Common C-ITS Service and Use Case Definitions

Version 1.7.0.TF.~~2~~3

C-Roads Platform

Working Group 2 Technical Aspects

Taskforce 2 Service Harmonisation

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Publication History

Version	Date	Description, updates and changes	Status
1.0	19.02.2018	This document integrates the individual document specifications of the services for In-Vehicle Signage (IVS 1.07), Other Hazardous Locations Notifications (OHLN v1.08) and Road Works Warning (RWW 1.06). The use case overview in the RWW service description was adjusted as the mentioned use cases 4-7 are not part of this document but potential candidates for further releases. No other changes were made to the content of the working documents used in the service working groups, the complete text was copied into this document for each specific service. The table of contents has been adjusted accordingly.	Draft
1.01	19.03.2018	Revision of complete document following comments received on OHLN for and in the WG2 meeting, all major changes discussed and agreed, minor comments were integrated into the document and presented during an additional TF2 Telco; no open questions remained. (All comments addressed, commented and resolved in the track /changes table.)	Draft
1.02	20.03.2018	Last adjustments based on the WG2 comments during the IVS conference call of 20.03.2018	Draft
1.03	21.03.2018	Last adjustments for RWW included based on the WG2 comments made during the WG2 meeting of March 12/13.	Draft
1.04	22.03.2018	Last adjustments for OHLN, based on the inclusion of WG2 comments, and feedback.	Draft
1.1	22.03.2018	Last smaller editorial issues	Final
1.2	12.06.2018	Included service descriptions for TLM/RLT v1.91. As agreed during the WG2 meeting of 29/30 May 2018 in Vienna the TLM/RLT service section is renamed into “Signalized Intersections”. Some minor editorial changes were made to make it conform with the current layout. Also, as agreed during the same WG2 meeting, the former service section “Other Hazardous Location Notifications” (OHLN) has been changed to “Hazardous Location Notifications” (HLN). This version of the document, the use of gender specific language is avoided. Nonetheless, further review and modification may be required; this will be taken into account for the next release 1.3.	Final
1.3	17-09-2018	Included the link between this TF2 document and the C-Roads TF3 document, “C-ITS Infrastructure Functions And Specifications”. Based on the WG2 conference call (13.09.2018) discussions of comments on the document “Proposal for linking TF2 to TF3 C_Roads_WG2_TF2_Service Descriptions v1.3 “. Also changed the format accordingly. Some minor editorial changes were made. In accordance with the outcome of the above-mentioned conference call, scenario was changed into “use case scenario”.	Final

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1.3	02-10-2018	Based on SC meeting of 02-10-2018: Release 1.3 is accepted for C-ROADS deployment by 14 member states: Austria, Belgium/Flanders, Belgium/Wallonia, Czech Republic, Denmark, France, Germany, Hungary, Italy, Netherlands, Norway, Portugal, Slovenia, Sweden and United Kingdom. Release 1.3 is not accepted by Finland and Spain.	Final
1.4	19-12-2018	This release has the following changes with respect to v1.3: - Incorporation of revised paragraph 4.2.2 based on the decision during the SC meeting of 11-12-2018 on the acceptance of the change request on R1.3. (the original paragraph 4.2.2 Signalized Intersections - Public Transport Prioritization, see for details *"C_Roads_WG2_TF2_TLM RLT Change Request on R1.3 after WG2 Budapest.doc"*). - Incorporation of new paragraphs based the acceptance of new use cases (see for more details: *"C_Roads_WG2_TF2_New Use Cases Release 1.4 (A) - after WG2 Budapest.doc"*). This meant the new paragraphs 1.2.3 IVS – Dynamic Lane Management, 4.2.3 SI - Signal Phase and Timing Information, 4.2.4 SI - Imminent Signal Violation Warning and 4.2.5 SI - Emergency Vehicle Priority. Some minor editorial changes were made as well as changes due to the inclusion of the new content (paragraph headers, number).	Final
1.5	11-07-2019	- This release has the following changes with respect to v1.4, agreed upon during the SCOM meeting of July 2, 2019. - Incorporation of agreed change request for IVS-EVFT use case from Slovenia. - Incorporation of new paragraphs based the acceptance of the new use cases (see for more details: *"C_Roads_WG2_TF2_Service Descriptions SCOM 2019-06-21 After WG2 Prague meeting Clean"*): new paragraphs 2.2.8, 2.2.9; an improved RWW service description 3.1; new paragraphs 3.2.4, 3.2.5, 3.2.6; the inclusion of a new service PVD paragraph 5.1, 5.2.1 and 5.2.2; and the inclusion of an Annex belonging to PVD. - Some minor editorial changes were made as well as some changes due to the inclusion of the new content (paragraph headers, number).	

