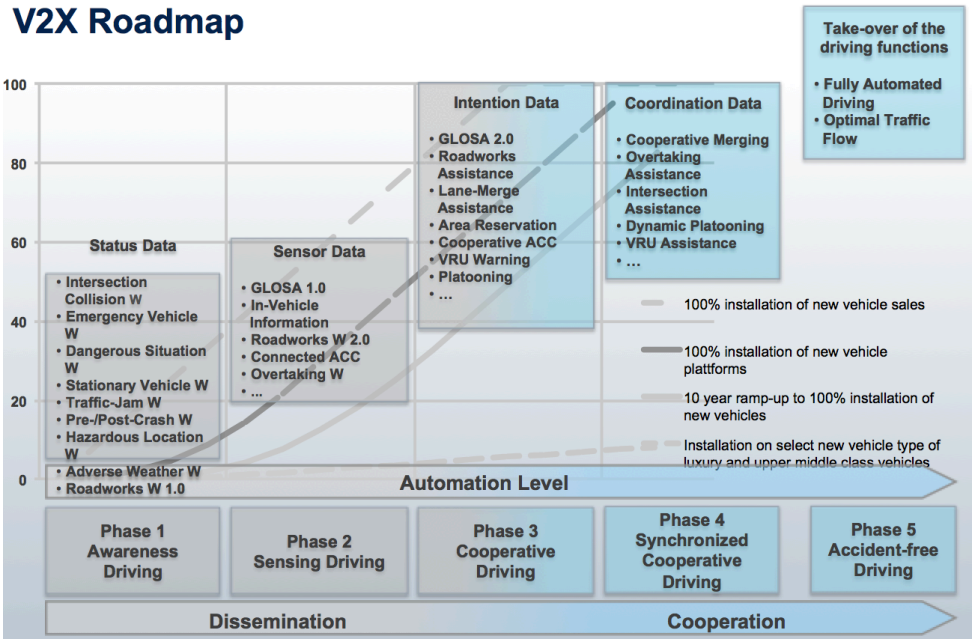

Figure 5: Stakeholders Use-Case roadmap (2016 Amsterdam Group)

3 The Europe connections

3.1 General representation of Dutch ITS initiatives

In the Netherlands there are a number of different ITS initiatives, by the Ministry of I&M (Beter Benutten), by RWS (ConnectingMobility), by Cities and local authorities as well as by industrial stakeholders.
Each of these authorities and industrial stakeholders have their own legitimate objectives. They are mainly focussed towards solutions within the Dutch context in mind and are active in the European context to meet there individual or project specific objectives. Not specifically with the focus Interoperability. From a very general perspective, it is clear to the European community that in the Netherlands there high interest and investment in C-ITS use case deployment. The Netherlands has been the initiator and driver of the Declaration of Amsterdam 2016 [15]). At the level of the deployment, where international interoperability plays is important, the different Dutch ITS initiatives are only very limited presented. In some cases they have recognized European relevance they are in contact with relevant other stakeholders to solve specific issues case by case only. There is no common approach such as Eco-AT in Austria where Eco-AT is the generalized place to align the internal Austrian interoperability and the recognizable point for European stakeholders to address European interoperability for the Austrian cases.
To ensure recognition and interoperability of the Dutch initiatives within the European context, a common Dutch use case and technology deployment roadmap and a single Dutch profile are highly important to be recognized by important interoperability European stakeholders. Alignment among the Dutch projects on these aspects will enable this and a single point of contact for European stakeholders will provide a place to communicate. Only this will provide us our European interoperability and possibility to influence the European ITS playing field.
The Dutch Round Table on Architecture and Interoperability is an initiative supported by the Dutch Ministry, Connecting Mobility and several important stakeholders to first define the Dutch profile and secondly to enable international coordination.

3.2 European Commission

The Commission as a hole prepares the required, EU-wide decisions and is supported by a number of expert area DG's. For ITS, DG MOVE and DG CONNECT are the most important but also DG GROWTH and DG Justice are of relevance. For ITS specifically the DG MOVE initiative for ITS deployment the ITS-Platform is of importance.

3.2.1 DG MOVE

This is the commission for Mobility and Transport (reference: [7]) Main Road related objective is to realize low-emission mobility. For this it expects to invest 6.7 billion. The Commission presented on 20 July 2016 a package of measures to accelerate the transition to low-carbon emissions in all sectors of the economy in Europe. As concerns transport, the Commission's "Strategy for low-emission mobility" sets clear guiding principles to prepare for the future. It frames the initiatives that the Commission is planning in the coming years, and it maps the areas in which it is exploring options. It also shows how initiatives in related fields are linked and how synergies can be achieved.
DG Move is the initiator of the ITS deployment Platform (ITS-P) and the most important DG concerned with Transport.

3.2.2 DG CONNECT (part source: HIGHTS D7.1)

The Communications Networks, Content & Technology (DG CONNECT) works with colleagues from the commission (other DG's) across the Digitan Single Market (DSM) project team [8] to develop a DSM in order to generate smart, sustainable and inclusive growth in Europe.

To be able to exchange information wirelessly between road users and infrastructure communication networks are crucial and therefore decision made by this DG can have major impact on the results of DG MOVE initiatives and the ITS community. Especially for radio spectrum DG CNECT Unit 4B is of importance.
The European Commission (DG-CNECT) is actively fostering the evolution of the existing technologies and standardization landscape as well. Two actions impact directly the C-ITS community. Firstly, the 5G-PPP is a joint initiative between the industry and the European Commission to create the Next generation (5G) of communication networks and services that will provide ubiquitous super-fast connectivity and seamless service delivery in all circumstances. Secondly, the Alliance for Internet of Things Innovation (AIOTI) was initiated by the European Commission in order to develop the interaction among the Internet of Things (IoT) various players, with the objective to create a dynamic European IoT ecosystem.

In DG CONNECT the Unit B4 is the responsible unit for all spectrum regulation issues. The main task of the Unit is to ensure the European-wide harmonization of the spectrum use where required. In order to fulfil this task a close cooperation with the CEPT and the national spectrum authorities is required. The Unit has two main committees on spectrum:

- RSC: Radio Spectrum Committee
- RSPG: Radio Spectrum Policy Group

3.2.2.1 Radio Spectrum Committee (RSC)

(source: https://ec.europa.eu/digital-agenda/en/radio-spectrum-committee-rsc)
The Radio Spectrum Committee (RSC) is responsible for specific technical measures required to implement the broader Radio Spectrum Policy. The RSC is composed of Member State representatives and chaired by the European Commission.
Established by the 2002 Radio Spectrum Decision (676/2002/EC) [24], the RSC is assisting the EU Commission for the development of technical implementing decisions to ensure harmonised conditions across Europe for the availability and efficient use of radio spectrum. It also develops measures to ensure that information on the use of radio spectrum is provided accurately and in a timely manner.
The activities of the RSC are established in a work programme, which allows prioritisation and scheduling of the various topics and issues it is required to address.
The RSC exercises its function through advisory and examination procedures that are set out in the EU's Regulation 182/2011 of the European Parliament and of the Council of 16 February 2011. The commitment process allows the EU Commission to discuss its proposals with national administrations before implementation in order to ensure that any measure is optimised to the various national situations.
The majority of RSC documents are openly available to interested parties and the public, as well as detailed information on the activities of this committee, including the rules of procedure and membership.

3.2.2.2 RSPG: Radio Spectrum Policy Group

The Radio Spectrum Policy Group (RSPG) is a high-level advisory group that assists the EU Commission in the development of radio spectrum policies.
The RSPG is established under Commission Decision 2002/622/EC to initiate long term policy goals, which was one of the EU Commission initiatives following the adoption of the Radio Spectrum Decision 2002/676/EC [24]. It adopts opinions, position papers and reports, as well as issues statements, which are aimed at assisting and advising the Commission at strategic level on:

- radio spectrum policy issues,
- coordination of policy approaches and,
- harmonised conditions, where appropriate, with regard to the availability and efficient use of radio spectrum necessary for the establishment and functioning of the internal market.

The remit of the RSPG has been extended as a result of the adoption of the new telecom regulatory framework in 2009 (Commission Decision 2009/978/EU of 16 December 2009 amending the Decision establishing the RSPG [25]). According to the new remit, in addition to the EU Commission, the European Parliament and/or the Council can request the RSPG to issue an opinion or produce a report on specific radio spectrum policy issues relating to electronic communications. Those opinions and reports shall be communicated by the EU Commission to the community and institutions. Where appropriate, they may be in the form of oral presentation to the European Parliament and/or the Council by the chairman of the Group or a member nominated by the Group.
The Members of the Group are senior representatives of the Member States and the official representative of the European Commission. Delegations include representatives from both the regulatory authorities and the ministries having responsibility for radio spectrum related matters in each Member State. Representatives of the European Economic Area (EEA) countries, the candidate countries, the European Conference of Postal and Telecommunications Administrations (CEPT) and the European Telecommunications Standardisation Institute (ETSI) are invited to attend plenary meetings as observers.
Consultations done by the RSPG are conducted with the objective of involving all relevant stakeholders, radio spectrum users, both commercial and non-commercial, as well as any other interested party. In addition, most of the deliverables of the RSPG are subject to formal public consultations.

3.2.3 DG GROWTH (part source HIGHTS D7.1)

In DG Growth (former DG Enterprise) main responsibility is to promote a growth-friendly framework for European enterprises with focus on smart, sustainable growth. At DG Growth, the sector Radio Communications and Telecommunications Terminal Equipment Industries encompasses all products using radio frequency spectrum (e.g. car door openers, mobile communications equipment like cellular telephones, CB radio, broadcast transmitters, etc.) and all equipment attached to public telecommunications networks (e.g. ADSL modems, telephones, telephone switches). The R&TTE is one of the few high-tech sectors where the EU is a global leader as in cellular communications. Here of relevance is, "Telecommunication Conformity Assessment and Market Surveillance Committee" (TCAM).

3.2.3.1 TCAM

TCAM was constituted by Article 13 of R&TTE Directive 1999/5/EC (Directive on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity) to assist the Commission. TCAM acts as both an advisory (Article 14 R&TTE and Article 45 RE-D) and a regulatory committee (Article 15 R&TTE and Article 45 RE-D) in matters of conformity assessment and market surveillance.
The TCAM committee is chaired by an EU Commission representative. Each EU member state is represented by the public authorities in charge of the implementation of the R&TTE Directive. Representatives of the EFTA states, national experts and experts from European organisations (e.g. CEPT) may also provide input. Particular regulatory issues are restricted to the representatives of the public authorities and the Commission, however, as an informal subgroup for market surveillance and conformity assessment, the ADCO group (Group of Administrative Co-operation under R&TTE Directive 99/5/EC – R&TTE ADCO) supports and complements TCAM's work. See for information on the ADCO group on the Agency's website.

3.2.4 DG Justice and Fundamental Rights

The EU is not simply a common market for goods and services. Europeans share values that are spelled out in the EU Treaties and the Charter of Fundamental Rights. We must never lose sight of those values in our efforts to fight terrorism, human trafficking, smuggling and cybercrime.
DG Justice [10] want to make life easier for Europeans who study, work or get married in other EU countries. One of our main goals is therefore to build bridges between the different national legal

systems across the EU. With concern to ITS, protection against privacy data flow and cybersecurity are major important. From this DG there is active involvement in the ITS-P to ensure that Road Traffic related requirements are supported. As Cooperative-ITS (C-ITS) makes use of not only standard point to point IP communication for which current data protection and security policies are created, but also make use of sensor networking based information sharing via Uni-cast and Broadcasting these policies need to be used, reviewed and updated to accommodate the deployment of ITS. This is currently an important topic being handled mostly in this DG and at the ITS-P.

3.2.5 ITS deployment platform

The ITS deployment platform (ITS-P) is an initiative from DG Move with cooperation of the other relevant DG's. The ITS-P was initially a response and recognition of the initiatives of the AG with the intention to get all European stakeholders involved and looks for a more general ITS deployment.

There were the Amsterdam Group focuses to concrete deployment, the ITS-P focuses on what strategically is needed and what the commission should support, recommend or legislate.
The first ITS-P was formed in 2014 to target initial general deployment issues. There were a number of working groups (see Figure 6).

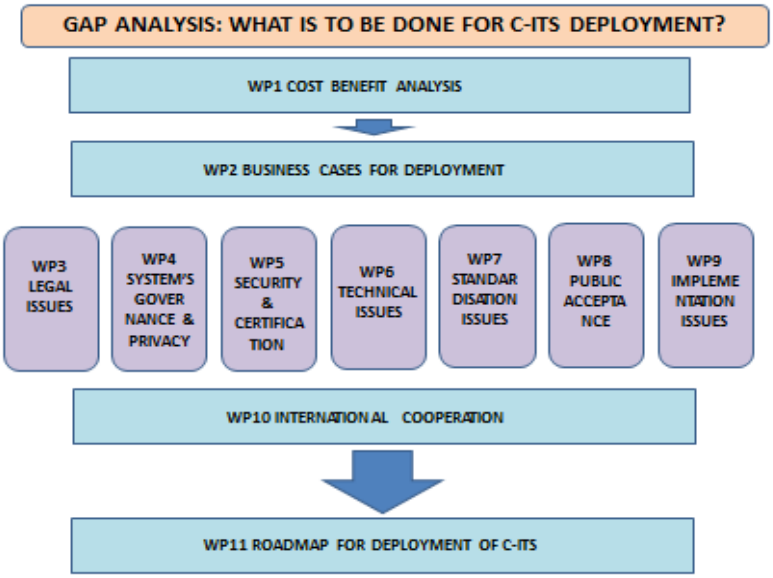

FIGURE 6: THE ITS-P WORKING GROUPS

During the period of 2014-2016 in the Netherlands Connect have been organizing information meetings to inform the Dutch industry and Authorities about the progress as well as that Dutch stakeholders could bring in ideas.
The First phase of work on the Platform has been finished and the results are presented in the final ITS-Platform report [6]. During the development of this report it became clear that a number of aspects could not be finalized and therefore a phase-2 of the ITS-Platform was initiated and has started in June 2016. The expectation is that this will result in a report in September 2017 timeframe.
This phase is differently organized and will focus on the following subject, see Figure 7, which may be organized differently later. During the development of this second report Connect will also organize information meetings such as done in phase 1.

1	WP C-ITS Security
2	WP C-ITS Compliance Assessment
3	WP Data Protection & Privacy
	Area C-ITS & Automation

4	WP Road Infrastructure (physical/digital)
5	WP Enhanced Traffic Management
6	WP C-ITS, Automation and Road Safety
7	WP C-ITS, Public Transport and Automation in Urban Areas
8	WP Horizontal Issues

FIGURE 7: ITS-P WORKING GROUPS PHASE 2

Experts contribution to these working groups is both experts own initiative as well as RWS initiated.

The activities at the ITS-P are of strategic value as they set a European direction. It is not directly of importance to the realisation of a Dutch profile or architecture but needs to be influenced to ensure that the Dutch ITS vision is supported and European interoperability and conformity ensured.

3.3 Amsterdam Group

The Amsterdam Group (AG) [11] is a strategic alliance of key actors for C-ITS deployment on European Roads, with involvement of infrastructure organisations and automotive industry. The Amsterdam group focuses on services with infrastructure involvement (I2V/V2I).
The Amsterdam Group (AG) was formed in 2011 with a letter of intent in 2012 (recommendation to members to get involved in C-ITS deployment). An Initial deployment roadmap was created in 2013 to guiding a common C-ITS deployment. The AG is formed by the key stakeholders with interest in C-ITS, CEDR (Conference of European Directors of Roads), ASECAP, POLIS and Car2Car CC.
The AG works with a 4 yearly general members meeting where current status of deployment and related issues are discussed and lead to actions and workshop initiatives for specific subjects. One frequently returning workshop is the interoperability workshop where the different deployment projects compare their results. (See Figure 8).

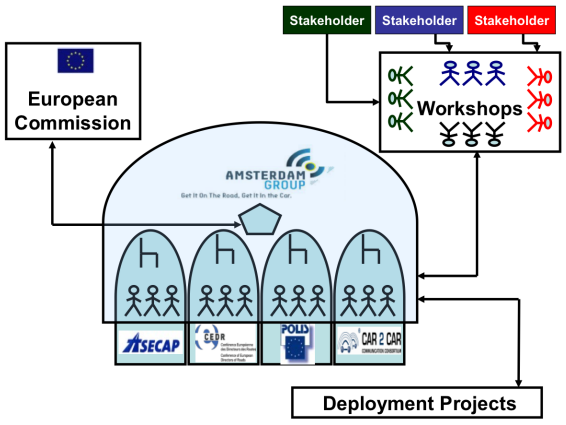

FIGURE 8: THE AMSTERDAM INVOLVEMENTS

The Amsterdam has built relations with all relevant European stakeholders via its members (Figure 10). Including relations with EU commission, ITS deployment Platform (ITS-P) and European Project CODECS that supports the Amsterdam group with European wide deployment and realisation of a European wide supported ITS roadmap.
As of end of June it is also know that the effort of the AG is further supported by DG MOVE by acceptance of 2 CEF projects, InterCor (2015-EU-TM-0159-S) and C-Roads (2015-EU-TM-0380-S). The Netherlands is initiative taker for the InterCor project and not a member of C-Roads but in each of these to projects alignment between them is arranged to enable the development of an initial interoperable and confirmative European Profile.

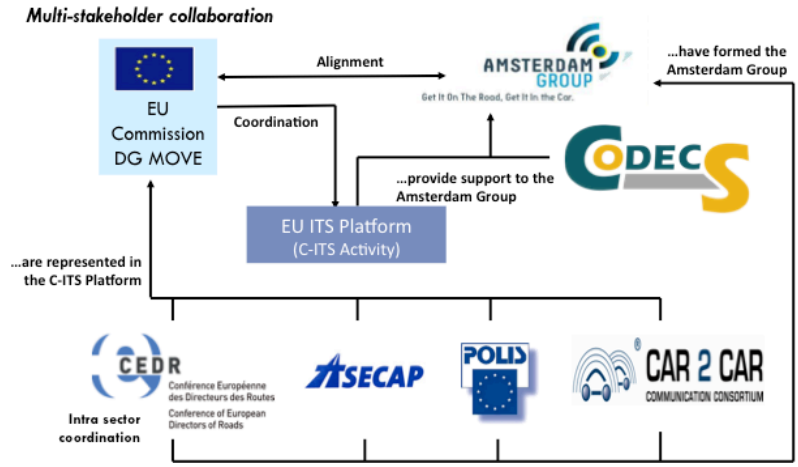

FIGURE 9: AG RELATIONS WITH OTHER ORGANISATIONS AND EU PROJECTS

As Austria, the Netherlands, Germany realized an Memorandum of understanding signed by the ministers of transport and France developed their internal strategy, these countries with interest in Cooperative ITS had their initial Dutch-German-Austrian Corridor [12] and Scoop@F [13] projects. Currently these project are followed by other countries with their own or collective initiative such as NordicWay by Finland, Sweden and Norway (see Figure 10).

FIGURE 10: EUROPEAN DEPLOYMENT PROJECTS

The alignment takes place based on the agreed set of use cases agreed which currently commonly are the Basic RWW and Probe Data use cases. The different countries all for see additional use cases but they are not yet seen as common use cases to align at the AG level. As the Netherlands sees many more use cases alignment on those needs to take place in individual cases and by cooperating in European projects. In case of In Vehicle Signage (IVS) direct alignment with Austria, France and Czech must be advised.

3.4 POLIS

POLIS is a European organisation for Cities and Regions for Sustainable Transport. This organisation mainly represents the European cities. It is here mentioned, as ITS technologies will provide many possibilities in urban environments Commission. When talking about POLIS also OCA (Open Traffic Systems City Organization) for the German speaking countries needs to be mentioned. This shows that there is no real single European Cities organization, which is also reflected, in the various different ICT Infrastructure systems currently in use. The European drive to a single market is here most far away compared to within other stakeholder groups. These groups are mentioned as they will be

stimulated by the European Commission with several EU project funding possibilities. Direct contribution to Polis looks not to be that important (from a technical perspective) but participation in project where POLIS is active may be of importance to the Dutch Infrastructure stakeholders.

3.5 Open traffic systems City Association (OCA)

The OCA is an association of German, Austrian and Swiss public construction authorities and operators founded it in 1999 in the course of the emergence of the OCIT-standards. The OCA represents the interests of all public administrations in the development of open standards for traffic signal systems, traffic computers and traffic control centers.
Being an OCA member and contributing specific requirements regarding the construction and operation of such facilities strengthens the position of public authorities as a whole.
OCA membership is motivated by the following objectives:

- Developing and implementing open interface standards avoids vendor lock-in in traffic signal technology and fosters competition, finally leading to significant cost reduction.
- Future traffic management challenges require cooperation beyond road operator boundaries not only in conurbations. Open interface standards enable interoperability between components and systems in traffic engineering and hence protect investments and ensure proper migration paths for the future.