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1.6	04.02.2020	- This release has the following changes with respect to v1.5, agreed upon during the SCOM meeting of December 17, 2019. - Incorporation of the English proofreading improvements (*C_Roads_WG2_TF2_Service Descriptions v1.5 - English Proofreading 0.3 after WG2)* - Incorporation of the SI improvements (*C_Roads_WG2_TF2_Service Descriptions v1.5 - SI improvements 0.3 After WG2 meeting)* - Incorporation of the 6 accepted new Use Cases: o *C_Roads_WG2_TF2_HLN UBR I2V v0.6* o *C_Roads_WG2_TF2_HLN-AWWD v0.10* o *C_Roads_WG2_TF2_HLN-PTVC v0.3* o *C_Roads_WG2_TF2_HLN-PTVS v0.3* o *C_Roads_WG2_TF2_SWD v1.0.13* o *C-Roads_WG2_TF2_HLN-EVI v0.6* - Some minor editorial changes were made as well as some changes due to the inclusion of the new content (paragraph headers, number).	
1.7.0.TF.1		- Added template, changed name with agreed upon version numbering, copied existing relation with TF3 document to the new template. All in Track Change mode	
1.7.0.TF.2		- Accepted all changes, clean version of 1.7.0.TF.1	
1.7.0.TF.3		- Incorporated as agreed upon in the WG2 chairs meeting the use case specific HLN-SV settings as starting point and some minor changes in the introduction part due to the adoption of the new use case description template. An example of PVD-EDC (Vehicle at Risk in a Critical Area) was added.	

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Introduction

In this document the C-Roads Platform describes a functional specification and use cases for services implemented in various C-Roads projects and pilots. These functional descriptions are the result of the harmonisation efforts that have taken place within TF2 (Service Harmonisation) and the alignment with the work of the other C-Roads WG2 task forces ~~TF3~~ where the harmonisation of the interoperability requirements ~~message profiles~~ for the specific services and use cases takes place.

In this context we make use of the following terminology:

- Service: a clustering of use cases based on a common denominator, for example, an objective such as awareness or a context like road works. Services are also known as 'applications'.
- Use case: function of the system, the desired behaviour (of the system and actors), specification of system boundaries and definition of one or more usage scenarios.
- Situation: describes relevant situation (everything required to describe a static snapshot) considering (driving) function-related goals and values.
- Scenario: describes temporal development of a sequence of situations (e.g. initial and after) based on events and actions. It is story telling.
- Actors: external (human) entities that interact with the system. The system affects and is affected by the behaviour of actors; these interactions are described in the use case descriptions.

Basic principle: "information need + context (situation) = use case". Meaning that:

- A different information need in the same context results in a new use case.
- The same information need in a different context results in a new use case.

However, note that the functional description of these use cases may seem to be largely identical as the main differences might become apparent only when reading the high-level technical descriptions. This document contains functional descriptions, not high-level technical descriptions, and are described in a technology agnostic way (where possible).

It is important not to confuse 'service' with 'use case'. Therefore, it is important to clearly refer to the information need and the context of use under a specific use case. Similarly, services should be defined carefully and economically as the one-to-many relation with use cases may lead to a nearly infinite number of services.

Next to the functional description of the specific use case, the specific interoperability requirements are included in the last part of the template. It contains generic references to the other C-Roads requirements documentation as well the yse case specific harmonized settings needed for interoperability.

The following format is used to describe the services:

Service introduction	
Summary	A summary of the service (one or two lines)
Background	A description of the motivation/rationale of the service
Objective	The intended outcome of the service
Expected benefits	A description of the expected added value and actor benefits of the service
Use cases	A list of use cases – for each listed use case, a use case table needs to be provided

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The following format is used to describe the use cases:

Use case introduction	
Summary	A summary of the use cases (one or two lines)
Background	A description of the motivation/rationale of the use case
Objective	The intended outcome of the use case
Desired behaviour	A description of the expected behaviour of the system and the intended behaviour of users
Expected benefits	A description of the expected added value and actor benefits
Use case description	
Situation	A description of one or more situations relevant to the use case
Logic of transmission	The transmission logic to be used (I2V, V2V, V2I, V2I2V… + broadcast / unicast / multicast)
Actors and relations	A list of all relevant actors and their relations/interactions with the system and their role in the use case (incl. sender and receiver). The actors are: road user, road operator, service provider, end user, vulnerable road user and other.
Use case scenario	A description of the story of the use case based on a sequence of situations (e.g. initial and after), events and actions, with illustrations. Sender and receiver should be addressed, in stakeholder neutral manner.
Display / alert principle	The triggering conditions and what is displayed to the user and when.
Functional constraints / dependencies	A description of functional constraints and dependencies that are requirements (if any) related to e.g. business, security, telecommunications, privacy, legal, human behaviour, etc.
Interoperability requirements	
Message profile requirements	Generic reference to the TF3 document "C-ITS Message Profiles and Parameters" and use case ~~S~~specific settings ~~of the profiled message sets in the C-Roads TF3 document "Infrastructure Functions and Specifications"~~ are described.
Security and data protection requirements	Generic reference to the TF1 document "C-ITS Security Requirements and Specifications" and use case specific settings are described.
Communication technology requirements	Generic reference to the TF3 documents "C-ITS Roadside ITS-G5 System Profile" and "C-ITS Mobile ITS-G5 System Profile" and use case specific settings are described. Generic reference to the TF4 document "C-ITS IP Based Interface Profile" and use case specific settings are described.
Test and validation requirements	Generic reference to the TF5 Test Case documents and use case specific settings are described.

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In this document the following services and use cases are described:

Service	Use Case	Release
In-Vehicle Signage	Dynamic Speed Limit Information (IVS-DSLI)	1.0
	Embedded VMS “Free Text” (IVS-EVFT)	1.1
	Dynamic Lane Management (IVS-DLM)	1.4
	Shock Wave Damping (IVS-SWD)	1.6
	Other Signage Information (IVS-OSI)	1.1
Hazardous Location Notification	Accident Zone (HLN-AZ)	1.0
	Traffic Jam Ahead (HLN-TJA)	1.1
	Stationary vehicle (HLN-SV)	1.1
	Weather Condition Warning (HLN-WCW)	1.1
	Temporarily slippery road (HLN-TSR)	1.1
	Animal or person on the road (HLN-APR)	1.1
	Obstacle on the road (HLN-OR)	1.1
	Emergency Vehicle Approaching (HLN-EVA)	1.5
	Emergency Vehicle in Intervention (HLN-EVI)	1.6
	Railway Level Crossing (HLN-RLX)	1.5
	Unsecured Blockage of a Road (HLN-UBR)	1.6
	Alert Wrong Way Driving (HLN-AWWD)	1.6
	Public Transport Vehicle Crossing (HLN-PTVC)	1.6
	Public Transport Vehicle at a Stop (HLN-PTVS)	1.6
Road Works Warning	Lane Closure (RWW – LC)	1.0
	Road Closure (RWW – RC)	1.1
	Road Works – Mobile (RWW-RM)	1.1
	Winter Maintenance (RWW-WM)	1.5
	Road Operator Vehicle in Intervention (RWW-ROVI)	1.5
	Road Operator Vehicle Approaching (RWW-ROVA)	1.5
Signalized Intersections	Signal Phase and Timing Information (SI-SPTI)	1.4
	Green Light Optimal Speed Advisory (SI-GLOSA)	1.3
	Imminent Signal Violation Warning (SI-ISVW)	1.4
	Traffic Light Prioritization (SI-TLP)	1.3
	Emergency Vehicle Priority (SI-EVP)	1.4
Probe Vehicle Data	Vehicle Data Collection (PVD-VDC)	1.5
	Event Data Collection (PVD-EDC)	1.5

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1 In-Vehicle Signage (IVS)