The OCA – in the context of the OCIT-Group – has contributed significantly to the development of the OCIT standard and has subsequently by itself developed the OTS-standard as a framework for open standards for networking traffic control centers.
OCIT is used as a similar interface as VLOG.

3.6 Car2Car Communication Consortium

The Car2Car Communication Consortium (C2C-CC) [14] Mission is to realize and deploy ITS systems for the purpose of traffic safety and efficiency. Vehicle manufacturers founded the C2C-CC in 2002. Today not only vehicle manufacturers (OEMs, Figure 11) are member, also other companies like infrastructure companies such as Siemens and KAPSCH are active members () and development companies () have joyed. Dutch Members of C2C-CC are: NXP (associated member) TASS (associated member); PaulsConsultancy (associated member); TNO (development member).

FIGURE 11: C2C-CC OEM'S MEMBERSTODAY

FIGURE 12: C2C-CC ASSOCIATED MEMBERS TODAY

FIGURE 13: C2C-CC DEVELOPMENT MEMBERS TODAY

The C2C-CC has installed working groups for profile, roadmapping, applications, architecture, communication, simulation, security, compliance assessment and deployment. They use the C2C-CC profile document as there leading specification supported by standards, their profiling and internal white papers. They additionally use a compliance assessment document referencing the test standards and additional internal test specifications. To ensure consistency among the documents and required changes resulted from testing there is a C2C-CC Change Control Board (CCB) installed.
Improvements requiring a change of standards are forwarded and driven to change by members towards the standardisation body at hand.
Access to these C2C-CC documents by none members are envisioned (and expressed) in terms of free to use (no commenting is possible) but so far this seems difficult. As Netherlands is a frontier in ITS influencing change is advised and therefore membership in similar form as de German Operator the BASt is proposed. Membership however requires contribution and membership fee.
In Figure 14 you can find the C2C-CC deployment process:

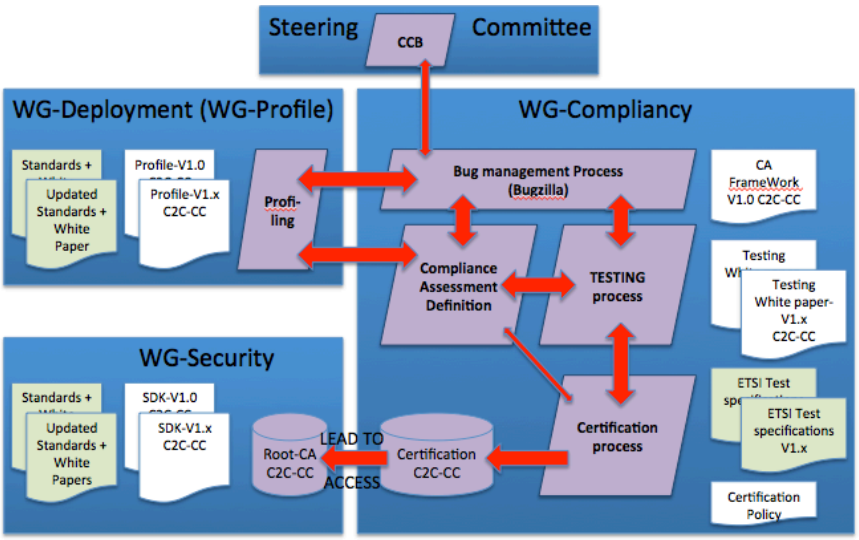

FIGURE 14: THE C2C-CC DEPLOYMENT PROCESS

3.7 Spectrum related organisations

The European commission is responsible for coming to European legislation; in most cases resulting in recommendations and decisions and related process. To support the deployment of any ITS use case compliant with the rules provided by any EU decision, the right spectrum and right priority of operation in this spectrum needs to be ensured. This is striate forward handled in processes by the ECC and ETSI however it is not that obvious that a request for spectrum leads to allocation. Although for years it was easy to get some allocation as there was enough spectrum, today there is competition in getting any.

In practice today t2 stakeholder groups can be distinguished, the telecom together with the network providers and the Functionally providers such as Broadcasters, Fixed link, Militarily and a minority group of spectrum users such C-ITS, Tolling, Rail, Urban Rail, Oil, Professional Audio and many others.

For ITS, we know that there are and will be use cases which are and can be supported by cellular technologies and we know that a number of them today are being and will be shortly deployed by use of ITS-G5 technologies. In case of those use cases covered by telecom related communication services the Transport sector doesn't need to be involved in any spectrum discussion, as the telecom market will take care of that. However to deploy ITS-G5 technology there is no communication provider to make sure spectrum is allocated. This means that the ITS-G5 stakeholders as a hole needs to ensure this spectrum themselves. Something is not naturally an aspect, which is within the focus of these stakeholders.

As the cellular market in general needs as much as possible spectrum to for fill there future objects it is seeking to maximise there access to spectrum and by that are direct competitors of the ITS-G5 stakeholders. For this reason it is important that representatives of the ITS-G5 stakeholders are effectively active in the spectrum discussions.

Observing current spectrum and standardisation discussions, it can be recognized that the presence of cellular stakeholders has increased and putting pressure on these processes. This compared to the limited availability of ITS-G5 stakeholders. To ensure access such that the use cases work, the contribution to these processes has to be made more visible and contribution ensured. Visibility as part of the Dutch Profiling could be a good solution.
An overview of the active organizations can be found in Annex B, Spectrum Organized

4 European projects

4.1 In General

In Europe there are a number of growing activities. Here are those currently being represented at the AMSTERDAM Group there where they harmonize their efforts to reach maximum interoperability at the functional level only. Here those projects are mentioned which are looking at interoperability and are of direct influence on the Dutch deployment. In Annex D an overview of other interesting projects is provided:

4.2 Corridor project (NL+DU+AU) (source CODECS D2.2)

The basis for the deployment of C-ITS was laid in June 2013, when the national transport ministries of Germany, the Netherlands and Austria signed a Memorandum of Understanding (MoU), in which the ministries agreed [37]:

- to develop a common launch/rollout timetable for the implementation of the first cooperative applications on highways
- to define common conventions that ensure a harmonized interface with vehicles in the three countries
- to implement roadside facilities for the first collaborative applications.

A corridor, extending across the highways from Rotterdam (Netherlands), via Frankfurt/Main (Germany) to Vienna (Austria), was chosen as the route for the first deployment (Figure 15).

Along this so-called Cooperative-ITS Corridor (C-ITS Corridor), German, Dutch and Austrian highway operators, in cooperation with partners from the automotive industry, have launched the gradual deployment of Cooperative Systems to allow for an exchange of traffic-related information between vehicles and the roadside infrastructure as well as to facilitate the information flows among the first vehicles that are equipped with Cooperative Systems.

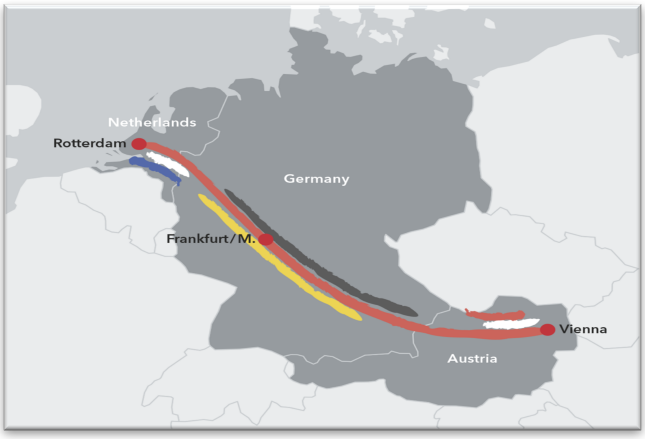

Figure 15: C-ITS Corridor Rotterdam – Frankfurt/M - Vienna
Source: Project Flyer of the Cooperative ITS Corridor ([37])

The effective cooperation among the three countries is a particular challenge of the C-ITS Corridor. Differences in their political and legal environment, as well as varying conditions in terms of procurement for cooperative systems result in different procedures for the conception and realization of the C-ITS Corridor. In spite of the individual, national views on the C-ITS Corridor project, the three participating countries rigorously follow the objective of a consistent, cross-border system solution. An effective coordination among the ministries of

transport and road operators of the three countries is ensured by strategic and operational level teams, harmonizing the three Corridor parts to the largest possible extent. Moreover, the project works closely with international organizations and other deployment initiatives to support the pan-European harmonization efforts. These include the close cooperation with the European Commission (in particular the C-ITS platform), the Amsterdam Group and international standardization bodies (CEN / ISO / ETSI), but also strong links to knowledge management and dissemination activities like CODECS, the EU EIP and C-Roads.

The Netherlands, Germany and Austria have agreed upon the introduction of two cooperative services to be provided along the whole C-ITS Corridor:

1. Road Works Warning (RWW)
2. improved traffic management by vehicle data.

Both are part of the list of “Day 1” services as defined by the Amsterdam Group [11], an umbrella organisation in which representatives from European public and private road operators (mostly on high level networks) as well as city representatives collaborate with the automotive industry to stimulate deployment of Cooperative ITS. Both applications have been selected because of their present relevance, as there are still many accidents related to road works, and with regard to the further dissemination of C-ITS technology. These first applications should help to pave the way for other services, which could be added at a later date.

- **Road Works Warning**

This service is about providing in-car information about road works, adjusted to the needs of the approaching drivers, whether as immediate warning in the vicinity of the actual road works site or as routing information.

The service can be realized by equipping road works safety trailers (Figure 16) or other roadside equipment with an appropriate communication system.

Figure 16: Road Works Safety Trailer, operated by Hessen Mobil, Germany
Source: Sandro Berndt, BASt

In the so-called ‘stand-alone mode’ (without connection to a backend system), the trailer is able to determine its own position, sign configuration and for special road works configurations also lane closures in the road works zone. This information can be transmitted to oncoming vehicles, using an event triggered “Decentralised Environmental Notification Message” (DENM [39]) on the ETSI ITS G5 channel (“WIFIp” using 5,9 GHz).

In the so called “Basic Service”, the infrastructure component (road works safety trailer) continuously determines its status (and position via GPS/GNSS), sends this information to the back office, where it is evaluated and enriched with additional background information about the road works (if available). The enhanced information is sent back to the roadside station, which transmits a warning to approaching vehicles via ETSI ITS G5. At the same time, the back office can provide data to a “Single Point of Access”, where it is made available for third parties, so that all providers of traffic information services are able to use data to improve their own services and distribute it via additional channels (TMC, DAB+, apps & web services). Examples for a Single Point of Access are the Mobility Data Marketplace (MDM) [40] in Germany and the National Data Warehouse (NDW) [41] in the Netherlands.

- **Improved Traffic Management by Vehicle Data**

The “Cooperative Traffic Management” service focuses on improving various services that are already set up by highway operator (e.g variable speed limits, incident detection, temporary hard should running), by improving the data base for the required traffic management decisions. Beyond that, the utilization of vehicle data will also pave the way towards a more individual traffic management, in contrast to the rather collective measures that are available for road operators nowadays.

In order to broaden the data base available in Traffic Control Centers, cooperative messages that are sent by equipped vehicles, are received by the ETSI ITS G5 unit of the infrastructure components (e.g. gantries, road works safety trailer), pre-processed and then forwarded to the backend systems.

Message formats to be used in “Day 1” scenarios have already been standardized as “Cooperative Awareness Messages” [38] and “Decentralized Environmental Notification Messages” [39]:

By using the information derived from these cooperative messages, the following benefits will be sought:

- Congestion avoidance thanks to optimized routes and network control, including environmental benefits
- Improved traffic safety and incident management
- Proliferation of C-ITS technology to make it usable for further applications

4.3 Scoop@F (F). Source: SCOOP@F

The C-ITS pilot deployment in France is organised via the project SCOOP. The project has been launched by the Secretary of State in charge of transport in 2014. The project goals comprise improving road safety and safety of road operating agents, making traffic management more efficient and contributing to the reduction of emissions, optimising infrastructure management costs, making vehicles fit for the future and developing new services.

In order to do so, vehicles are equipped with sensors to detect events such as slippery road, emergency braking manoeuvers, etc. and with on-board units to transmit the information to vehicles behind (V2V) and to the road operator (V2I) through road side units. Road operators can also transmit information (roadworks, etc.) to the vehicles through their on board units (I2V). In total, SCOOP aims at deploying 3,000 vehicles over 2,000 km of roads. The five pilot sites in France cover Ile-de-France, the motorway between Paris and Strasbourg, Isère, the Bordeaux ring road and Bretagne. The pilot sites comprise a very different mix of road types and operating environments, involving motorways, major arterial roads in conurbations, bi-directional interurban and local roads, see Figure 17.

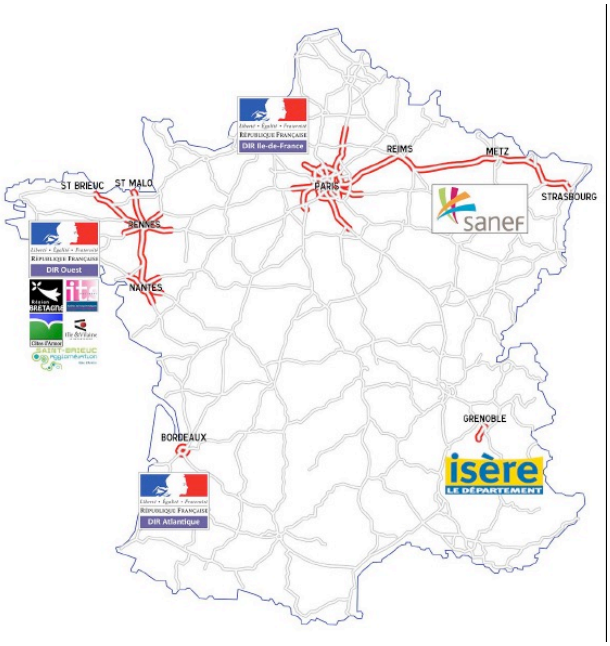

Figure 17: SCOOP@F Pilot Sites, Source SCOOP@F

The SCOOP pilot deployment is coordinated by the French Ministry of Environment, Energy and the Sea, comprises numerous public and private partners. The French automotive industry is represented by PSA and Renault. Local authorities and road operators are part of the collaborative team as well as universities and research institutes. SCOOP phase 1 has been carried out in the years 2014 and 2015. With the transition towards phase 2 of SCOOP (2016-2018) new partners have joined the project, amongst others a telecom operator and a trust services provider. In order to address the important issue of cross-testing of services, partners from Austria, Spain and Portugal are now also involved. The SCOOP pilot deployment receives EC co-funding (phase 2: 50% co-funding of 20 Mn EUR eligible costs).

SCOOP brings on the road a number of services congruent with the Day One services of the C-ITS Platform and more general with the scope of the ITS Directive 2010/40/EU. Key services are hazardous location warnings (on board signaling of unexpected and dangerous events), road works alerts and data collection to enable enhanced traffic management. The service concept in general represents a closed loop, and congruent to other initiatives its elements are transmitting information to road users and taking up vehicle data in order to improve the processes for traffic management.

A list of standards applicable to specifications and development is available at SCOOP. It covers standards for the different layers of ITS stations, security, I2I communication (DATEX II) and testing Figure 18.

Drawing	Name	Pictogram	Objectives
	Temporarily slippery road warning		• Accident risk reductions
	Animal warning		• Accident risk reductions • To provide information as fast as possible and ensure real time update.
	Human presence on the road warning		• Accident risk reductions
	Obstacle on the road warning		• Accident risk reductions
	Stationary vehicle warning		• Accident risk reductions
	Broken vehicle warning		• Accident risk reductions
	Unmanaged accident warning		• Accident risk reductions
	Bad visibility warning		• Accident risk reductions
	Unmanaged blockage of the road warning		• Accident risk reductions • To redirect traffic
	Emergency brake warning		• Accident risk reductions • To avoid multiple braking that could create an early congestion
	Traffic jam ahead warning		• Accident risk reductions • Eventually, to redirect traffic
	Extreme weather condition warning		• Accident risk reductions

Figure 18: SCOOP@F On board signaling of unexpected and dangerous events., Source SCOOP@F

4.4 Austria (Eco-AT) (Source CODECS)

In Austria, the project ECo-AT (European Corridor - Austrian testbed for Cooperative Sytems) is the national building block for the joint deployment in the C-ITS Corridor. The EcoAT project is cofounded by the Austrian Federal Government via the Climate and Energy fund (KliEn).

The project is led by ASFINAG, Austria's national highway and expressway operator, and is split into two distinct phases, a "specification definition and testing phase" and an actual "deployment phase." In the first phase the system specifications are defined and tested in several iterative test cycles. During phase one, the work progress on the specification documents is made publically available through a set of several releases up to the end of 2016. Within each release, a system overview is given, the individual subsystems and

component are described and the interfaces connecting them. Moreover use case descriptions and data models, e.g. DATEX II profiles, are published.

In addition to the common use cases of all three C-ITS Corridor partners, ECo-AT is working on the deployment of additional cooperative services like

In-Vehicle Information (IVI), which is used to inform drivers about present speed policy/advices and other relevant (hazard) information which are shown on dynamic traffic signs**; Intersection Safety (ISS),** which means that Cooperative Traffic Lights will provide information on the traffic lights status (SPaT – Signal Phase and Timing) and a geographical representation of the vicinity of the traffic light (MAP); as well as

Other DENM based applications, which includes the types of events that are currently covered by so-called „cause codes“ within the DENM messages. This use case covers the information provision from the traffic control centre to the vehicles and vice versa, one direction as a service for the road users,and the other broadening the data base for traffic managers.

Interested parties can get access to the all the specifications and documents of the individual releases by free registration at the Eco-AT homepage [35].

In parallel with the finalization of the specifications and in transition from the first to the second phase, a “Living Lab” for testing is set up by ASFINAG, which allows vendors to deploy and test roadside equipment along certain stretches of the road network and check for conformance with the system specifications.

In the second phase, after verifying the results of the first phase, ASFINAG will commence with the actual deployment on the Austrian part of the corridor and further sections of the highway and expressway network from 2017 onwards (Figure 19).

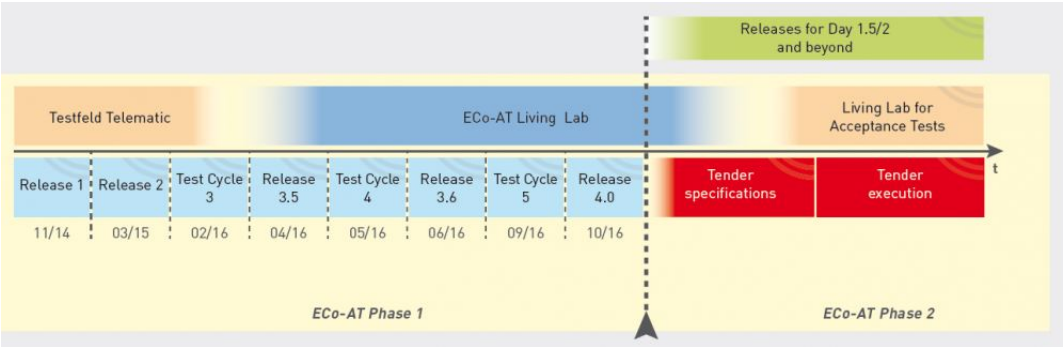

Figure 19: Eco-AT phases specification/testing, followed by tender/deployment

4.5 Czech Republic ITS deployment (Source CODECS)

C-ITS deployment in the Czech Republic is supported by national strategic documents approved by the Ministry of Transport and the Government of Czech Republic. The documents follow and further enhance EU strategic documents (e.g. Directive 2010/40/EU). In particular, the ITS Action Plan implemented by the Government in 2015 specifically defines the need to deploy C-ITS services nationwide until 2020 and to head towards autonomous driving in 2050. The C-ITS deployment is also included in an associated document – The national ITS Implementation Plan which was approved by the Government in June 2016. The Implementation Plan contains pool of ITS projects that are either under development or yet to be realized in order to fulfill the objectives of the ITS Action Plan. Activities in C-ITS deployment between years 2013-2016 (Figure 20) are shown on the picture bellow. From this picture is clear, that three levels of activities focused on Projects, Strategy documents and Support activities support the deployment.

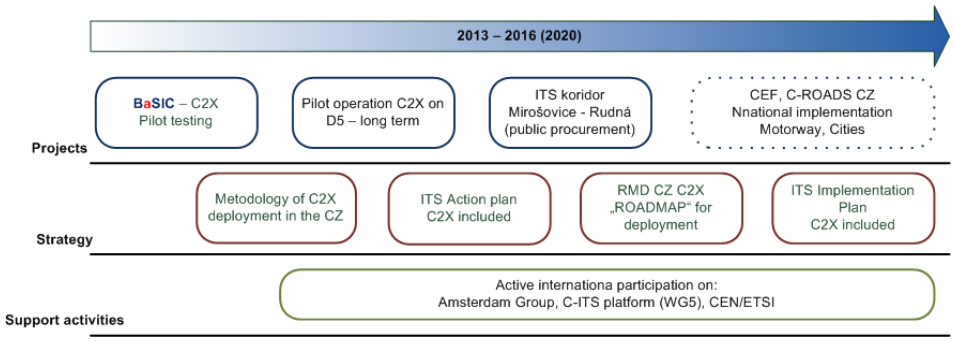

Figure 20: Overview of C-ITS deployment in the Czech Republic

Each of these activities is set into time frame to logically follow previous action and support the following.

There have already been couple of R&D projects carried out in the Czech Republic dedicated to C-ITS pilot testing and verification of theoretical knowledge in real operation. The BaSIC project (2012-2013) was focused on short-term testing of the following applications:

- Slow moving vehicle warning
- Stationary vehicle / trailer information
- Decentralized FCD
- Approaching Emergency Vehicle Warning
- Traffic Jam Ahead Warning
- In-Vehicle Signage (IVS)
    - Road line traffic control (max. speed, lane allowance)
    - Other information (road works, rain, fog, snow etc.)
- Road Works Warning (RWW)

The communication was based solely on the ITS G5 technology. The tests were carried out on the Prague outer ring road and were a major success. Whole set of technical, legal and operational recommendations for future deployment were developed as a result of the tests.

Another pilot testing is currently undergoing on the D5 motorway between Prague and Pilsen. This project is focused on long-term testing of C-ITS in real operation and related deployment issues from the road operator perspective (warranties, responsibilities, duties, operation etc.) Within this project two RSUs were mounted on the highway along with number of equipped maintenance vehicles and warning trailers. Apart from 'conventional' C-ITS use cases (RWW, SMVW), further applications are being tested, i.e. maintenance monitoring and performance evaluation.

In 2015 the Road and Motorway Directorate implemented a Roadmap for C-ITS Deployment on the Czech road network (Figure 21:). The roadmap splits the C-ITS deployment in 5 stages in terms of geographical coverage, deployed services (use cases) and stakeholders' involvement.

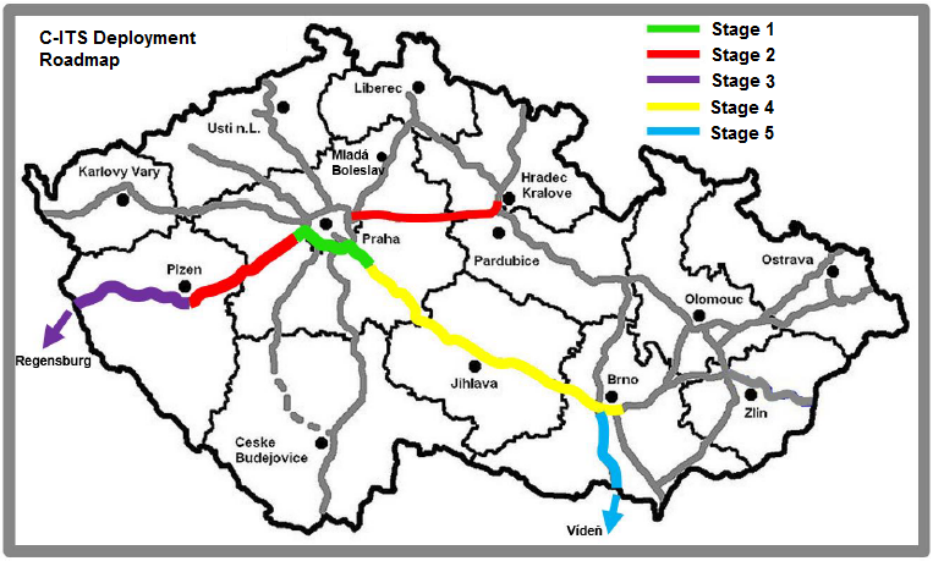

Figure 21: Roadmap for C-ITS deployment on the Czech road network

In fact, Stage 1 (also known and Cooperative Corridor Mirošovice – Rudná) is already in the tendering process and to be realized by the end of 2016, as it is included in the ITS Implementation Plan. It covers the Czech's busiest highway sections – parts of the D5 motorway, the D0 Prague Ring Road and the D1 motorway with total length of 50 km. Along with 29 RSUs, more than 150 maintenance vehicles and mobile trailers are to be equipped with hybrid ITS G5 / GSM technology. The following services are to be deployed within the Stage 1:

- Probe Vehicle Data
- Road Works Warning
- In-Vehicle Information
- Additional traffic data collection (WiFi- and Bluetooth based)

In addition, the Czech national C-ITS back-office platform is to be developed and put into operation as a part of this project.

In 2016 Czech Republic has built a strong consortium of infrastructure operators (both road and railway), telco operators, researchers, and ITS consultants, supported by automobile manufacturer SKODA and led by the Ministry of Transport, to join the international C-ROADS initiative within the CEF funding scheme. As a result, the C-Roads CZ project has been approved by the European Commission and commences in September 2016. The ambitions of the project are high – it covers all the remaining stages of the C-ITS Roadmap as the D1 (Prague – Brno), D5, D11 and D52 motorways are to be covered with hybrid ITS G5 / LTE technology, along with additional deployment in the city of Brno, and field testing in the cities of Ostrava and Plzeň. On top of this, C-ITS deployment on railway crossings is to be deployed on 2 railway crossings in the Pardubice region as a part of the C-Roads CZ project. Following the actual deployment, international cross-site tests will be carried between different member states of the C-ROADS initiative in order to secure interoperability. The project will be in operation between 2016-2020 and covers the following applications:

- Emergency vehicle approaching
- Slow or stationary vehicle(s)
- Traffic jam ahead warning
- Hazardous location notification

- Road works warning
- Weather conditions
- In-vehicle signage
- Probe vehicle data
- Signal violation/Intersection safety

Number of previously defined issues of technical, legal and administrative nature have yet to be resolved within this project in order to proceed to large-scale deployment. Such barriers include interoperability with the 5,8 GHz toll collection system, security aspects, interoperability with neighbouring countries (i.e. Austria and Germany) and clear definition of responsibilities and duties of stakeholders.

4.6 EU project HIGHTS

The HIGHTS project is an EU H2020 project (nr 636537) [32]

HIGHTS is a Europe-base research project supported by European Union under the funding scheme "Horizon 2020". Our theme is "Smart, Green and Integrated Transport" and our focus area is Cooperative ITS. The goal of the HIGHTS project is to achieve high precision positioning system with the accuracy of 25cm.

This project addresses these problems by combining traditional satellite systems with an innovative use of on-board sensing and infrastructure-based wireless communication technologies (e.g., Wi-Fi, ITS-G5, UWB tracking, Zigbee, Bluetooth, LTE...) to produce advanced, highly-accurate positioning technologies for C-ITS.

HIGHTS platform will be a key enabler to C-ACC and Platooning. In particular C-ACC and Platooning will provide smoother driving conditions, optimization of traffic flows and high precision lane detection for more efficient guidance in urban and highway environments.

Our platform will increase the safety level of vulnerable road users (motorcycles, scooters, pedestrians) through bi- directional danger detection and by detecting slight deviations from driving courses, thus detecting danger before it occurs.

The results will be integrated into the facilities layer of ETSI C-ITS architecture and will thereby become available for all C-ITS applications, including those targeting the challenging use cases Traffic Safety of Vulnerable Users and Autonomous Driving/platooning. The project will therefore go beyond ego- and infra-structure-based positioning by incorporating them as building blocks to develop an enhanced European-wide positioning service platform based on enhanced Local Dynamic Maps and built on open European standards.

4.7 EU project CODECS (Cooperative ITS Deployment Coordination Support)

The CODECS project is an EU H2020 project (nr 653339) [33]

C-ITS provide a wide array of information and warning services for a safe, sustainable and comfortable future mobility. Deployment of vehicles communicating among each other and with road infrastructure lies ahead, initially progressed in corridor projects and pilots all over Europe. Coordination between these front-runners and aligned rollout plans for the phased deployment are inevitable to let traffic participants experience the benefits of C-ITS seamlessly.

CODECS acts as a nodal point pooling stakeholders involved in C-ITS deployment in the consecutive implementation phases. The Coordination and Support Action establishes a stakeholder network for stimulating a transparent information flow and exchange of lessons-learned from initial deployment. Through workshops, webinars and personal consultation, CODECS takes inventory on the status and implementation approaches in early deployment activities (technologies, specifications and functions), roles and responsibilities of different stakeholders as well as issues for strategic decision-making. CODECS consolidates these procedures, stakeholder interests, preferences and requirements and plays them back into the network. Through interactive discussion, it develops:

- A V2I/I2V standards profile,
- White papers closing gaps in standardisation, and
- A blueprint for deployment

These results of CODECS sustain the interoperability of systems and services across hot spots of early deployment; enabling end-users to witness benefits of cooperative road traffic first-hand, in turn impacting on the penetration rates. CODECS promotes the idea of cooperative road traffic to a broad target audience to support this effect.
To give guidance for a future concerted C-ITS roll-out also for later innovation phases with corresponding research, testing and standardisation, CODECS transforms the fused stakeholder preferences in:

- An aligned use case road map and
- Recommendations for strategic decision making.

With this goal setting, CODECS supports the Amsterdam Group, the C-ITS Deployment Platform of the European Commission, Standards Setting Organisations and other key deployment players to come to a concerted C-ITS roll-out across Europe.

4.8 EU project CIMEC (Cooperative ITS for Mobility in European Cities)

The CIMEC project (Cooperative ITS for Mobility in European Cities) [34], as a Coordination and Support Activity (CSA), aims to facilitate the take-up of C-ITS by increasing the alignment of technological solutions with user needs, thereby reducing perceived barriers and risks in deployment. CIMEC focuses especially on this urban C-ITS context.
CIMEC brings together key collaborative institutions, supported by a panel of core cities and by the European city network Polis and members of multiplying organisations represented in the consortium. These meta-networks have extensive experience in bringing together cities and suppliers to optimise ITS.
The project will identify the cities' main transport challenges and associated strategies, and barriers towards take-up of C-ITS solutions, providing insight into internal and external conditions which guide the choices and priorities of cities in employing C-ITS solutions for solving transport challenges. This will be done through the organisation of individual workshops with the cities.
The purpose of the workshops is for cities to present their transport challenges, their strategies for dealing with these challenges and the role that ITS/C-ITS (potentially) plays in both strategy and practice. The workshops will particularly emphasise the cities' barriers and obstacles towards greater use of C-ITS solutions, related to costs and benefits, compatibility and interoperability with existing infrastructure, and effectiveness.

4.9 EU project C-Roads

With regard to the three level approach of DG MOVE (policy development – support – implementation, see Figure 22, EC has called for proposals to pilot and deploy C-ITS services. This call, launched in November 2015 and closed in February 2016, has been addressed by a number of proposals, most notably the C-Roads "family" and INTERCOR. Nearly all of the proposals are recommended to receive CEF co-funding. It is expected that the projects will start either end of 2016 or beginning of 2017.
C-Roads consists of a family of national pilots within the C-Roads Member States. Figure 22 (stemming from the proposal phase) illustrates the geographical extension of planned C-ITS pilots. A related mapping of planned services per pilot is illustrated in Figure 23. The list of services is again congruent with the list of Day One Services from the C-ITS Platform.
The C-Roads family consists of C-Roads Austria, Belgium/Flanders, Czech Republic, France, Germany and Slovenia. All C-Roads pilots will contribute to a harmonization effort labeled as C-Roads Platform. It is expected that also other pilots (e.g. INTERCOR), including existing ones (e.g. NordicWay) will contribute to the C-Roads Platform (managed by Austria). The harmonization efforts

comprise Working Groups on pilot tracking, organisational aspects, technical aspects as well as evaluation and assessment.

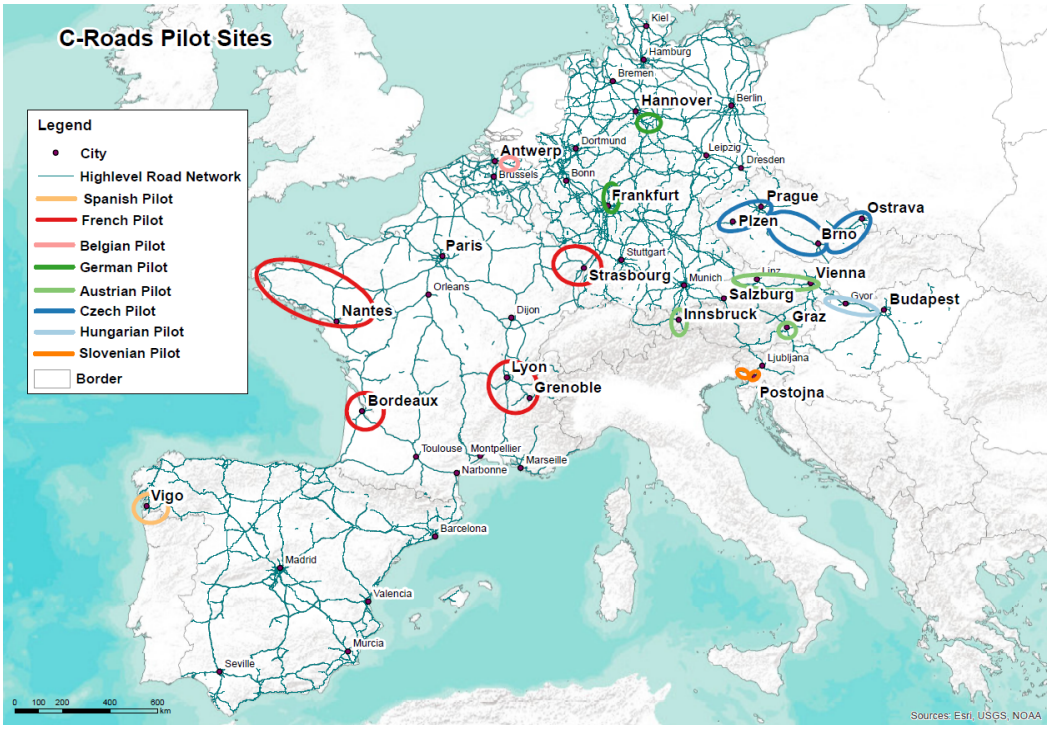

Figure 22: C-Roads pilot sites covering the TEN-T network. Source: C-roads

	Austria	Belgium	Czech Republic	France	Germany	Hungary	Slovenia	Spain
Communication technologies used								
ETSI G5	X		X	X	X	X	X	X
Cellular Communication	X	X	X	X	X		X	X
DAB					X			
RDS							X	
WiFi and Bluetooth				X				
Day-1-services covered								
Emergency electronic brake light								X
Emergency vehicle approaching			X					X
Slow or stationary vehicle(s)	X	X	X	X	X			X
Traffic jam ahead warning	X	X	X	X	X	X	X	X
Hazardous location notification	X	X	X	X		X	X	X
Road works warning	X	X	X	X	X	X	X	X
Weather conditions	X	X	X	X		X	X	X
In-vehicle signage	X		X	X	X	X	X	X
In-vehicle speed limits	X					X	X	X
Probe vehicle data	X		X	X	X		X	X
Shockwave damping		X			X			X
Green Light Optimal Speed Advisory (GLOSA) / Time To Green (TTG)	X			X	X			X
Signal violation/Intersection safety	X		X					X
Traffic signal priority request by designated vehicles								X

Figure 23: Services and technologies covered by C-Roads. Source. Source: C-roads

4.10 EU project InterCor

Intercor stands for Interoperable Corridors linking the C-ITS corridor initiatives of the Netherlands C-ITS Corridor NL-DE-AT and the French SCOOP@F and extending to United Kingdom and Belgium C-ITS initiatives to achieve a sustainable network of corridors providing continuity of C-ITS services and offering a testbed for beyond Day-One C-ITS service development. InterCor is a 3 year study that seeks to enable vehicles and the related road infrastructure to communicate data through cellular, ITS G5 or a combination of cellular and ITS-G5 (hybrid) networks on a road corridor through the Netherlands, Belgium/Flanders, UK and France to achieve safer, more efficient and more convenient mobility of people and goods.

The objectives of InterCor study are:

1. Demonstrating a large-scale interoperable deployment of C-ITS through the Netherlands, Belgium / Flanders, UK and France to achieve safer, more efficient and more convenient mobility of people and goods.
2. Foster four member states cross border interoperability by ensuring *interoperability testing*, *security* and *certification*, *seamless continuity of service*, *operation* and *maintenance*.
3. Provide C-ITS services on a broader scale by specifying, using and fostering an *hybrid communication* approach to utilise a combination of cellular and ITS-G5 communication.
4. Extend the strategic cooperation between C-ITS front running countries and assist other Member states to step-in in a cost-effective and future-proof way to develop and apply the common deployment framework through the consistent and cohesive network of corridors.
5. Evaluate through a common evaluation framework the cumulative, real-life benefits of C-ITS applications towards increased safety, efficiency, flexibility, user acceptance, sustainability of road transport, to support public and private stakeholders to invest in C-ITS.

This study supports the ambition of the Dutch EU-Presidency (2016) on Smart Mobility which aims to ensure a smooth and effective transition from navigation of vehicles to truly connected, cooperative, and automated vehicles on European roads. The study will achieve the kick-off of C-ITS (V2V, V2I and V2X) communication deployment on European roads and ensures new services and systems are compatible and interoperable on a EU level.

It also will support the EU ambition to share best practices by providing large scale cross border test possibilities in Europe for example by facilitating the exchange of best practices between and within Member States emphasising the added value of a coordinated approach amongst all stakeholders on investments along a common roadmap and shared learning.

Through the C-ITS project “SCOOP@F”, the French Ministry of ecology, sustainable development and energy (MEDDE) has already very important experiences of how to deploy C-ITS services, from specification to interoperability testing between its 5 pilot sites. A particular focus is the security challenge of such data exchanges, treatments and services: the security of the transmissions, but also in terms of privacy and further use. In addition, MEDDE has already quite extensive experience in collaborative initiatives regarding interoperability solutions for the freight sector through its ITS Taskforce.

The Dutch Ministry of Infrastructure and the Environment (Rijkswaterstaat) and the Province of Noord-Brabant bring its extensive knowledge of traffic management approaches, to be linked with the freight specific services that the consortium wants to explore together. Rijkswaterstaat also gained important experiences and learnings via its work with Germany and Austria on the respective C-ITS Corridor, the Shockwave and Pilot Project Amsterdam (PPA).

Both the Dutch Ministry as the Flemish Ministry pursue a strategy of optimising freight moves for smarter and more efficient transports to offer a better use of existing (road) capacity, security and added value services to its freight transporters and logisticians, and other road users. Flanders so far gained little knowledge on the deployment of C-ITS services and will take advantage of the proposed joint.

The United Kingdom’s Department for Transport, along with its road authority partners, bring extensive knowledge of C-ITS trials having been involved in Compass 4D, CVIS, MOBINET amongst other EU projects. This experience will be applied to deliver C-ITS solutions that mitigate common traffic

problems all partners face related to road safety, congestion, emissions and in particular freight logistics around TENT ports and strategic road tunnels, such as the Blackwall Tunnel in London.

ERTICO will utilise the Communication expertise and channels set-up for all ERTICO Partnership activities ensuring a maximum outreach of both the results, functionalities and take-up of InterCor study.

Lastly TTP/i-Trans, specifically through its team at the freight specialized i-Fret innovation platform, is active in sensibilisation actions on ITS for transport and logistics companies in Northern France.

- The 4 countries have agreed on a common set of standards, profiles and specifications for C-ITS and will bring these results to the C-ITS platform whereas wider adoption will be promoted through close cooperation in C-ROADS platform study.
- Multiple communication media can be used, in particular ITS-G5 and cellular networks, so end users can benefit from the continuity of C-ITS services via a communication technology implementation strategy which provides complementarity.
- Security measures are in place, so an end user can access all services at all corridors within the limitations of the local security provisions.
- Logistic services related to traffic management are available at relevant areas across the network of corridors.

This study supports European, national and regional policies and ambitions regarding road transport in general (i.e. safety, efficiency, sustainability, competitiveness) with a specific additional focus on freight and logistics.

Figure 24: **Intercor connecting France, Belgium, The Netherlands and England.**

4.11 CHARM Programme (2013-2017)

The CHARM Program has the intention to develop the next generation of Traffic management. The Charm Programme is an cooperation between Highways England and Rijkswaterstaat. The intention is to facilitate smart cars and integrate technological innovation in their traffic management. The Dutch and English road authorities work together in the procurement and implementation of COTS (commercial off-the- shelf) software for their traffic management centres? This is realized by cooperation with their Belgium, Dutch and English's partners, triggering the market to develop innovative modules.

The collaboration between these stakeholders is a unique, international programme (2011-2018) and aims to modernise traffic management centres and innovate traffic and incident management in the Netherlands and England.