1.1 IVS: Service introduction

Service introduction IVS	
Summary	In-Vehicle Signage (IVS) is an information service to inform road users on actual static or dynamic road signs (or additional information mimicking virtual road signs) via in-car systems. The road signs can be mandatory or advisory.
Background	The In-Vehicle Signage (IVS) service is meant to inform road users via in-car information systems about static and dynamic road signs mirroring physical road signs along the road. Additionally, further information (virtual road signs or additional free text) can be provided. IVS may target information to specific vehicle types or to individual vehicles. IVS is a subset of the broader scope of In-Vehicle Information service (IVI). The IVS information is sent out by means of Infrastructure-to-Vehicle (I2V) communication. Today, in addition to fixed road signs, VMS systems are used by road operators to provide operational, tactical or strategic information to road users. Different types of variable or dynamic traffic sign systems are used, with both static pictograms and text and variable pictograms and text on: • Variable Message Signs (VMS) • Variable Text Panels (VTP) • Variable Direction Signs (VDS)
Objective	• Increase attentive driving • Increase awareness on the content of road signs by providing sign information directly in the vehicle where it can potentially be displayed throughout the period of its entire validity. This will severely reduce observation problems attributed to physical road signs, such as limited line of sight, obstructions obscuring sight of a sign, limited attention by drivers passing signs • Display in driver's own or preferred language potentially
Expected benefits	• In-Vehicle Signage allows the driver to be informed earlier and more completely by providing continuous signage information directly in the vehicle. This should result in better adaptation to current regulations and traffic conditions. • The primary expected impact is more attentive driving by providing relevant and continuous information on road signage (e.g. speed limits), which improves traffic safety as it reduces (the severity of) accidents and congestion. • Another benefit is the option to present information in the language as selected by the road user, or to present only information valid for the respective vehicle type (e.g. trucks), improving the relevance of information provided what might result in less distraction.
Use Cases	IVS consists of several use cases where VMS, VTP or VDS are used: • In-Vehicle Signage: Dynamic Speed Limit Information (IVS-DSLI) • In-Vehicle Signage: Embedded VMS “Free Text” (IVS-EVFT) • In-Vehicle Signage: Dynamic Lane Management (IVS-DLM) • In-Vehicle Signage: Shock Wave Damping (IVS-SWD) • In-Vehicle Signage: Other Signage Information (IVS-OSI) Other IVS use cases are under review and may be added in future releases.

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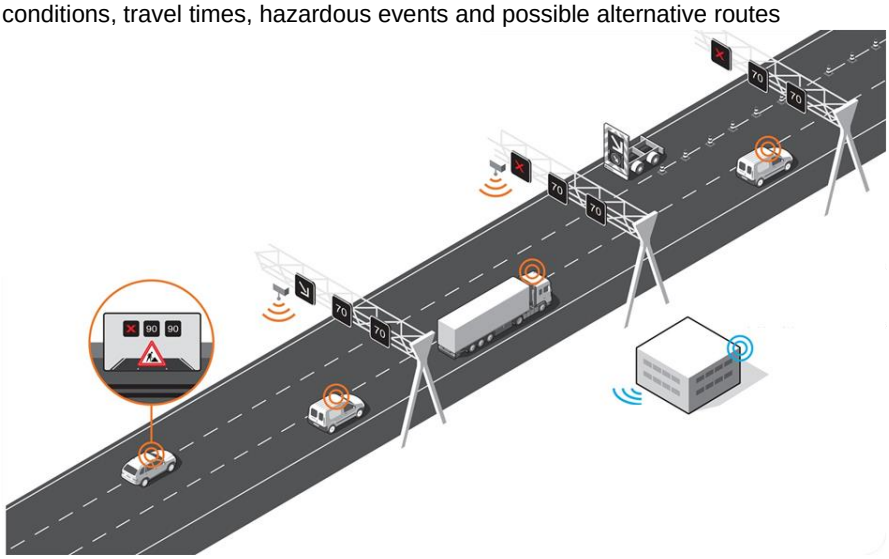
1.2 IVS: Use cases

1.2.1 IVS - Dynamic Speed Limit Information (IVS-DSLI)

Use case introduction IVS-DSLI	
Summary	The road users receive in-vehicle speed limit notifications as they drive. The message subject is the dynamic speed limit given by the road operator.
Background	Inform the road users about the actual dynamic speed limit so they can adapt their speed appropriately and promptly to avoid speeding.
Objective	The aim is to inform the road users about the current valid dynamic speed limit set by the road operator, as indicated by variable message signs (VMS).
Desired behaviour	The road users adapt their driving behaviour to be compliant to the applicable driving speed limit. In the future the information may be used by Advanced Driver Assistance Systems for supported or automated driving or ISA (Intelligent Speed Adaptation).
Expected benefits	More convenience for road users, resulting in better compliance to speed limits, improved safety and potential environmental benefits.
Use case description	
Situation	The aim of In-Vehicle Signage (IVS) is to relay the information presented on (electronic) traffic signs into the vehicle. To that end, variable or dynamic message sign (VMS) systems have been deployed on sensitive parts of the motorway network all over Europe. They are being used in conjunction with monitoring systems to enforce traffic regulations (such as speed control and lane management) and inform road users about driving conditions, travel times, hazardous events and possible alternative routes  *Figure 1 Example of In-vehicle information: status information of dynamic speed limit signs on a variable message system also sent as in-vehicle signage service* This use case foresees transmission of information on the current valid speed limit continuously, as set by the road operator because of e.g. roadworks, incidents, traffic jams.