In the CHARM programme, it is chosen to use COTS software to revive their traffic management and to work more efficiently in their traffic management centres. A joint procurement resulted in the authorities choosing the Advanced Traffic Management System DYNAC®. Rijkswaterstaat and Highways

England bought the software, by separate contracts, and are now implementing the system in 26 months whilst still working together as partners in the CHARM

DYNAC®, by Austrian Kapsch TrafficCom, will be implemented for the first time in Europe (England and The Netherlands). The software is developed in the USA and is already implemented there, in Australia, and in New Zealand. This ATMS will replace many applications that require excess time and effort of operators to manage properly. It will enable Rijkswaterstaat and Highways England to work more efficiently and to maximize capacity for each agency. RWS and HE will use DYNAC® for their traffic and incident management, but bridges and tunnels can be managed by this ATMS software as well. The ATMS DYNAC® software can be extended by the innovative modules of the third-party developers. Procurement of these innovative models is out of scope for CHARM.

4.11.1 Development of innovation module

In CHARM, the market is challenged to develop new modules for innovative functions (Advanced Distributed Network Management / Detection and Prediction of Incidents / Support of Cooperative ITS Functions (in- car systems) in traffic management in a pre-commercial procurement (PCP) procedure The aim is to realize innovation of traffic management by creating new functions for Road Traffic Management Centres.

The prototypes of eight innovative modules are ready and in 2016 the third phase, testing of the modules on DYNAC®, will start:

- Module 1: Distributed Network Manager
- Module 2: Qualicision
- Module 3: Autopilot
- Module 4: ADAPT (Advanced Data Patrolling)
- Module 5: Virtual Patrolling
- Module 6: uCan Data® Selection
- Module 7: Next Vehicle ™
- Module 8: Charm Cooperative Systems (ChaCoSy)

5 Standardisation organisations

5.1 In General

Standards are tools to enable conformity and interoperability between services and systems. It includes both functional and technical specification in which mandatory aspects (shall's) as well as maybe implemented aspects are presented. For those aspects not begin mandatory the C-ITS stakeholders need to jointly decide which aspects to use and how the standards will be used. Here the relevant standardisation organisations are mentioned which have direct influence. In Annex C those organisations are mentioned which have indirect influence, mainly by the fact that harmonisation between the relevant standardisation organisation have influence and therefore for some aspects these organisations need to be monitored. in chapter **Error! Reference source not found.** the joint decision aspect process, so called profiling, is presented. Those standardisation organisations have been selected covering an Hybrid Communication approach.

This chapter is an update of the chapter "Standardisation & Legislation" from the 2014 report.
In this chapter an overview of the relevant standardisation organisations (SDO's). It provides an overview of the relevant SDO's for the deployment of ITS with focus on Hybrid-Communication. The relevance of the SDO's, their status of and upcoming developments are presented. There are 3 main European standardisation bodies (SDO's), ETSI [16], CEN [17] and CENELEC [18]. Beyond the European standardisation there are also none European SDO's of importance.

Direct relevant SDOs and there Technical Committees (TC) for C-ITS:

- ETSI
  - TC ITS
  - TC ERM
  - TC BRAN
  - TC RT JTFIR
  - TC IOT
- 3GPP
- M2Mone
- ISO/CEN
  - TC204-WG14 (Automation)
  - TC204-WG16 (CALM)
  - TC204-WG18, (CEN TC278-WG16)
  - CEN TC278/WG17 Urban ITS (aligned with ad-hoc coordination group in TC204 called “Intelligent Mobility”)
- IEEE
  - 802.11
- ITU C-ITS
- Road Infrastructure platform DATEXII [55]
- Traffic Information broadcasting oriented platform TISA [58]
- IVERA for V-LOG, iVRI (NL) [47]
- DVM-Exchange (NL) [48]

Indirectly and supporting SDOs Technical Committees (TC) and industry standards for C-ITS:

- IEEE
  - P1609
- SAE
  - J2735
  - J2945
- Industry Standards
  - Dynamic Location Referencing, OpenLR™ [57]
  - SENSORIS “HERE” [29]
  - GENIVI [42]
  - MirrorLink [43]

For details on these indirect and supporting SDOs see Annex C.

The European H2020 project HIGHTS (pr.nr. 636537) [21] realized a complete report on ITS standards and legislation organisations, report D7.1, “Worldwide standards and regulation landscape for cooperative ITS systems”.

5.2 ETSI

ETSI is the communication oriented (well known for its communication standards especially those relevant for 3-4G mobile phone technology) and frequency spectrum related standards, M2M standards and others. The ETSI Standards may have direct relation with spectrum regulation and are often referenced to by these regulatory bodies.
ETSI in general is driven by contribution of mostly industrial stakeholders. Contribution is based on payment as a portion of the net income of telecommunication equipment sales. So operators and companies as Qualcomm pay the most but also have most voting rights. Car OEMs have one to three votes. Research organisations and others in general have one vote.

5.2.1 ETSI TC Intelligent Transport Systems (ITS)

This Technical Committee covers Intelligent Transport Systems, in particular within the 5.9 GHz band, and has direct relationship with ETSI TC ERM, related to spectrum issues. This Technical Committee addresses all ITS-related aspects from Application down to the lower communication layers. As ITS are highly relying on location-based service principles, Geolocation referencing is an essential element and especially Geolocation requirements can be derived from ETSI TC ITS specifications.
The EU commission mandate 453 gave ETSI TC ITS the task to be responsible for the realisation of all the C-ITS technical communication as well as all safety related functional standards and C-ITS architecture covered by ITS-G5. CEN was asked to be responsible for all the Infrastructure related functional specifications.
The ETSI standards have a European focus but based on the success of the ETSI TC ITS standards they are recognised worldwide. Interest for C-ITS standards has been expressed by Japan, and Australia has adopted these standards for deployment of C-ITS in Australia. In Europe ITS-G5 is currently used as bases for all short-range safety and traffic management related C-ITS use cases. This is also stressed in the EU commission mandate M453.
As voting rights depends on turnover in telecom, the Dutch authorities could have quite an amount of votes as they earn billions in sales of radio spectrum to telecom operators. It needs to be investigated if ETSI membership can be reached to be able to influence the ETSI standards. Austria is also following this approach.

5.2.2 ETSI TC ERM

All spectrum related standards are handled within TC ERM, therefore all spectrum related communication with the CEPT and EU commission goes through this technical committee.
For C-ITS, ERM TG37 is of great importance. At the moment European NORM EN 302 571 which is specifying how to use the ITS spectrum is being updated and is currently in common resolution status expected to be finalized after the summer of 2016.

5.2.3 ETSI TC BRAN

BRAN is of importance in the European context. As normal RLAN (WiFi) specifications are covered by IEEE 802.11, BRAN covers the specific European aspects. One of which is the coexistence between normal WiFi an ITS-G5. Contributions by the ITS-G5 community is required to ensure no interference by WiFi devices will occur.

5.3 3GPP

5.3.1 In General

The 3rd Generation Partnership Project (3GPP) unites seven telecommunications standard development organizations (SDOs) from different regions of the globe and develop standards for cellular telecommunications network technologies, including radio access, the core transport network, and service capabilities, ranging from 2G (GPRS), 3G (UMTS, to 4G (LTE and LTE-Advanced), and in the future, 5G (see 5G-PPP in 5.3.2). 3GPP has recently started working on C-ITS for LTE-Advanced and 5G (known as Smarter).
The Mobile Broadband Standards are developed within 3GPP [19]. Currently 3GPP is working on the definition of the next generation Mobile standards to be part of the 5G (5^{th} Generation of Communication Standards, including all communications also WiFi and ITS-G5). Especially the Technical Specification Group (TSG) SA is of interest as here the next generation standards are initiated. For the purpose of ITS especially the working groups Services (SA1), Architecture (SA2) en Security (SA3) are of relevance. 5G will support more use-cases then earlier generations before. There where current mobile technologies provided communication for general traveling information and routing, next generation(s) will be able to provide more real time related services and therefore enable more time and location critical applications. As this of interest to ITS it is relevant to follow and review the 3GPP developments.
Active at 3GPP is TNO.

5.3.2 5G-PPP for 5G networks (part source HIGHTS)

To stimulate and accelerate the achievement of the evolution towards 5G networks, the European Commission and the European ICT industry, through the 5G Infrastructure Association, have launched the 5G Infrastructure PPP, in short 5G PPP, as part of the Horizon 2020 Research Programme. Its objective is to rethink the infrastructure and to create the next generation of communication networks and services. The 5G PPP is aiming at securing Europe's leadership in the areas where Europe is strong or where there is potential for creating new markets such as smart cities, e-health, intelligent transport, education or entertainment & media. The 5G PPP will deliver solutions, architectures, technologies and standards for the ubiquitous next generation communication infrastructures of the coming decade.

The 5G-PPP has published a white paper on C-ITS, "5G Automotive Vision" [12]. In this document, representatives from both the automotive and the telecom industry provide their vision on how 5G will enable the next generation of connected and automated driving and new mobility services, identify the limitations of present wireless technologies, and describe the key research and innovation areas that need to be explored and advanced in order to realize the 5G automotive vision.

The white paper defines position accuracy KPIs according to the use case:

- Automated Overtake manoeuvres: 30 cm
- Cooperative Collision Avoidance: 30 cm
- High Density Platooning: 30 cm
- Vulnerable Road User Discovery: 10 cm

According to the report, one of the most critical issues with the VRU use case is a reliable localization of the VRUs. Combining several positioning techniques – including satellite and natively integrated in 5G – should be able to increase the accuracy of the positioning, especially the relative positioning to vehicles in all environments (urban and rural).

5.4 AIOTI for IoT ecosystem (part source: HIGHTS 7.1)

The Alliance for Internet of Things Innovation (AIOTI) is a tool launched for supporting the policy and dialogue within the Internet of Things (IoT) ecosystem and with the European Commission. The near-term objective is to support the Large Scale Pilots (LSP) which are planned in the H2020 work program. Two working groups have a special interest in C-ITS standards, WG03 for standardization and WG09 for Smart mobility (smart transport/smart vehicles/connected cars). All the AIOTI working groups have published reports of their first year of action in October 2015.

WG03 published the "IoT LSP Standard Framework Concepts" report [22], which draws a landscape of IoT standardization. Vehicular / Transportation domain is one of the vertical domains considered.

WG09 published a "Smart Mobility" report [23]. It considers the applications of the Internet of Things to the mobility domain (Internet of Vehicles) as next step for future smart transportation and mobility applications and draws the baseline for future performance requirements.

The action of WG03 is completed by an ETSI Specialist Task Force (STF 505) on "IoT Standards landscaping and IoT European LSP gap analysis". This group of experts, funded by the European Commission, is commissioned to provide two ETSI technical reports, one on an in-depth analysis of the IoT Standardization landscape, and a second on the identification of the IoT standardization gaps to which the LSPs will be confronted.

The industry is organized within oneM2M [20] for which the specifications are standardized at SMARTM2M at ETSI. OneM2M focuses on a scalable architecture with focus on interoperability allowing oneM2M can be deployed where industrial grade solutions are required.

At the moment this is not of major importance to the current ITS-G5 air interface deployments but it is of importance to infrastructural architecture definitions. First implementations such as from IBM are available and of interest for ITS related Infrastructural implementation.

5.5 CEN/ISO

5.5.1 In general

There is a close cooperates between CEN and ISO when it is concerns to ITS resulting in many mirror working groups. ISO is therefore equally important for Europe as to CEN, only when we Europe has something special or when the use is only in Europe this is led by CEN.
Active at CEN TC278 is Lex Eggink (VWM)

5.5.2 ISO TS 204 WG14

WG 14 focus on Automated driving and has the following interesting standardisation on the way.

5.5.2.1 Intelligent transport systems - Traffic congestion assist systems (TCA).
5.5.2.2 Intelligent transport systems - Divided highway assist systems (DHAS).
5.5.2.3 Intelligent transport systems - Partially Automated Lane Charge Systems (PALS)
5.5.2.4 Intelligent transport systems – Cooperative adaptive cruise control (CACC)
5.5.2.5 Intelligent transport systems – Road Boundary Departure Prevention Systems (RBDPS)
For details see HIGHTS D7.1

5.5.3 ISO TC 204-WG18 / CEN TC278-WG16

ISO TS 204 WG18 / CEN TC278-WG16 is the working group responsible for development of C-ITS related standards that are non-safety related Infrastructural use cases according to mandate 453. CEN has agreed to develop related standards in direct cooperation with ISO although the business models are different. All related standards will be categorized as World standards and be distributed by ISO. CEN TC278-WG16 / ISO TC204-WG18 is key for a limited set of specific facility layer related service standards such as SPAT and MAP for traffic light information exchange, IVI for sign information exchange and PROBE DATA standards for the support of additional traffic related information exchange. For PROBE DATA standardisation the developed standards in ISO TC204-WG16 are also important.

5.5.4 ISO TS 204-WG16

Besides this CEN/ISO group there is the ISO TC204-WG16 working group. This is the working group where early ITS standardisation started and is the so-called CALM working group. CALM has been used within CVIS and other projects at that time. It is IP-based and does not allow to manage liability properly. This is the reason why it is seen as a problem for safety related use cases.

5.5.5 CEN TS 278-WG17

CEN TC278-WG17 Urban ITS (aligned with ad-hoc coordination group in TC204 called “Intelligent Mobility”) is currently being established based on the CEN N3363_Prestudy_Urban_ITS_final_report. The initial start of the group is planned for end of 2016. This group is not specifically expected to develop standards but to setup strategies for it and give direction to other CEN working groups.
The basis of its work is the PT1701 report which gives a generic overview of open issues. It is expected this in this WG these are discusses and seen whether these need standardisation. Standardisation which then most probably in the ISO working groups WG16 and WG18 will be realized.

5.6 IEEE

The Institute of Electrical and Electronics Engineers (IEEE) covers many different areas of electrical and electronics engineering standardization. Here only the ITS related standards IEEE P1609 and IEEE 802.11p are covered.

5.6.1 IEEE 802.11

IEEE 802.11 is the RLAN (WiFi) communication standard. This standard provides the underlying lower layer standard (MAC-PHY) used within C-ITS communication in Europe, Australia, parts of Asia and the USA being the IEEE 802.11p derivative.
For Europe the ITS-G5 protocols run on top of the IEEE 802.11-2012 version including this 11p amendment (Specifically required for ITS-G5). As these standards are fundamental to the proper operation of ITS-G5, they are essential to the deployment of C-ITS in Europe.
Where in Europe the ITS-G5 protocol is running on top of the IEEE 802.11-2012, in the USA the IEEE 1609.x standards run on top of IEE 802.11-2012. Harmonisation of this WAVE standard with ITS-G5 has been done but there are still some (regional) differences.
With respect to security aspects there is agreement between CAMP (the USA car-manufacturers) and the C2C-CCs for the security hardware so that different hardware is not required for different regions. Experience build up during this process tells us that more harmonisation may be possible and required in future.

5.7 ITU C-ITS

The ITU efforts in C-ITS have not yet resulted in worldwide standards, though this may change and these could be of influence in a later stadium. So far ITU only provided reviews and produced comments on the C-ITS standards as provided by the other SDOs. At this point of time there is no need to participate. Reviewing the progress to recognise possible grow in importance is applicable.

5.8 TISA [58]

The Standardisation of TISA (supported by ERTICO) is more traffic information oriented although new versions cover some safety related elements, Main interest is to none time critital as the message can be large and not very useful for awareness characterized information exchange. For IP based none-safety and bulk data related Information exchange this protocol besides DATEX II is recommendable. In general this protocol is used in large area broadcasting networks such as DVB-T.

5.9 DATEX II [55]

The DATEX II standard is a CEN/ISO standard especially fitting to exchange data between (road) traffic centres and between (road) traffic centres and service-providers. It is mostly used for provision of traffic information, traffic analyses and large area traffic management and control. Now version 2.3 is available.
NDW makes use of DATEX II. Based on this standard a Dutch profile has been established. On 3 June 2015 The genial group Smart Mobility and ITS has established a DATEX II Dutch profile 2015-1 and is foreseen to replace the NDW Interface specification version 2.2. This Dutch profile is available.
Based on the large packet size DATEX II data it is not well suited for short range ITS-G5 communication. DATEX II is out of scope for this report. Further investigation is needed to identify the exchange of data between the local and inter-local traffic management layers of the ITS system. Questions such as; “do we need to translate information provided by ITS-G5 related communication into DATEX II specific information and how will this be used”, need to be answered but are out of scope for this report.
Active in DATEX is Dick de Winter (VWM).

5.10 IVERA (V-log, iVRI) [68]

The IVERA-protocol is a data communication protocol facilitating the information exchange between traffic light systems and the central traffic management system. It is a specific Dutch standard comparable to for instance the OCID protocol as used in the German speaking countries. So far there is no common European protocol. In other countries there are additional specifications available.

Harmonization of these protocols may be of interest and should be part of the European discussion such as this has been done for DATEX II where there is more alignment between the countries.
Compared to other countries the IVERA protocols have been especially enhanced in the area of dynamic traffic management compared to others. The initiative of BB of the development of an enhanced intelligent protocol (iVRI) prepared the way to support Cooperative ITS service realization.
Currently version 3.1 is available.

5.11 DVM-Exchange [[48]

The DVM-Exchange protocol is an open standard to support the traffic management related information to be exchanged between different stakeholders such as authorities, Infrastructure and service providers. It is an open standard. It is the Dutch standard to support dynamic traffic management information exchange between authorities themselves but also with the market such as service providers such as TomTom. It allows to combine information from different sources and to do

5.12 C-ITS ITS-G5 status relevant standards in 2014

This section is not updated as the report was starting point of the standardisation table where the list of standards and Dutch Profile are now maintained and therefore for updated status we need to refer to the relevant papers provided by DITCM.
Here the original status from 2015 is left as general reference.
The relevant standards are grouped by their communication layer. We can recognise several layers, based on the C-ITS Architecture standard ETSI TC ITS EN 302 665 V1.1.1 (2010-9) Figure 25. This architecture is a commonly used reference architecture.

1. Application Layer
2. Facility Layer
3. Network & Transport Layer
4. Access Layer
5. Management Layer
6. Security Layer

Additional process related
7. Process and Responsibility
8. Legislation & Certification

In this report we will focus on the Functional related Layers, Application and Facility, but do touch the other layers to indicate related important aspects for further investigation.

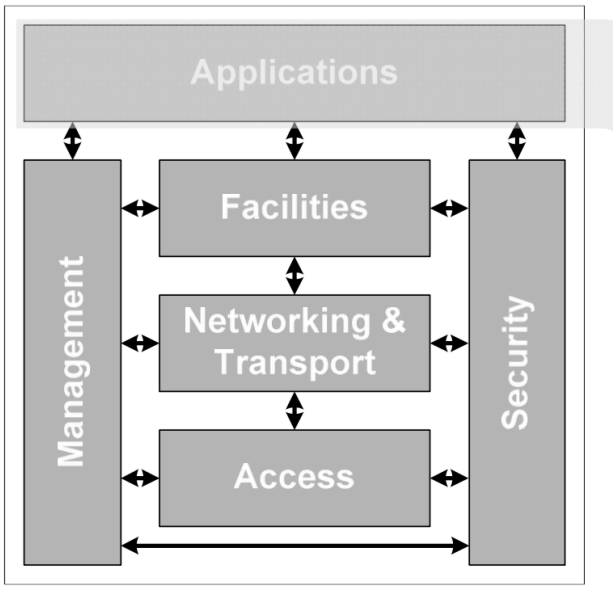

Figure 25: The C-ITS reference Architecture

5.12.1 Application Layer

Differentiation between stakeholders in the market is accomplished by differences in functionality, performance and perception (in form, feel and fit). When the functionality is more common as in the case of Cooperative Systems, stakeholders differentiate especially in perception and by adding additional information from other sources such as systems internal sensors. Industrial standardisation of applications is therefore not easily reached. To establish an expected behaviour at the receiving ITS-S, V2V triggering conditions at the transmitting end are commonly agreed upon among the stakeholders. So far these V2V triggering conditions are not yet standardised but are part of the V2V Profile at the Car2Car Communication Consortium (C2C-CC) to ensure interoperability. In this profile only a limited set of use cases is covered and only V2V technology and B2B aspects have been incorporated.