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Logic of transmission	I2V Broadcast
Actors and relations	• Road operator: The source of a majority of dynamic speed limit information is the road operator via the Traffic Control Centre (TCC). The road operator is expected to have validated the content of the message before sending this message into the system. • Road user: The speed limit information is continuously received by all C-ITS equipped vehicles and displayed to the road user. The exact details of the presentation (how and when) is based on the individual application designer's decision. The road user can use the information to better comply with the current speed limit. • Service provider: disseminates dynamic speed limit information to the road user. If the dynamic speed limit information is disseminated using a direct communication link between road operator and road user, the road operator acts in the role of the service provider. If communication is using an external communication network, either the operator of that network or the service recipient (car manufacturer) itself becomes service provider.
Use case scenario	• The Traffic Control Centre (TCC) sends a message with the dynamic speed limit for every lane or all lanes. The speed limit can be targeted to a specific vehicle type (e.g. heavy goods vehicle). • The message is received in the vehicle and displayed to the driver if relevant to that road user. • The road user can adapt their speed.
Display / alert principle	• IVS information shall be displayed to the road user and shall be consistent with the current valid dynamic traffic signs. • The information needs to be displayed to the driver early enough and in the appropriate location.
Functional constraints / dependencies	• How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle Information system with HMI how information is presented. Information may be translated to the preferred language of the driver. • The information presented by means of I2V is not legally binding: Information should be handled as 'convenience information' and presented accordingly to the road user, as currently done within navigation systems.
Interoperability requirements	
Message profile requirements	• The IVI message for IVS-DSLI is profiled in chapter 3.2.2 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, ISO14823 DF is set with serviceCategoryCode = regulatory, nature = 5, serialnumber = 57, attributes/spe/spm = the value of the speed limit in km/h and unit = 0 (i.e. kmperh) or the equivalent for other countries (e.g. 1 for milesperh). • With regards to the end location of the speed limit zone the following may be used: ISO14823 DF with serviceCategoryCode = regulatory (12), nature = 6, serialnumber = 14 (Notice of the end of speed limit) or serviceCategoryCode = informative (13), nature = 6, serial number = 63 (notice of the end of all restrictions by electronic signs) if this sign is shown on the road. This ending message might be redundant to the end point of the relevance zone of the initial IVI message. • vehicleCharacteristics are used only if the DSLI is applicable to specific vehicles. • applicableLanes are used only if the DSLI is applicable to specific lanes.

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	• extraText can be present, but is absent most of time.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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1.2.2 IVS - Embedded VMS “Free Text” (IVS-EVFT)

Use case introduction IVS-EVFT	
Summary	The goal of this use case is to display to the road user in-vehicle information of type “free text”. The information will either reproduce what is displayed at a physical VMS (e.g. variable text panel) or display a completely new message that does not mirror a physical VMS (a virtual VMS).
Background	• Rather than conveying completely new information, the value of this use case is to provide already existing information, enhancing its visibility by enabling continuous displaying in the vehicle, reducing the need (and anxiety) to perceive and comprehend rather complex information in the few seconds that the VMS panel is visible to the road user during transit. • Another added value would be to enable the information to be displayed in the driver’s preferred language, if available. • Compared to traffic signs, it is possible to display additional content (text, images). • Compared to physical VMS: there is a greater possibility to send more contextualized information than can be presented on a physical VMS; there is more time to read and comprehend the information that is shown directly in the vehicle. Hence, presenting more information should not lead to more distraction of the driver.
Objective	• Transmit to road users information in “free text” that is not provided by other (in-vehicle signage) use cases. • Add details (in preferred language) to existing messages in order to provide more precise and comprehensible information to the road users to achieve the desired behaviour. • The information may already be displayed on a physical VMS or other means of signalling on the road.
Desired behaviour	The road user adapts their driving behaviour compliant to the applicable driving regulations and any advice or guidance provided.
Expected benefits	• Traffic management: the use case permits greater traffic management control (e.g. regulation, smart routing, etc.), because information can potentially be transmitted on the scale of the complete network, beyond the limited coverage of the physical VMS. • Comfort: the use case allows continuous display of information in the vehicle compared to the short-term awareness provided by the physical VMS, thus limiting stress for the road user to comprehend the content of the information and react accordingly. • In case of regulatory information, the virtual VMS allows display of a message exactly in the zones of application, enhancing the compliance with regulations.
Use case description	
Situation	• Traffic management plan • Pollution • Amber alert • Special events (sports, demonstration...) • Travel time • Speed advice • Available parking spaces on highway rest areas • Information on services available on highway parking areas