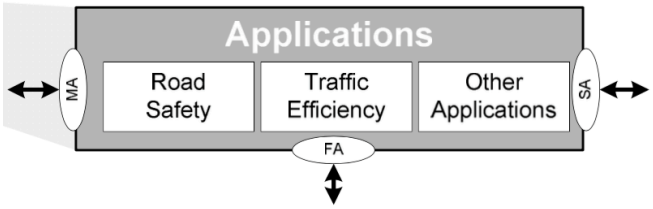

Figure 26: Application Layer

In future, commonalities between the different stakeholders may become more clear with possible common application standards in later phases as a result.
A general overview of the C-ITS applications are captured in the Basic Set of Application standards (BSA), ETSI TS 102 638. A new work item is initiated at ETSI to accommodate the extension of this Set of Application standards to include new upcoming use cases such as Vulnerable Road Users (VRU) and C-ACC.
Although standards for Road Hazard Signalling (RHS), ETSI TS 101 539-1, Intersection Collision Risk Warning (ICRW), ETSI TS 101 539-2 and Longitudinal Collision Risk Warning (LRCW), ETSI TS 101 539-3 have been realised, they are currently not used in current deployments.
With regards to the Road Operator oriented application standards In Vehicle Signage(IVS), TS17425 and Contextual Speed, TS17426 are under development at CEN TC278 WG16 / ISO TS204 WG18. The industry including a number of road operators, recognise many issues especially within the IVS specification. Although it may be implemented at the Road Operators (at the transmitting end), still at

the receiving Vehicle side many issues such as liability related aspects, need extensive discussion and agreements among all stakeholders. As the process is now mostly industrial driven with limited influence from Road Authorities this might hinder the implementation of the standard. It also needs to be considered whether the Contextual Speed standard will/can be used in deployments. This standard needs to be better evaluated before use as it has been developed with very limited contributions from the stakeholders active in the development of use cases such as GLOSA.

5.12.2 Facility Layer

The facility layer provides application support services and can be seen as the gateway to communications. Together with the triggering conditions it forms the interoperable information exchange service required to operate applications and realise use cases. It additionally is responsible for making other ITS-Ss aware of its existence in the ITS network through sending Cooperative Awareness Message (CAM). For the Road Operator these services provide the most important information exchange. Therefore contribution to the development of these standards is important to reach C-ITS objectives.

So far we can recognise the following essential facility functions and services:

5.12.2.1 The Cooperative Awareness Message (CAM) service, ETSI EN 302 637-1.This message service is an autonomous running service generating messages at the facility layer of an ITS-S to inform other ITS-Ss about its situation (speed direction, location, ...). The current version is Vehicle specific. Although a Road side container is available further development for use by road operators is required. For instance Probe requests could be enabled by this container.

5.12.2.2 The Decentralized Environmental Notification Message (DENM) service, ETSI EN 302 637-2. This is an event based message set to enable ITS-Ss applications to generate a warning such as the Road Hazard Warning. As with CAM no effort has been put into Road Infrastructural Notifications such as slippery road etc. In coming year(s) extension for Road management use are required and should be part of the second release.

5.12.2.3 The Common Data Dictionary (CDD), ETSI EN 302 894-1 provides message elements required by all service related ETSI standards. Based on the comments from 4.2.2.1 and 4.2.2.2 contribution to this standard needs to be expected.

5.12.2.4 A new Work Item (NWI) has been created at ETSI to accommodate the realisation of a message service to support Vulnerable Road Users (VRU) use cases specifically targeting the use in urban environments. This is of relevance for further work in coming 2 years

5.12.2.5 Additionally a NWI has been created at ETSI to realise Platooning and Cooperative-ACC (C-ACC). In a first view this does not seem to be of interest to Road Operators. There are however issues of interest justifying monitoring this activity. Especially merging traffic and safety require specific attention. At least monitoring of the activity is advised to ensure that merging can be ensured in future deployment

5.12.2.6 For Crossing related data exchange, Crossing Topology (MAP) and traffic light Signal Phase and Timing (SPAT) message elements were expected to be developed within the ISO TS 19091 message set specification, including referencing normative for many aspects to SAE J2735 release 2, not including Facility protocol and communication requirements. In the last month all EU requirements have been adopted by SAE and therefore it is the question what the value is of the ISO TS 19091 for EU use. The USA has been managing the work item with the focus of creating an engineering document and it is now expected that it will be used not as a message specification but as an engineering document especially of interest to the DOT. Within the EU we can now use the J2735 (SAE will published this document in November 2014) for deployment and only need additionally an Facility protocol and communication requirement specification.
NOTE 1: For deployment of related use cases Facility protocols and communication requirement will be defined within an ETSI TS for which the Work Item (WI) has been accepted in the October 2014 meeting and is expected in 2015.

5.12.2.7 The In Vehicle Information (IVI) message set, TS 19321 and dictionary is been developed at CEN278-WG16 / ISO204-WG18. With multiple referencing to different sign catalogues such as the ISO TS 14823 an alternative catalogue of the C2C-CC whitepaper can be used. The selection of options, needs to be part of the profiling process.
NOTE 2: NOTE 1 applies.

5.12.2.8 The development of the Probe Vehicle Data (PVD) specification TR 20025 is recently started at CEN278-WG16 / ISO204-WG18.
ITS Stations (ITS-Ss), such as to be used in Vehicles and Road Side Units collect information about their own state through integrated sensors. ITS-Ss collect information about the environment through sensors specifically tailored for that like radar sensors and cameras. Compared to today's vehicles, next generation vehicles equipped with ETSI TC ITS-G5 communication will be able to provide information from their own sensors to other ITS-Ss through the broadcasting of Cooperative Awareness Messages = CAMs. When RSUs are equipped with an ITS-S they can receive CAM messages and be aware of the situations of vehicles along the road. However as the ITS-G5is short range communication (400-500m ITS-S to ITS-S) and as RSUs may not necessarily be placed within a distance of 800m away from each other, the infrastructure may not be able to receive all CAM (also others) messages sent by other ITS-Ss of relevance to the road operator. To overcome this gap of not receiving this (historical) information a data collection mechanism is proposed to overcome missing the information.
When ITS-Ss are integrating history functions, this historical information can be provided by other ITS-Ss on request. A request from one station to others could be a request for specific parameters but could also be a generic request. Privacy regulation brings restrictions about what may and may not be provided.
Based on existing Road Operator use cases such as AID it initially is known that for Traffic Management as well as Traffic Information purposes the following parameters are of interest:

- Vehicle speed
- Vehicle location
- Vehicle load (an privacy issue)
- Weather conditions
    - Directly (measured, like temperature or humidity)
    - In-directly (use of fog lighting or windshield-wipers)
- Road conditions
    - Bumps
    - Slippery
- Information on nearby vehicles (hazard related information)
  (specific Decentralized Environmental Notification Message = DENM)

use case investigations are required to show concrete functional and behavioural requires supporting V2I use cases. The Facility protocol and communication requirements are not covered in this specification.
NOTE 2: NOTE 1 applies. This may result to the adoption of all EU specific ProbeData requirements as mentioned here within this WI

5.12.2.9 A new Work Item (NWI) addressing Location Referencing Service (LRS) is not yet available but expected in the coming 1-2 years.

5.12.2.10 There are 2 Local Dynamic Map (LDM) standards. One developed by ETSI, the Basic LDM, EN 302 895 and the LDM developed by CEN278-WG16 / ISO204-WG18 the TS 18750. For Road Operator use these standards need to be compared and a decision needs to be taken which to use. They are not compatible, the EN 302 895 was earlier available but CEN/ISO did not harmonise.

5.12.2.11 Position and Time are relevant for all Cooperative services and applications and are essential to a correct operation of the C-ITS environment. As Road Side systems are

different from Vehicles, the position aspects are different. Limited reviewing and contribution to the realisation of related White Paper at C2C-CC is required as well as monitoring the he realisation of the ETSI standard TS 102 890-3.

5.12.2.12 For general information exchange the Service Announcement Message Service (SAM) will be of relevance at a later stage of the deployment of C-ITS services. The ETSI TS 102 890-2 is currently in development and will be based on the IEEE1609 standards to realise a harmonised approach.

5.12.2.13 To identify the different Applications and Services an identifier is required. The Application and Service Identifiers are defined in the ISO TS 17419. An updating process is currently created and is expected to be managed by the CEN and executed by NEN.

5.12.3 Network Layer

The Network layer is the first technical oriented layer. Road Operators might expect there is no need for them to get involved in the development of any technical specification and leave these developments to the industry. However, participation is needed to realise uniformity and enable competitive business models. Furthermore involvement is required to ensure that the road side unit can contribute effectively to the overall C-ITS system. Contribution to the realisation of technical communication is important for the Road Operator use cases. One example related to the network layer:
Road Infrastructural systems are able to route information on a different scale then vehicles can do. Forwarding of information can be easily executed upstream one or two stations. It therefore is of relevance to influence the standards also at the Network layer. It also enables a more easy exchange with 3-5G which is of benefit to the Road Operator. For Geo Oriented dissemination over the complete IP network a new Work Item is required "Geo-Dissemination over IP".

5.12.4 Access Layer

Regarding the possibilities of using ITS-G5 channels for data exchange by Road Operator, it is important to participate in activities related to spectrum. For some I2V communication there are also Road-side related aspects, not covered by the current V2V oriented standards and white papers at the C2C-CC. One of the aspects not considered is an RSU oriented transmission profile and antenna configuration. The antenna of a roadside is different from that of a car and the transmission power could be differently considered.

5.12.5 Management Layer

The main management layer aspect to consider is the Multi-channel Decentralized Congestion Control (M-DCC). An non-Multi channel version is available at ETSI, TS 102 687. A multi-channel version is currently in development at ETSI and will be available in 2015. Contribution by road operators is needed to ensure a proper use of the ITS-G5 channels to guarantee and facilitate the road operator use cases. This does not need to be further investigated within on the coming 2 years.

5.12.6 Security Layer

In general security specifications need to cover not only data trust (most often seen as where security is for) but also privacy aspects. To ensure that information received from other ITS-Ss can be trusted, the protocol is secured by a security system agreed among the stakeholders. To ensure required privacy policies additional security mechanisms are required to be integrated so that not only trust but also privacy related policies are supported.
According to current knowledge from the Cooperative ITS Corridor discussions between the German Car OEMs, Road Operators and the ICT security/privacy regulator, the German regulator has formulated a statement showing that implementation and deployment of C-ITS from a normal Business environment can be realised. However implementation by public services is not yet sufficiently supported and needs further development.
The Dutch perspective is currently being evaluated. As the Dutch situation is different bringing the services to the market could be an option and needs further evaluation.

Regarding security there is a set of standards available at ETSI as can be found in the technical roadmap. Based on these standards the security related part of the C2C-CC V2V profile has been realised. Evaluation of related aspects are not part of the considerations in this report. Assessment of related standards may lead to change recommendations based on legal considerations.

5.12.7 Roles & Responsibility related

A first standard in this area is realised at CEN278-WG16 / ISO204-WG18, Roles & Responsibilities ISO TS 17427. Additional process standards may be developed but most will be developed as specifications between the stakeholders themselves, possibly within the C2C-CC or AG.

6 Interoperability and Conformity

6.1 In general

To ensure that use cases, services, applications and processes work seamlessly in Europe, Interoperability and conformity between the different systems, services, applications and processes owned and managed by different identities (users, service providers, system suppliers, technology providers, governmental and local authorities) needs to be ensured.

Here insight is provided about what Profiling is, what specifically needs to be profiled in case of C-ITS, what current steps are taken and what is planned and needed in near future in general terms based on the work done within the European H2020 project CODECS (pr.nr. 653339) [26] and presentation at the European Congress 2016 in Glasgow.

First Profiling was done by the Car2Car Communication Consortium (C2C-CC). A first C2C-CC profile support a set of specific Vehicle to Vehicle (V2V) safety use cases from which only the information exchange and related communication aspects have been profiled. Infrastructural requirements or system aspects are not included.
To ensure overall interoperability and the exchange of goods and open transport in Europe a European profile supported by Hybrid Communication is required which support all stakeholders.

6.2 What to profile?

To ensure Interoperability and Conformity a set of relevant specifications must be commonly agreed, realized, checked by Compliance and ensured by certification for a final acceptance by all involved stakeholders. Therefore such a set of specifications needs to cover both functional and technical but also test specifications to satisfy the normal “V” model development process (Figure 27:), which ensures the seamless operation of functions among the stakeholders.

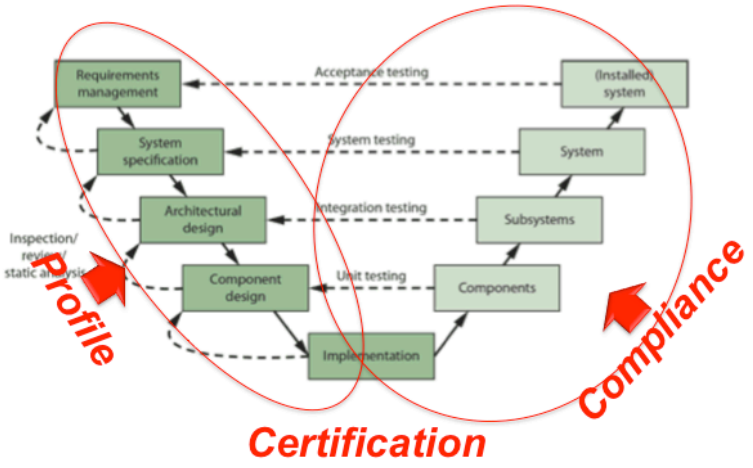

Figure 27: The “V” model process
source: CODECS, Profiling presentation Glasgow 2016

Within this model it can be recognized that besides profiling which focuses towards the functionality specifications that compliance focusing on the testing specifications is an additional aspect to cover.

In many cases interoperability is market specific and interfaces between the market players well easily defined within standards and managed by the related stakeholders from out of there role such as the network providers and technology providers in the Mobile market. There is a simple and clear roles

and responsibility model here with the result that the profiling is done at the right level at standardisation and for differentiation in the market by the operators.

In the case of the ITS there are many different stakeholder groups, systems and technologies. At the end of the day ITS stations need to be able to understand each other, they need to speak the same language, use the same words and construct known sentences while using the same Media. . Standards provide the bases for this; they are enabling and need to be open to allow future innovation. The ITS standards defined are as much as possible generic. To realize interoperable solutions they still need to be profiled and agreed commonly use case by all stakeholders.

Example: *In the CAM standard the sentence format and many possible information elements (words) are formulated but the sentences to be exchanged are not defined and how/when they are sent are not fixed.*

In general an ITS system consists of 2 or more ITS Stations (ITS-Ss). The interoperability End to End, from one application on on one station to another application on another station needs to be guarantied. To ensure that this is possible and knowing that information flows through all layers of the system all layers need to be checked for their Interoperability and Compliance. (Figure 28:).

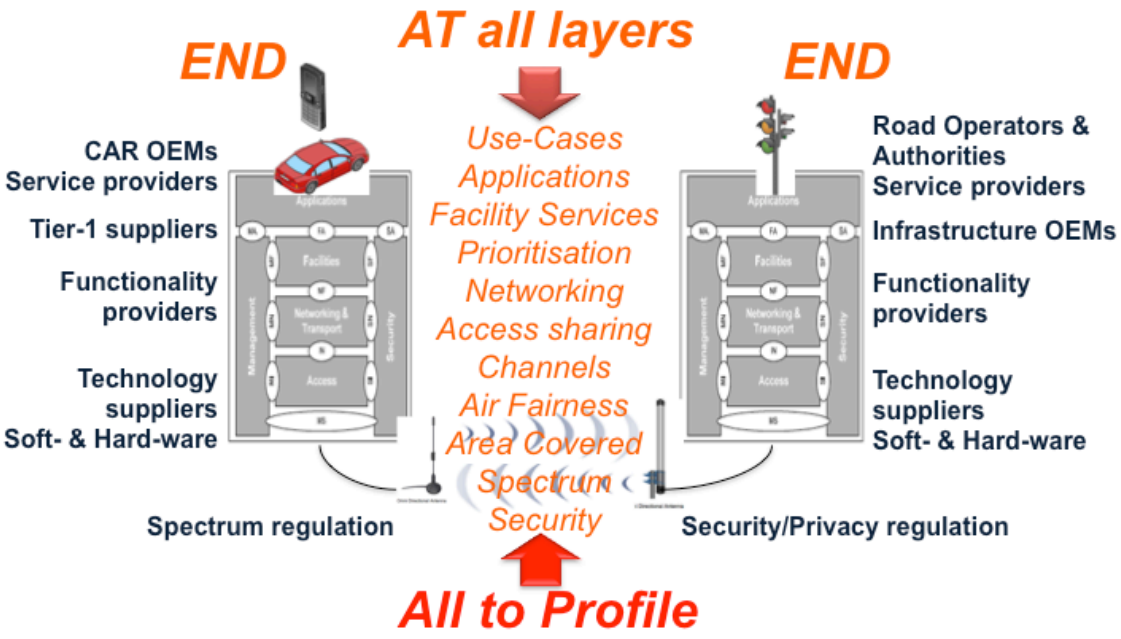

Figure 28: End2End Interoperability
source: CODECS, Profiling presentation Glasgow 2016

For none safety application in general this interoperability requirement is covered as it makes use of standard communication IP based communication protocols based on handshaking agreements and simple business models. ITS communication however is not based on this principle; it is based on making others aware without really knowing whether information is received. It must be seen as sensor network in which ITS stations share their information freely to allow others to improve their decision-making. Of cause this does not come for free. This sharing is provided in the expectation to also receive this information from others. For this reason for ITS safety related applications there is quite some more profiling to do.

6.3 Organize European profiling

For local and governmental road operators it is important to maintain Country specific profiles as every country have their specific infrastructure ICT, specific traffic safety, efficiency challenges and organizational structures. The development of country specific profiles to ensure interoperability at the country level is therefore essential to ensure interoperability at the country level. Based on these country specific and the market (Vehicle) profiles boarder crossing and market sharing should be realized by comparing and aligning of all the existing profiles by the realization and future growing European profile. To realize this there are 2 EU SEF project proposals, InterCor and C-Roads accepted by the European commission to commonly make a first step towards a European Profile. A first European profile realization will have to be followed by a process to maintain and extend European profile to realize improvement, extend the coverage and growth of services.

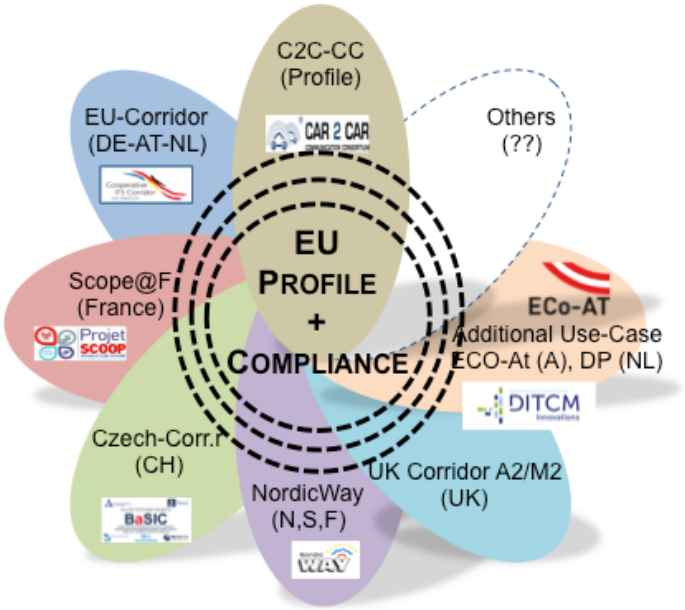

Figure 29: Going from Country specific profiles to a European interoperability (Profile)
Source: CODECS, Profiling presentation Glasgow 2016

7 Ensuring Dutch C-ITS Interoperability in the European Context

7.1 In general

To ensure European C-ITS interoperability from Dutch Solutions with other C-ITS initiatives in Europe, European alignment is proposed here as being recognized and agreed among the Dutch stakeholders at the DITCM A&I table.
At the European level this C-ITS interoperability until now has had an ITS-G5 focus. Which means only about the interface between road users (mainly cars) themselves (V2V) as well as between road users and the traffic management infrastructure (I2V and V2I). Only late 2015 hybrid Communication, making use of several communication protocols came in the picture but at Interoperability level are not yet discussed.
Besides this specific air interface from device to device and from device to infrastructure there is also in the infrastructure different actors such as authorities and service providers and telecom providers. For which no interoperability aspects are identified. When looking at the IVERA protocol for instance, for this interface there are several other protocols in Europe used (such as OCID in Germany).
For information exchange between traffic centres there is a drive to have a more common European approach based on DATEX II but for other interfaces this is the question.
Where and how to ensure the specific interoperability we would like to have for the Dutch situation and how far we would like harmonise at the European level could be identified by each organisation however as this is about cooperative oriented services a common approach for a number of use cases, information exchange protocols and even some technologies has been recognized.
3 areas of common and sharing aspects to align are:

- What do we want to align with European partners organisations and projects?
- Who are active in the European context with Standardisation, Interoperability and conformity?
- Where do we need further align aspects in Europe?

In the following paragraphs the feedback is incorporated.

7.2 The aspects to align within Europe

At the DITCM Architecture table the DITCM Architecture is aligned with Dutch authorities and business stakeholders explicitly in cooperation with the Spookfiles A58, Corridor, PPA and Beter-Benutten (BB) projects such as the iVRI project. The DITCM Architecture [[46]] identifies a number of interfaces to consider for alignment with European stakeholders.

The interoperable interfaces to consider are those where there is information exchange between different stakeholders. For business reasons (commonality to encourage open market) it could also be desired to realize common European specifications for other interfaces being recognized as internal (seen as internal interface for a specific stakeholders), such as DATEX II. Additionally there are some general aspects which require interoperability. These are aspects such as a common approach on roles and responsibilities (especially between different authorities and operational responsible identities related to infrastructure).

This report provides an overview of those protocols and other specifications currently recognized as of relevance and; there status in relation with European developments as far as this could be provided within the scoop of this report.

The detailed DITCM architecture [46] physical view shows the different physical components and interfaces as presented in Figure 30. The physical view uses four layers (marked with different colours). Although for the top two layers it may be seen as the same, in general each of the layers represents a specific group of stakeholders. Especially the interfaces active between the different layers includes protocols for which a technology change and/or interoperability may be desired.

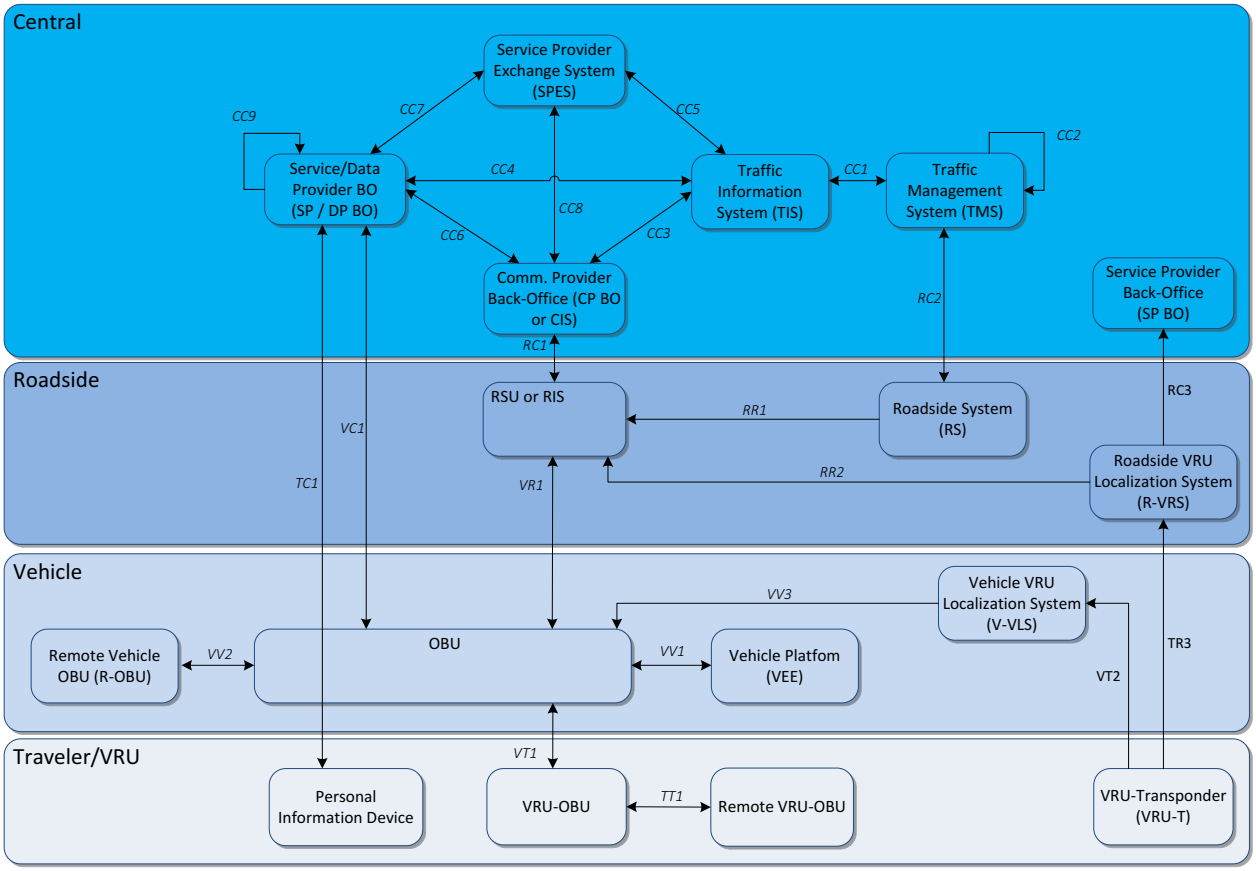

Figure 30: The DITCM physical architecture

The main interfaces to consider are:

- C2U = the Central to the road user direct (Vehicle and Traveller/VRU (TC1 and VC1);
- R2U = the Roadside to the road user safety related (VR1, VR2 (not shown, RIS to VRU-OBU or PID) and VT)
- C2R = the Central to Roadside (RC1, RC2 and RC3)
- V2U = the Vehicle to other road users (VT1 and VR2)

As at the Central level there are many roles with both authorities and business stakeholders active additionally the following interfaces need to be considered:

- All CC interfaces (CC1-CC9)

From an Authority perspective to encourage an open market it could be of interest to also normalize:

- RR1 and RR2

A common approach for the R2U and V2U have been recognized already quite some time ago and interoperability is actively being established for an first set of use cases via the ITS-G5 protocols also part of the current Dutch Profile. For other interfaces interoperability aspects have been partly recognized and on specifications for these interfaces there is active work going on in the projects but interoperability is not yet covered nor agreed. New use cases such as traffic prioritization require additional considerations.

- For Central to the road user (C2C) direct interoperability is important as all Car-OEM's and Mobile market suppliers should be able to work with the same protocols. (here the information exchange via the RSU is not considered) There are some options:
  - TPEG via Cellular or DAB+ broadcasting is currently extended to support additional features such as currently embedded in DENM, SPaT/MAP.
  - Optional communication could be based on DATEX II via Cellular of DAB+ (work on this is currently done by the French)

    - Also the standard messages such as DENM and SPaT/MAP could be distributed via Cellular or DAB+. Most considerable would be to do MAP via cellular and do SPaT via short-range ITS-G5 communication. Especially when the MAP message size is large.
- For Roadside to Road user (R2U) there are some aspects to consider.
    - For safety related short-range information exchange for the Day-1 C-ITS use cases as defined by the European commission, The EU commission identified that the information exchange will be based on ITS-G5 and therefore based on message set's such as CAM, DENM, SPAT/MAP, IVI.
    - For beyond Day-1 C-ITS use cases other communication such as LTE-V2V, 5G or others may be considered.
    - For Periodization there exists different kind of country specific protocols. In the Netherlands there is the KAR protocol. For interoperability reasons this installed base does not need to be replaced however die to spectrum regulatory changed the operation of current protocols are expected not correctly to operate from about 2020 onwards as others will use the same spectrum and interference can be expected. Current SPaT specification includes a number of prioritization capabilities and it is advised to look at SPaT as the next protocol to replace KAR. Using the same technology and same system as for safety related would reduce costs. Interoperability has not yet been discussed.
- For Central to Roadside (C2R) current protocols are.
    - Via the RC1 interface the road safety related messages such as CAM, DENM and Probe Vehicle Data are exchanged.
    - Via the RC2 interface the road safety DENM and IVERA (Green Time, VLOG, iVRI) can be expected in the Netherlands. This is different from other countries where for instance OCID, (Germany) and form of DATEX (France) are used. Currently this interface is country specific and not yet considered for European alignment.
- For Vehicle to other road users (V2U) it is a business-to-business interface. Interoperability should in the first place be of interested to the related stakeholders. However with regards to social impact there could be of importance to have authority influence in terms of legislation. So far this has not been considered. With regards to Interoperability the following can be considered.
    - To use information exchange (CAM and DEN) via short-range ITS-G5 communication as currently being used for some VRU applications and location improvement. For instance it could be considered to integrate this into electrical bicycles and rental bikes as in both there is already some electronics.
    - The VRUITS project also shows addition VRU use cases may be realized by making use if Cellular technologies. Perceptional aspects however are for many VRU use cases an issue and especially with none specific OBU's not easy to be realized (also valid for VR2).
- At the Central level there has been alignment on some traffic management information exchange which generally goes by the Internet. For the 9 internal interfaces identified the following aspects can be mentioned.
    - Information exchange via DATEX II is uses more and more at different interface levels but specifically at the CC1, CC4 interfaces.
    - Information exchange via DVM-Exchange is used at the CC2 interface. In other countries there is a similar approach. Question is whether to harmonize and come to a European common interface specification. This would benefit mostly the service providers.
    - Information gathering such as Probe Vehicle data is used at the CC3 and CC6 interfaces
    - Standard and tailored Internet Publish/Search/Subscribe mechanisms are used at the CC5, CC7 and CC8 interfaces. Tailored for instance by the Converge or MOBiNET projects (see project documents).
    - For the CC9 interface there is none specific reference.

- In the Roadside layer we find the RR1 internal interface for which initially the IVERA interface for Green time is used. In Germany they are using OCIT and Austria (Eco-AT) a specific interface. As this is internal each country can realize its own interface specification however as technology is changing now it could be considered to discuss European commonality. This is not yet discussed at the table. For RR2 there is only a specific implementation, none standardized by the VRUITS project.

Interoperability focus is in most cases at the information exchange layer, the so called Facility layer (OSI model). In most cases the communication protocols below the message is generically and common and therefore do not need to be specified for a specific purpose. In some cases however, in case a protocol stack is specific for a specific purpose other layers need to be considered to ensure interoperability.

At this moment this is needed for the short-range ITS-G5 communication stack as a predictable behaviour needs to be ensured. Therefore additionally key ITS-G5 lower layer standards need to be profiled and commonly be agreed, this is realized by profiling. For the Netherlands there is the Dutch Profile taking care of this, however this has been mostly functional oriented by which some specific technical aspects related to radio performance by roadside units have been not yet aligned with the Vehicle industry. Which needs to be realized before further deployment in the Netherlands. This however is also not yet covered in other countries and therefore expected to be realized within the C-Roads and InterCor projects.

Other aspects are to agree common European wide security and privacy legislation, policies and standards with roles and responsibilities as a part of that. Currently main effort in creating legislation and policy proposals is realized at the European Commission ITS-Platform working group 5 (WG5). Especially at the C2C-CC, in the France Scoop@F and the Austrian ACo-AT projects implementations are realized. ETSI TC ITS WG5 produced a number of security standards and based on the agreements made at the ITS-platform currently improvements are made. The roles and responsibilities are specified in the ISO standard TS 17427.

Interoperability is ensured by Compliance and Interoperability testing and test specifications. They are in integral important part to ensure interoperability. Currently there are six levels/activities where this takes place:

- European Commission ITS-Platform
- C-Roads
- InterCor
- Car2Car Communication Consortium
- In the individual projects
- ETSI plug-tests

Currently none of the Dutch Stakeholders have been at the ETSI plug-tests and mostly only operate in the individual projects. Question is how this needs to be further developed.

7.3 C-ITS involvement in Europe.

The involvement of Dutch stakeholders depends on the organisational and business strategies. Companies such as Dynniq, Siemens and Swarco have a European view while authorities generally have local objectives. All partners to think about and to come with propose during the Workshop.
This paragraph provides a snapshot of the involvement of Dutch parties based on the provided feedback during the existence of the DITCM tables.

An initial overview of the international connections from out of the perspective of the Dutch Ministry I&M, RWs, RDW was created in the first half of 2016 based on internal and external, industry and knowledge institutes interviews. It provides an overview of the ITS (**Figure 31**), C-ITS (**Figure 32**) and Automation (**Figure 33**) connections in a European-National context. The purpose was to provide an overview of the different forums and platforms and to come to an effective matching between Dutch authorities and the different forums. At this moment the matching has not yet been presented to the DITCM partners.

Individually DITCM partners are also participating in different forums and standardisation bodies. Here we provide an overview of those known to the Architecture and Interoperability table writing team and provided by the partners. The contributions here presented are towards forums and standardisation. The participation in European oriented project is not included.

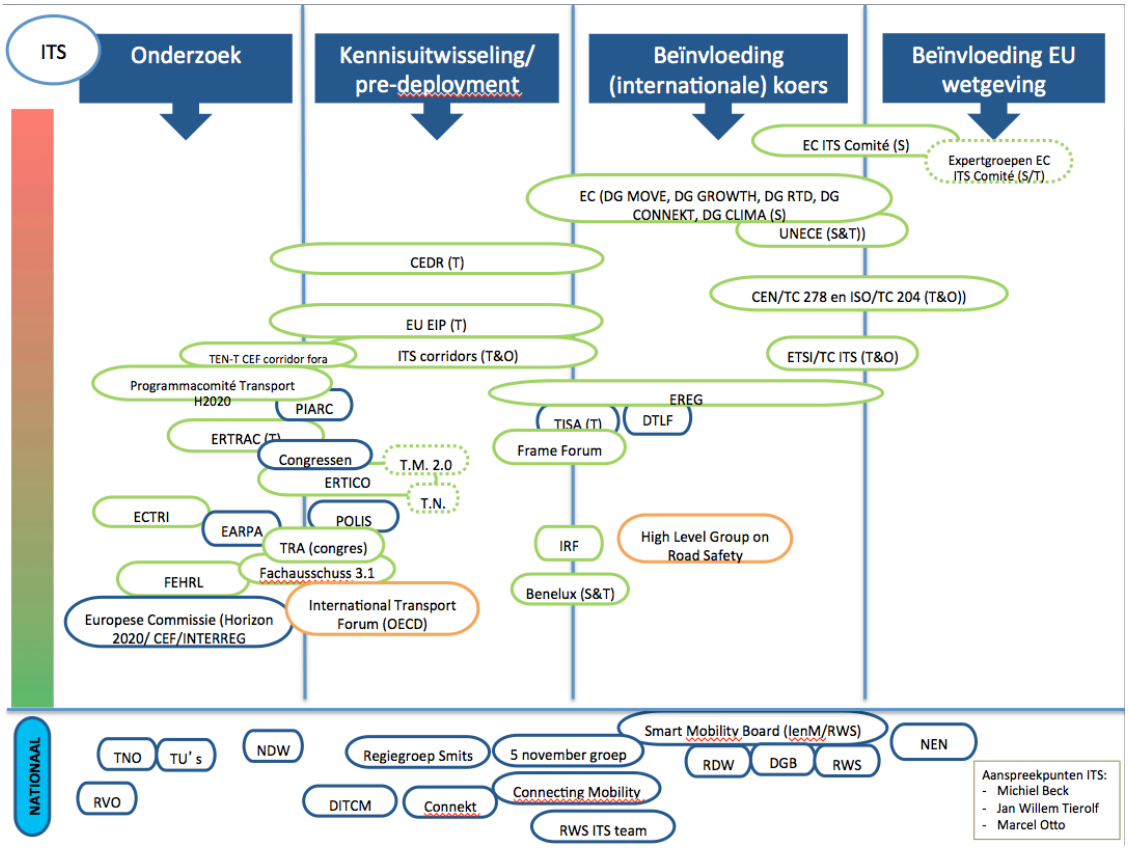

Figure 31: The European ITS landscape

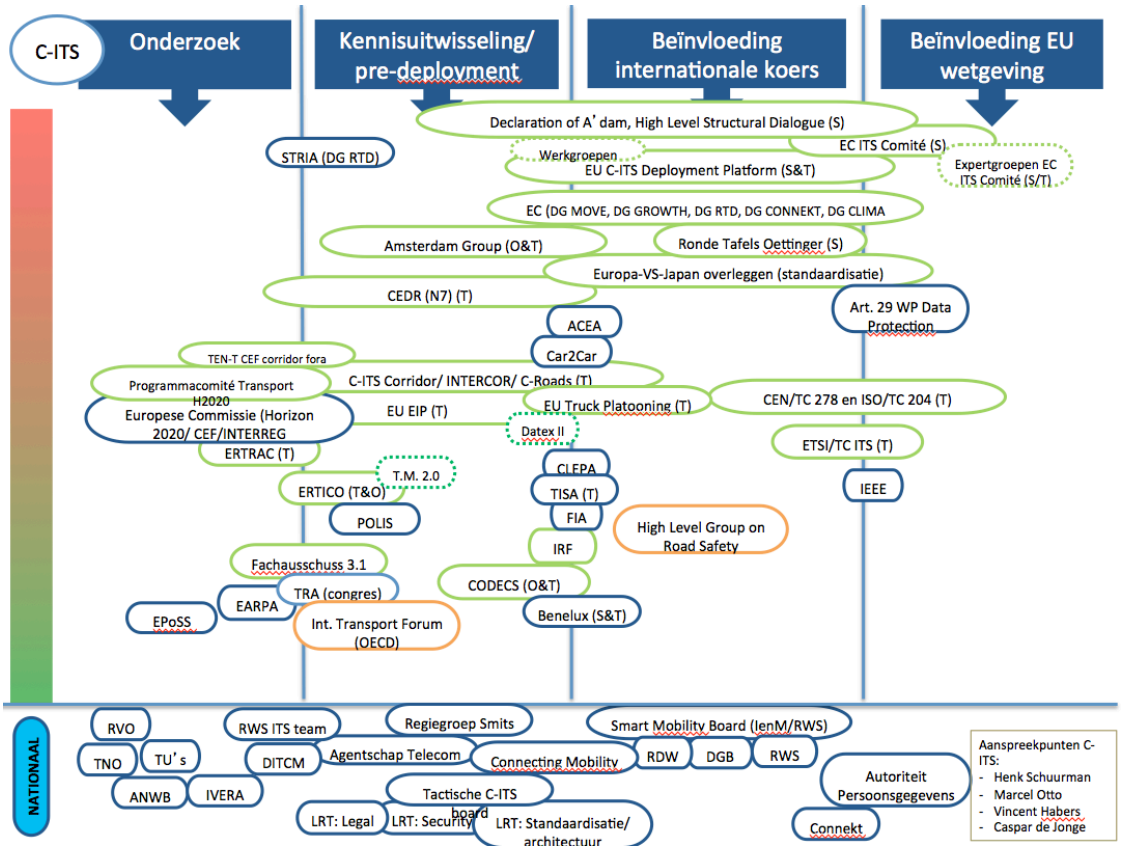

Figure 32: The European C-ITS landscape

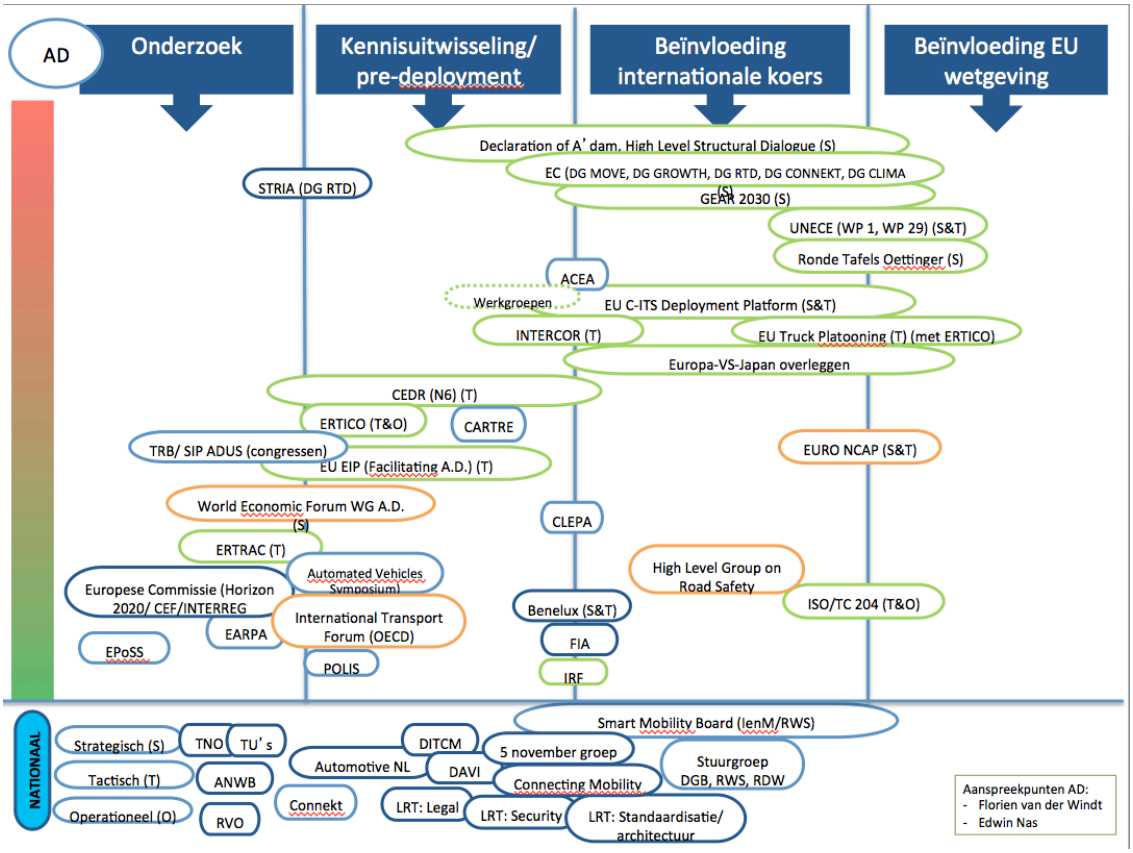

Figure 33: The European Automation landscape

7.3.1 Standardisation

With regards to participation in standardisation mostly C-ITS aspects are covered. That what is known by the DITCM Architecture and Interoperability table writing team and provided by DITCM partners is provided here.

- ETSI TC ITS
  Focus of ETSI TC ITS is short-range oriented services via ITS-G5 based on IEEE 802.11p and extensions.
  - RWS — for security in WG5 supported by Gilles Ampt.
  - TNO — for physical and network layer
  - TASS — for interoperability / test specifications / PlugTests
  - NXP (Qualcomm) — for physical layer in WG4.
  - Siemens (Vienna) — for all WG's, especial responsibility to MAP/SPAT testing and facility protocol aspects.
  - Dynniq — for test specifications
  - PaulsConsultancy — vice chair of applications, WG1 and architecture WG2, and specific responsibilities on Position and Time, MCO + Hybrid (Multi Channel Operation), VRU and CPM (Collective Perception Message).
- ETSI ERM
  - NXP (Qualcomm) — for physical layer aspects.
  - PaulsConsultancy — for physical layer aspects.
- ETSI BRAN
  - NXP (Qualcomm) — for physical layer aspects.
  - PaulsConsultancy — for WLAN aspects.
- IEEE 802.11
  - TNO — for algorithm and physical aspects
- 3GPP
  - KPN — functional facility oriented but also technical activities.
  - Ericsson — mainly technically oriented but also participate in functional activities
  - TNO — Coordinator of the application workgroup
- TISA
  The TISA standards are formally ISO standards but TISA is a separate organisation.
  - RWS — DATEX II
  - TomTom — TMC, TPEG
  - BE-Mobile — TPEGM (C-ITS related)
  - TNO — TMC, TPEG
- SAE
  Specific aspects for European use have been harmonized with SAE and not specified in specific EU oriented standards.
  - Siemens (Vienna) — SPAT/MAP
  - Swarco (Germany) — SPAT/MAP
  - PaulsConsultancy — SPAT/MAP, VRU and general SAE-ETSI functional harmonisation.
- CEN-ISO
  - CEN278 WG17 (Urban ITS)
    - MAPtm — active member
    - PaulsConsultancy — active member
  - CEN278 WG18, ISO204 WG16 (ITS)
    - Siemens (Vienna) — active member
    - Swarco (Germany) — active member
    - PaulsConsultancy — active member
  - ISO WG16 (CALM)

- PaulsConsultancy passive member

- EVERA (Dutch) [68]
  - Siemens active member
  - Swarco active member
  - Dynniq active member
  - Vialis active member
- DVM-Exchange (Dutch) [68]
  Essential partners active in ITS are:
  - RWS active member
  - Gemeente Amsterdam active member
  - Beter Bereikbaar ZB active member
  - Province NH active member
  - Vialis active member
  - Siemens active member
  - Swarco active member
  - Dynniq active member
  - CGI active member
  - Technolution active member
- KAR (Bison, Dutch)
  Kar is specific for Public Transport (mainly traffic periodization). Most Dutch related authorities, operators, private companies and traveling organisations are member. C-ITS active members are:
  - RWS active member
  - Siemens active member
  - Swarco active member
  - Dynniq active member
  - Vialis active member
  - CGI active member
  - Technolution active member

7.3.2 Forums and Platforms

- European Commission ITS-platform phase 2
  - RWS WG1-WG8
  - Province NH WG7, PT and Urban Areas
  - Gemeente Helmond WG7, PT and Urban Areas
  - TASS WG2, Compliance Assessment
  - Gilles Ampt WG1, Security
  - Dynniq WG4, Physical/Digital Infrastructure; WG5, Enhanced Traffic Management; WG7, PT and Urban Areas
  - TNO WG4, Physical/Digital Infrastructure; WG7, PT and Urban Areas;
    WG8 Horizontal
  - MAPtm WG4, Physical/Digital Infrastructure
  - PaulsConsultancy WG4, Physical/Digital Infrastructure; WG6, Automation Road Safety; WG7, PT and Urban Areas; WG8 Horizontal
- Amsterdam Group
  - RWS member and Co-Organizer from out of CEDER
  - PaulsConsultancy member, rapporteur standardisation
- ERTICO TM2.0
  - RWS active member
  - Gemeente Helmond active member
  - Vialis active member
  - Dynnic active member

    - Technolution active member
    - Swarco (Germany) active member
    - TomTom active member
    - TNO active member
- European Commission coordination action CODECS
    - RWS Work package (WP4) responsible
    - PaulsConsultancy Project member WP2, WP3 and WP4
- European Commission interoperability project C-Roads
    - RWS active member
- European Commission interoperability project InterCor
    - RWS Coordinator
    - TNO WG2 leader and Hybrid Communication (HC)
    - Gillis Ampt Security and Privacy
    - TASS Compliance and HC
    - MAPtm Use Cases
    - InnoMo (original PaulsConsultancy) International Connection and HC

7.4 Dutch alignment with European initiatives

For many subjects and interfaces stakeholders find each other to accomplice common objectives, there is nothing new to that. Generally this takes place as soon as a common objective is recognized and therefore no additional initiatives are requires as it is a common practice. In case of multi stakeholder relevant objectives in many cases it is enough when one of the stakeholder groups takes the lead and all other follows. In case of Cooperative Systems many of the problems are already encapsulated in the word Cooperative itself.
In case Cooperation is the bases of success the profit and therefore the business model is commonly not easy, something which makes is a difficult argument to invest by any organization especially as there are multi stakeholder group investment dependencies. The amount of different stakeholder groups all to invest in the same time in ITS makes is multiple. At an initial stage, more then a decade ago, the Car Industry had seen an opportunity to do only a set of specific safety related use cases among themselves but with the possibility of integration of Infrastructure based services supplied by the authorities. Now authorities and others see many ITS use cases and especially after working on C-ITS for more then a decade the car industry has recognized autonomous driving as another appealing feature. All of this leading to more and more different stakeholders interested in the area of ITS and Automation. The question is how to manage Interoperability in this playing field.

There are many stakeholder groups but also many technologies involved. Specific solution/technology/ interface interested stakeholder groups create and will stay creating specifications and standards such as those presented in this document. As indicated in Chapter 6 agreeing these specifications and standards does not guaranty interoperability. Additional common profiling is required. Due to different regional interests and investments different profiling for Europe an 2 level alignment has been advised. These levels are presented in Chapter 6, one at the country level and one at the European level. In the Netherlands this has been realized as an alignment platform, the DITCM Architecture and Interoperability Table so that all Dutch individual initiatives could be align. Other countries, for instance the Austrians and the French realized the Eco-AT and the Scoop@F projects. At the European level, the European Commission initiated the EC projects C-ROADS and InterCor to see to realize Interoperability. Within this context the alignment of what is made interoperable for what use cases are supported is essential.

Within the Dutch context at the DITCM Architecture and Interoperability table is clearly agreed what roadmap is used for this interoperability and that the day-1 use cases realized on the VR1 interface

(See Figure 30). The Interoperability on the VR1 interface is also a major aspect for C-Roads and InterCor.
However the Day-1, Basic safety related and RWW are covered. There are still issues open and for discussion especially for those things where infrastructure related aspects need to be including. These aspects will also have effect on standards, leading to updated ones and some new.
Although activities for this are in progress and will be reflected in the Dutch profile specific contributions from infrastructure for these technical and from the authority side contributions related to roles of responsibilities, security and privacy will be needed.
For this short-range, ITS-G5 communication specific VR1 interface there are DITCM processes but a check whether all and who from the Dutch stakeholders will ensure Dutch interoperability at EC level and Dutch consolidation in 2017 will be needed.
Although Initiatives have been taken to look what interoperability activities would be needed and of interest for the other interfaces have been recognized. No specific actions could be taken but are a subject for the further development of interoperability on also other ITS interfaces as identified in Chapter 7.2.
Further discussion expected in 2017.

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Annex B Spectrum Organized

For Spectrum issues the EU commission can rely on the ECC for advice. Such as can be seen in **Error! Reference source not found.**. In case of C-IT'S a mandate went from the commission to CEPT to study sharing possibilities between RLAN and ITS which resulted into an update of the recommendation. The commission DG Connect RSCOM (Unit B4) turned this into an improvement of the decision.
To ensure that what is needed by the active stakeholders like OEMs, Authorities and Infrastructure suppliers, these stakeholders have to help the process by influencing the CEPT by participation and contribution the CEPTS working groups while in parallel support DG Move by providing the right ITS requirements and needs as arguments for DG Move to align with DG Connect. Of cause instead or additionally stakeholders can bring argumentation to DG Connect themselves.

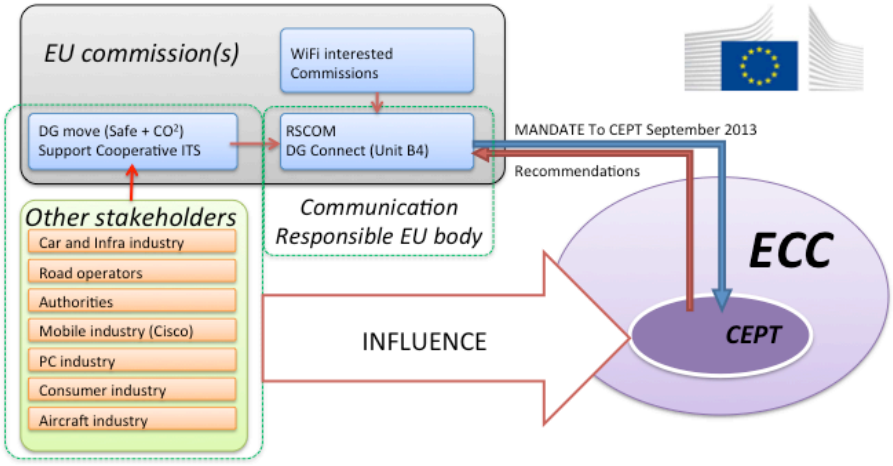

FIGURE 34: THE SPECTRUM DECISION PROCESS

As none European services (CAR's Mobiles, Laptops etc.) may operate in the same radio frequency spectrum as European ITS services alignment with other regions are a necessity.

From a European perspective there are 2 main regionally related processes of importance, the legislation of ITS radio frequency spectrum in the USA and the World overall ITU legislation process at the World Radio Conferences where spectrum is aligned at the overall world level. Beside this the alignment with the USA is important, as from the start alignment with the USA have been taking place with the result that they are using the same spectrum with the same technology but with in some way harmonized but with to some extent differentiating protocols. The alignment with the USA is here not further specified as this takes care of by the bilateral cooperation's within the industry, between countries and between the European commission DG move and American DOT. Direct influence is not required at this time.

7.4.1 DG Connect

As DG Connects objectives are mostly directed towards a single market requiring information exchange, standardisation and communication are of main importance. At the moment of writing this report there are 2 main topics:

1. ITS spectrum in the 5.9 GHz band
2. Overall spectrum strategy.

With regards to the first, sharing the spectrum is now initially regulated with priority to ITS but no agreed sharing mechanism for other services are included yet. Further development of that is on going and from the ITS side mostly contributed by the C2C-CC members including NXP and

PaulsConsultancy. Additional effort is not required at the moment however involvement from "Agentschap Telecom" is of importance to ensure benefit for NL and its stakeholders.

With regards to the second, there is pressure from the mobile industry to allocate as much as possible radio frequency spectrum for mobile services also when this will limit others.
Although the technology is not a discussion at the spectral specification level and radio frequency spectrum allocation is done technology agnostic, the mobile industry claims that 30MHz is for ITS-G5 and that they need the rest however this can't be legislated. Further more the decision what technology to use is up to the product or service provider who will decide based on function and costs. The ITS stakeholders are very much interested in any technology with attractive business model so also one from the mobile and service providers.
As the influence of the mobile market is quite large, although business models so far were not successful for ITS services (several attempt have not led to business) they may get the favour when the ITS stakeholders don't act. We can't leave DG MOVE alone in this matter. DG MOVE needs to be helped and stakeholders themselves have to address the issues at DG CONNECT.
A spectrum study is on the way to identify the real traffic safety and efficiency service needs. As indications show that also safety related services, such as urban-rail needs to be supported (20 MHz needed), we may even at forehand assume that all 70 MHz ITS spectrum should get the designated status (now 70MHz allocated and 30MHz designated). This is not a big step as 70 MHz was already allocated and therefor recognized for ITS. To realize support from stakeholders is needed. Additional mobile ITS services could be imagined in the 6GHz band (discussion is on going to reorganize the fixed links here). From this all ITS services could benefit in future.

7.4.2 Conférence Européenne des Postes et des Télécommunications (CEPT) [28] (additional source HIGHTS D7.1)

The CEPT is an organisation where policy makers and regulators from 48 countries across Europe collaborate to harmonise telecommunication, radio spectrum and postal regulations to improve efficiency and co-ordination for the benefit of European society. CEPT is a voluntary association of European countries. The CEPT conducts its work through three autonomous business committees:

- ECC: European Communication Office
- Com-ITU: Committee for the ITU policy
- CERP: European Committee for Postal Regulation

The chairs of these committees form the organisation's Presidency, supported by the European Central Office (ECO). The overall structure of the CEPT is given in **Error! Reference source not found.**.

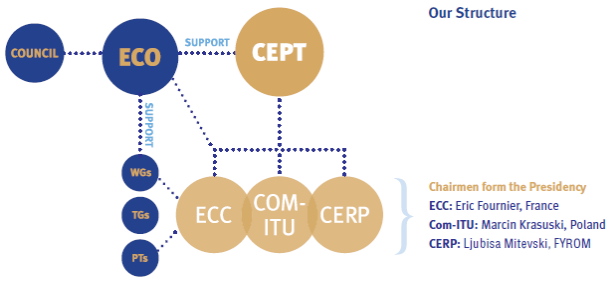

FIGURE 35: OVERVIEW OF CEPT ORGANIZATION INCLUDING ECC AND ECO

7.4.3 Electronic Communications Committee (ECC) [28] (for details HIGHTS D7.1)

In one of the three business committees of the CEPT the Electronic Communications Committee (ECC), the 48 member countries develop common policies and regulations in electronic communications and related applications for Europe, and provide the focal point for information on spectrum use. Its primary objective is to harmonise the efficient use of the radio spectrum, satellite orbits and numbering resources across Europe. It takes an active role at the international level,

preparing common European proposals to represent European interests in the ITU and other international organisations. The ECC's focus is on regulatory aspects. The main working groups relevant for ITS are the WG FM and WG SE. Working Group FM is responsible for the development of ECC decisions and recommendations and the final delivery of CEPT reports to the commission.
Working group SE is responsible for carrying out the technical studies.
SE 24 is the subgroups relevant for the Short Range Device spectrum allocation and regulation. Concerning ITS, SE24 is studying the sharing possibilities to respond to the EU 5 GHz European Commission Mandate (2013) to CEPT/ECC on spectrum sharing in the 5 GHz band, (RSCOM13-32rev3). This resulted in 2 steps. Step 1 is reached and Report A came available March 2015 in which ITS is protected. Report B is expected mid 2016. For this CEPT SE24 asked ETSI BRAN, TC ITS and TC ERM to come with an recommendation. Current discussions at ETSI are ongoing. Additionally the ECC opened the floor in the 5 GHz Mandate to study the possible sharing with LTE-U beside WLAN. Require lots of effort from transportation stakeholders in coming year(s). From NL het Agentschap Telecom is involved.

7.4.4 ITU-R, World Radio Conference (WRC) 2019 [1]

At the World Radio Conferences worldwide spectrum and radio related agreements are realized under United Nations treaties. For the European and therefore for the Dutch deployment of ITS use cases, realization of services and systems the WRC 2019 meeting is of especial importance as ITS required spectrum and coexistence with other spectrum users is on the agenda for discussion. A clear agreed approach in the Netherlands expressed in the European preparation and the WRC 2019 participation is therefore essential.
The WRCs take place under the responsibility of the International Telecommunication Union (ITU). The results of the WRC are captured in the "Final Acts" which form an extension of the ITU radio treaty. Agreements to be made at the WRC 2019 meeting are of influence to the deployment of ITS services and their coexistence with other services.
The "Agentschap Telecom" [2] represents the Dutch spectrum and radio interests. Dutch interest and standpoint are formulated in the document "dynamisch-document-nvc-2015" [3] (draft at this time).
Contribution to the Dutch discussion can be realized through direct participation in the Dutch discussions See reference.

Annex C Indirect important Standard Organisations

IEEE

7.4.5 IEEE P1609 (part source: HIGHTS D7.1)

IEEE 1609 is a suite of standards for Wireless Access in Vehicular Environments (WAVE) developed in the IEEE Vehicular Technology Society (VTS). They define architecture and a complementary standardised set of services and interfaces that collectively enable secure vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications.
The family of standards includes the following documents:

- IEEE 1609.0: IEEE Guide for Wireless Access in Vehicular Environments (WAVE)--Architecture
- IEEE 1609.2: IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages. An OER encoding is used and the last version includes several new features.
- IEEE 1609.3: IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services. Major update to the WAVE Short Message Protocol and significant update to the WAVE Service Advertisement was established including adoption of Ether Type Protocol Discrimination (EPD).
- IEEE 1609.4: IEEE Standard for Wireless Access in Vehicular Environments (WAVE)--Multi-channel Operation.
- IEEE 1609.11: IEEE Standard for Wireless Access in Vehicular Environments (WAVE)-- Over-the-Air Electronic Payment Data Exchange Protocol for Intelligent Transportation Systems (ITS).
- IEEE 1609.12: IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – PSID Identifier Allocations. In the last version a few additional PSID's have been added, e.g. WAVE security, CAM, DENM, Vulnerable Road User (VRU), Misbehaviour Report, Certificate Revocation List. The development of a formalized procedure for requesting PSIDs is in development. The IEEE Registration Authority Committee (RAC) has now published the allocation list currently not including all EU required PSID's.

SAE

SAE is of importance in the USA. They are the SDO to establish the higher layer protocol standards such as message service standards, minimum set of requirements etc. Direct alignment on related definitions at ETSI TC ITS and CEN TC278-WG16 / ISO TC204-WG18 to harmonise the standards is in place. Monitoring their activities is relevant to make sure that developments in Europe are not blocked by their efforts. For instants alignment for vulnerable road user standards do need attention and cooperation. Their related ITS standards are J2735 and J2945.

J2735 (source HIGHTS D7.1)

Dedicated Short Range Communications (DSRC) Message Set Dictionary.
Defines Basic Safety Message (BSM, USA equivalent to ETSI CAM) as well as others such as warning message such MSG_EmergencyVEhicleAlert (EVA).MSG_ProbeDataManagement (PDM) and infrastructure messages similar to MAP/SPAT. It defines a Data Element for position accuracy by means of an error ellipse with major/minor axis between 0.5 and 12.5 meters, and orientation between 0 and 359.99 degrees, related to one standard-deviation. This PosAcc is included in the BSM message. And in ProbeVehicelData. The MAP message (that describes road/lane geometry), does not use PosAcc. It also defines a MAYDAY_Location_quality_code element that states 'A value

representing the goodness of the position estimate (accuracy). The element is used to convey the relative quality of a GPS generated location'. The BSM encoding used UPER and has undertaken a minor reconstruction compared to the earlier version. It now also include a first version of the Personal Safety Message (PSM) to be used by Vulnerable Road User (VRU) applications.

J2945

The J2945 is a collection of standards:

- The J2945/1 covers the On-Board System Requirements for V2V safety communication
- The J2945/2 covers the DSRC Requirements for V2V Safety Awareness for other Vehicles then car's.
- The J2945/6 covers the Performance Requirements for Cooperative Adaptive Cruise Control and Platooning.
- The J2945/9 covers the Performance Requirements for Safety Communications to Vulnerable Road Users.

Industry standards

Dynamic Location Referencing, OpenLR™ [57]

TomTom launched OpenLR™ as royalty-free technology and open Industry Standard, and it invites the ITS Industry to join and adopt it.
OpenLR™ is an open source software project launched by TomTom International B.V. in September 2009. This provides dynamic location referencing method, which enables reliable data exchange and cross-referencing using digital maps of different vendors and versions.

SENSORIS (HERE) [29]

This is HERE's proposed industry standard for shared car data. Vehicle sensor data exists in many different formats across automakers internally in the Vehicle. Efficient creation of autonomous vehicle applications will require a common approach to how vehicle sensor data is gathered by connected cars and sent to the cloud for processing and analysis. To that end, HERE published the first open specification and initiated SENSORIS in June 2015 (**Error! Reference source not found.**). This is a development supported by ERTICO and envisioned to be standardized however when looking at the current specifications many elements are already provided by existing standards such as Cooperative Awareness Message (CAM) EN 302 637-2) and Decentralized Environmental Notification (DENM) EN 302 637-3. Further investigation however is of interest.

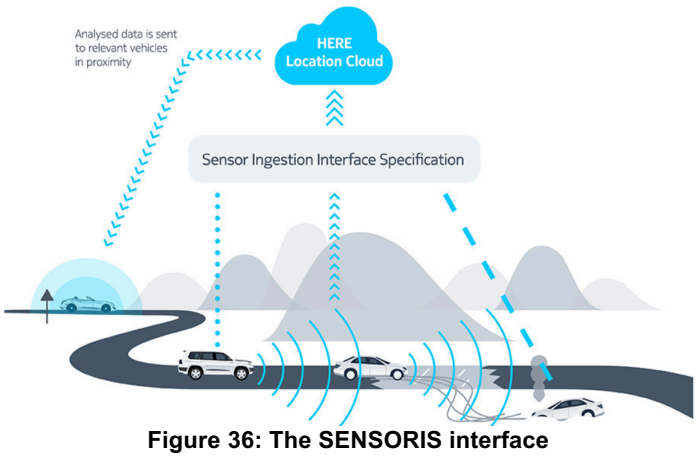

Figure 36: The SENSORIS interface

GENIVI [42]

GENIVI® is a nonprofit industry alliance committed to driving the broad adoption of specified, open source, In-Vehicle Infotainment (IVI) software. The alliance develops an open standard for aligning automotive and consumer infotainment cycles.

MirrorLink [43]

The MirrorLink is a standards developed by the Car Connectivity Consortium. It is deployed in many car head units, cellular phones and Car aftermarket audio systems. A large number of car OEMs supports it in various classes of cars. This industry standard is accepted by ETSI to be formally standardized at ETSITC ITS (See for the concept **Error! Reference source not found.**). There are some similar developments such as from Google with GoogleCar.

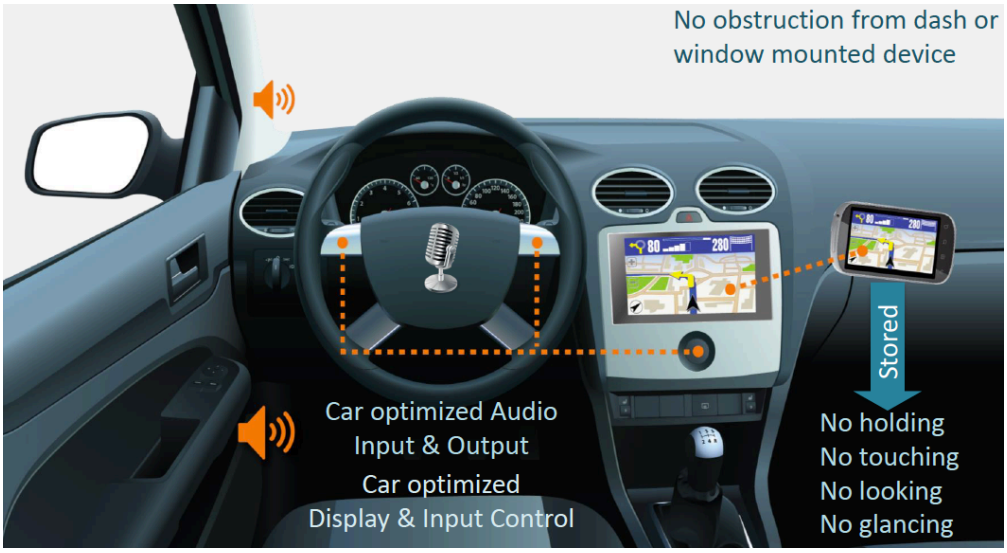

Figure 37: MirrorLink Concept

Annex D Other European projects

Introductions

Here only a few other projects are presented. This must be seen as general information. Beside these projects there are many other project which could be of interest to specific future use cases.

NordicWay (DK, F, S and N)

NordicWay [44] puts emphasis on building a sustainable business model on the large investment of the public sector on the priority services of the ITS Directive. NordicWay is fully based on European standards and will act as the last mile between C-ITS research and development and wide-scale deployment.

Within the Nordic countries basically all communication is wireless through cellular networks and therefore thier communication infrastructure includes this automatically. Related functional capabilities therefore can be limiting. For none safety related this is no issue but for safety this may be the case.

Within this project the focus is to see how to deploy none safety and as much as possible safety C-ITS use cases by means of cellular (3G and 4G) technology. There are 3 common services:

- Hazardous location warning
- Cooperative weather warning
- Probe vehicle data

Additional national services vary, including:

- In-vehicle signage
- Cooperative traffic management
- Road works warning

Within this project 2000 vehicles will be equipped.

Figure 38: In NordicWay Slippery road and Block roads are seen as important use cases.

The UK Connected Vehicle Corridor A2/M2

The UK Connected Vehicle Corridor looks into a high level of integration, it is dedicated to integrate traffic and travel data and information service for the Corridor to enable cooperative development between national, regional and local road providers. It will include physical links to TEN-T ports of Dover and Calais. Potentially multi-modal transport approach by linking road users to sea, international rail (High Speed 1 at Ebbsfleet International) and regional coach services will be investigated. Additionally the potential to help manage freight movement (the Corridor connects the third largest container port at Thamesport with the cross-Channel port at Dover) will be investigated. The total program will be supported by a 100 million Pounds budget. **Error! Reference source not found.** gives an overview of the trajectories.

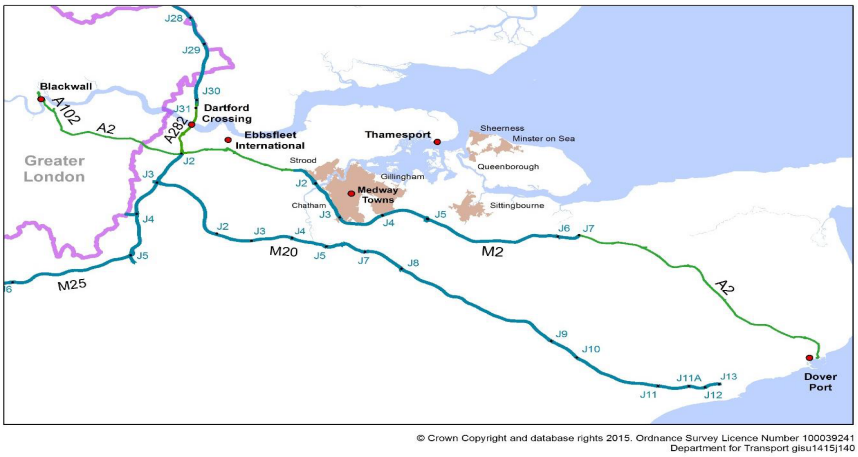

Figure 39: Equipped Highways in UK

C-ITS Pilot in Hungary (source CODECS)

One of the main drivers to foster C-ITS deployment in Hungary was the involvement in the European CROCODILE project. The project objectives were to improve the quality and availability of traffic data, to secure exchange of this data with neighbouring countries in DATEX II format, to improve road safety, i.e. in work zones, and to provide quality traffic information services to the drivers.

In line with the above mentioned objectives, the Hungarian Public Road Management Company has selected part of its network for C-ITS services deployment. The 136km-long stretch of the M1 motorway (**Error! Reference source not found.**) between Austria and Budapest has been equipped with 27 fixed- and 20 mobile RSUs towards the end of 2015. The fixed units were mounted on VMS gantries and SOS stations, whereas the mobile devices were put in maintenance vehicles as well as mobile trailers. The communication between RSUs and OBUs is thus far based solely on ITS G5. The following use cases have been implemented within the Hungarian C-ITS pilot so far:

- Traffic jam ahead warning
- Hazardous location notification
- Road works warning
- Weather conditions
- In-vehicle signage (trailers equipped with VMS)

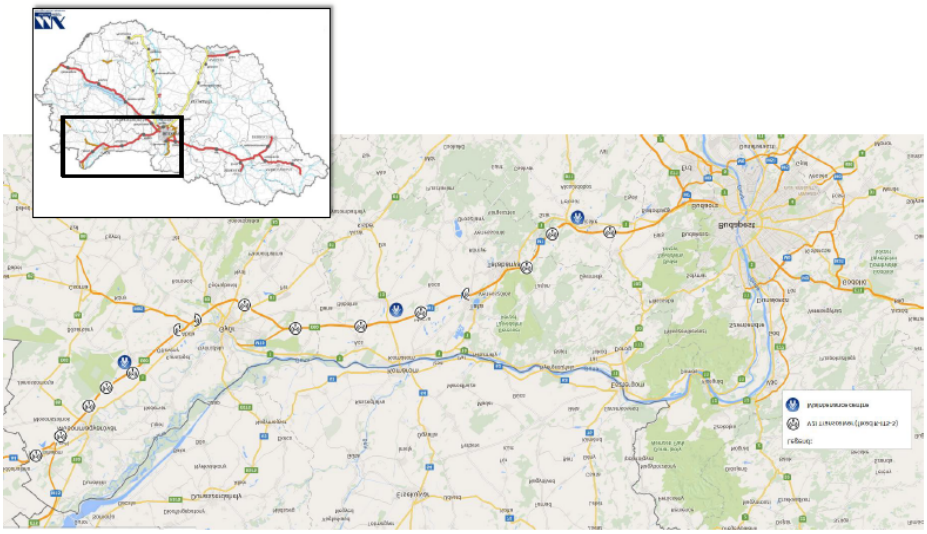

Figure 40: Location of the Hungarian C-ITS deployment activities

The Hungarian Public Road Management Company intends to extend the C-ITS deployment both in terms of geographical coverage, and offered services. The focus shall be put on urban deployment, in particular GLOSA/Time-to-green as well as intersection safety (signal violation). The upgrade should also concern the communication technology – deployment of hybrid DSRC / cellular technology is envisaged in near future.

SISCOGA (source CODECS)

The SISCOGA cooperative corridor is located in the area of Vigo, Galicia (Spain). It comprises 120 kilometres of interurban roads – the selected road are AP-9, A-52 and A-55 – but also urban environment (main streets of Vigo). The pilot is part of the DRIVE-C2X EU Project (**Error! Reference source not found.**). **Error! Reference source not found.** gives an overview of the Spanish test-site.

Figure 41: SISCOGA as part of the DRIVEC2X project landscape

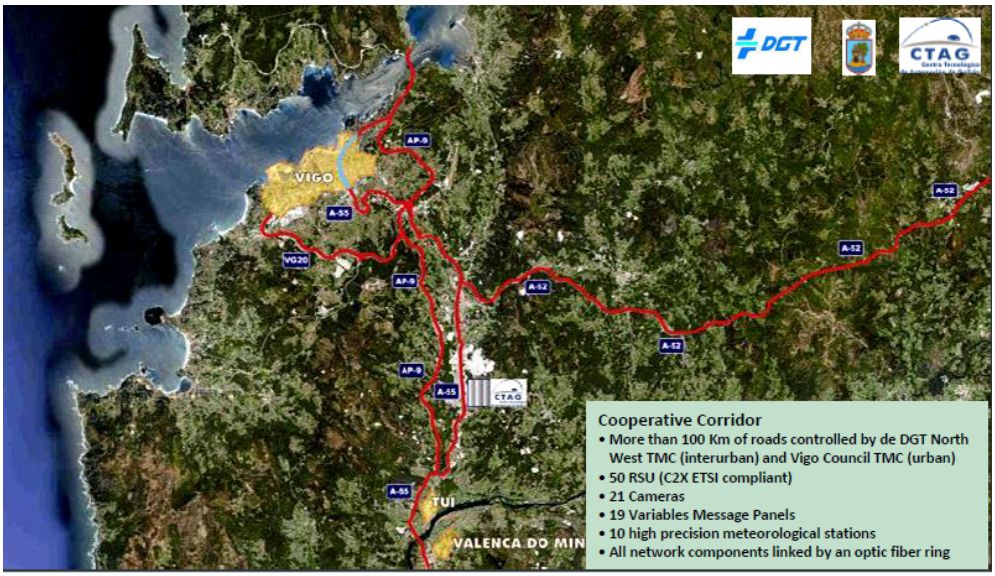

Figure 42: Detailed view of the Spanish project site

The Services initially selected for the SISCOGA initiative are:

- Accident / Traffic Jam Ahead Warning
- Alternative Route Information
- Road Works Warning
- Cooperative Floating Car Data
- Adverse Weather Warning
- Regulatory and Contextual Speed Limit

As next steps the initiative has defined a set of future services to be implemented:

- Priority for public buses at intersections
- Priority for emergency vehicles
- GLOSA (Green Light Optimal Speed Advice) for normal cars
- Cooperative parking management
- Contextual traffic information and alternative route

EU project AutoNET2030

The AutoNET project is an EU FP7 project (nr 610542) [30]
AutoNet2030 shall develop and test a co-operative automated driving technology, based on a decentralized decision-making strategy, which is enabled by mutual information sharing among nearby vehicles. The project is aiming for a 2020-2030-deployment time horizon, taking into account the expected preceding introduction of co-operative communication systems and sensor based lane-keeping/cruise-control technologies. By taking this approach, a strategy can be worked out for the gradual introduction of fully automated driving systems, which makes the best use of the widespread existence of co-operative systems in the near-term and makes the deployment of fully automated driving systems beneficial for all drivers already from its initial stages.

European Truck-Platooning challenge

The European Truck Platooning Challenge 2016 [31] is initiated by the Dutch Ministry of Infrastructure and the Environment, the Directorate General Rijkswaterstaat, the Netherlands Vehicle Authority (RDW) and the Conference of European Directors of Roads (CEDR).

Six brands of automated trucks - DAF Trucks, Daimler Trucks, Iveco, MAN Truck & Bus, Scania and Volvo Group - have been driving in columns (platooning), on public roads from several European cities to the Netherlands. The aim of the Challenge was to bring platooning one step closer to implementation.

EU project COMPASS 4D (source CODECS report D2.2)

ITS is not new to cities; it is widely deployed for managing traffic and fleets (eg, buses, public bikes, trucks), providing traffic and travel information, paying for transport services and enforcing traffic rules (parking, access restrictions, etc) among others.

In many cities, there already exists infrastructure-vehicle communication, mainly for fleet priority systems (public transport and emergency vehicles). Such systems make use of a range of communication technologies: GPS, short-range (tag and beacon) and cellular. However, current systems are not using standardised messages (SPaT/MAP, CAM, DENM) nor are they using the dedicated short-range frequency for vehicle-infrastructure communications, ITS G5.

For what concerns mainstream C-ITS (standardised message sets, cellular or ITS-G5), cities are not as advanced as highway authorities with regards to deployment. Nonetheless, some cities are considering deployment and some have piloted a number of C-ITS applications (GLOSA, priority at traffic lights, red light violation, etc.) over the years in the context of European and national-funded projects (COMPASS4D [36], Freilot, Smart freight, CVIS, URBAN, etc.). Building on the experiences of these demos and pilots, some cities are making plans for deployment and in a small number of cities, the C-ITS services piloted remain post-project, albeit for a small number of vehicles. COMPASS4D [36] is one such project, which is promoting the continuation of C-ITS services post-project.

Overview

Compass4D, which ended in December 2015, has piloted three cooperative services

- Energy Efficient Intersection Service (EEIS)
- Road Hazard Warning (RHW) and
- Red Light Violation Warning (RLVW)

in seven European cities: Bordeaux, Copenhagen, Helmond, Newcastle, Thessaloniki, Verona and Vigo. Nearly 300 roadside units have been installed, more than 600 vehicles have been equipped with C-ITS capability and over 1200 drivers have been involved in the pilots.

Services

Energy efficiency intersection service (EEIS) provides advice to optimise the way vehicles pass through an intersection. Information on the traffic light status is transmitted from the traffic light control unit to the oncoming vehicles. Inside the vehicle the driver receives information on when the traffic light ahead will change, either in the form of a time countdown or as a speed advice.
Road hazard warning (RHW) provides a variety of safety warnings to vehicles where there is an upcoming, and possibly dangerous, event. Such an event may include road works, a pedestrian crossing, an accident, an end of queue or an emergency vehicle approaching, among others.
Red light vehicle warning (RLVW) aims to improve safety at signalised intersections by detecting and/or predicting dangerous situations at intersections, such as conflicting turns across a junction or a vehicle violating a red light.

Annex E Example detailed description use cases

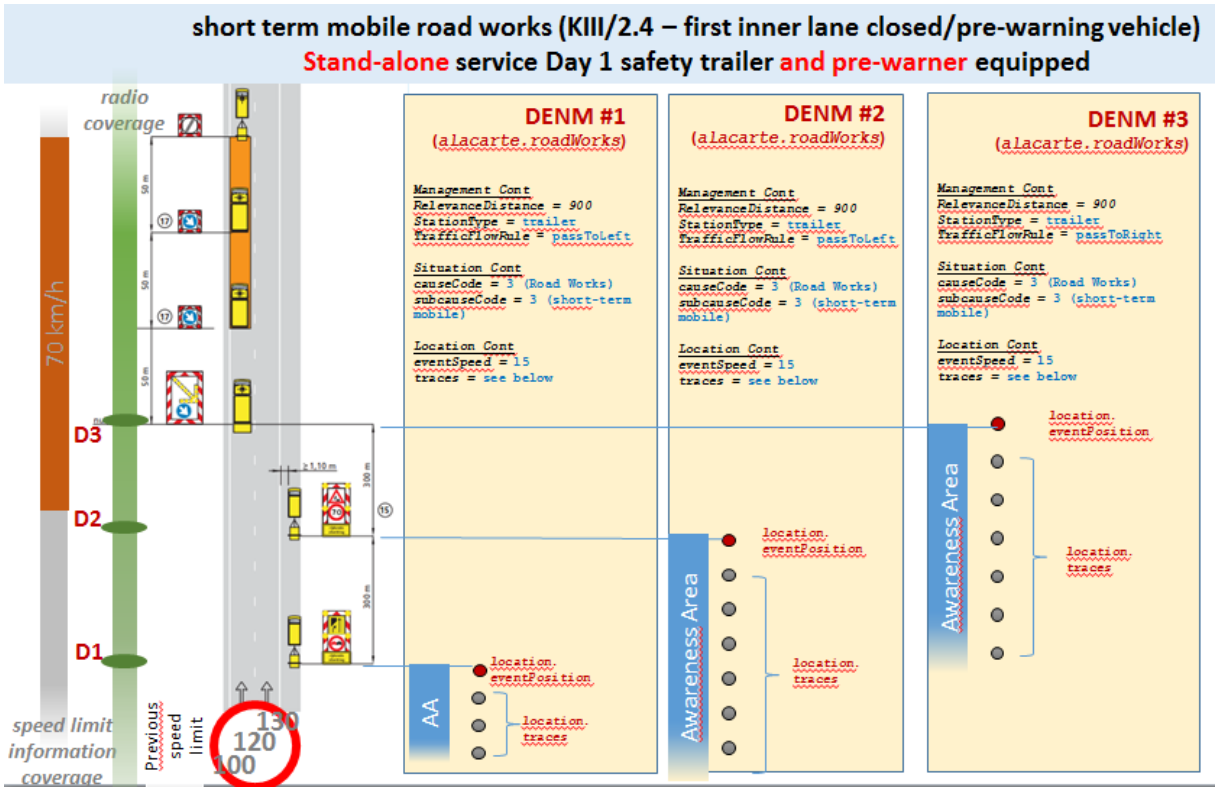

Figure 43: Short term mobile road works

Annex F Prioritised use cases

Use-Case		Priority			Transmition		Standard Facility						Standard Application				
No	Name	1	2	3	4G	G5	IVI	DENM	CAM	PvD	...	...	IVS	Context Speed	....	....	...
Road Works Warning																	
1	Short Term Mobile	X				X		X		X							
2	Short Term Static	X				X		X		X							
3	Long Term Static		X		X	X		X		X							
4	Ad-hoc Road Works	X				X		X		X							
Traffic Management																	
5	Virtual Signs			X	X	X	X	X					X				
6	Energy Efficient Intersection Service			X	X	X	X	X		X				X			
7	Dynamic Speed		X			X	X	X		X				X			
8	Dynamic Sign Information			X	X	X	X	X					X				
9	Network Flow Optimization			X	X	X	X	X		X				X			
10	Green Light Optimizaiton Speed Advisory			X	X	X	X	X		X				X			
Traffic Information																	
11	Virtual VMS			X	X		X			X							
Traffic Safety																	
12	Automatic Incident Detection		X			X	X	X	X	X			X	X			
13	Traffic Jam Warning			X	X	X	X	X		X			X				
14	Red Light Violation Warning			X		X											
15	Road Hazard Warning		X		X	X	X	X	X	X							
16	Emergency Vehicle Approaching			X		X	X	X	X	X							
Incident Management																	
17	Incident Management		X		X	X	X	X	X	X			X				

Figure 44: Prioritised use cases