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	• Etc.
Logic of transmission	I2V Broadcast
Actors and relations	• Road operator: The source of this information is the road operator via the Traffic Control Centre (TCC). The road operator is expected to have validated the content of the message before sending this message into the system. • Road user: The free text information is continuously received by all C-ITS equipped vehicles and displayed to the road user. The exact details of the presentation (how and when) is based on the individual application designer's decision. The road user will benefit from the information contained in the free text information and act accordingly. • Service provider: disseminates the “free text” information to the road user. If the “free text” information is disseminated using a direct communication link between road operator and road user, the road operator acts as the service provider. If communication is using an external communication network, either the operator of that network or the service recipient (e.g. car manufacturer) itself becomes service provider.
Use case scenario	• The road operator wants to send information to road users. The virtual VMS is a possible means, as well as physical VMS, radio, the internet, etc. • The road operator sends information via all or selected information channels
Display principle / alert logic	Free text information shall be displayed to the road user and shall be consistent with the actual dynamic traffic signs. If presented, the information needs to be displayed to the driver early enough and at the appropriate location.
Functional constraints / dependencies	• How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver. • The In-Vehicle information system cannot determine the content of the “free text” message. Therefore, it is the responsibility of the road operator to determine when and at what location(s) this message should be available for displaying in the vehicle. • The information presented by means of I2V is not legally binding: Information should be handled as ‘convenience information’ and presented accordingly to the road user, as currently done within navigation systems.
Interoperability requirements	
Message profile requirements	• The IVI message for IVS-EVFT is profiled in chapter 3.2.2 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, ISO14823 DF is set with appropriate serviceCategoryCode, nature, serialnumber and attributes (optional). • vehicleCharacteristics are used only if the DSLI is applicable to specific vehicles. • applicableLanes shall not be used with EVFT use case because several free text messages differentiated by lane(s) are not displayable.
Security and data protection requirements	
Communication technology requirements	

Test and validation requirements	

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1.2.3 IVS - Dynamic Lane Management (IVS-DLM)

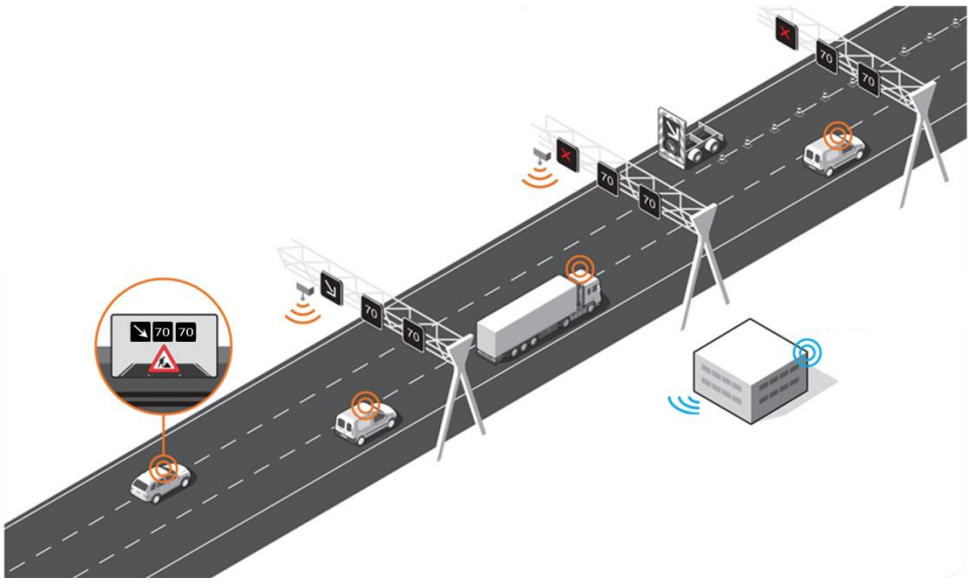
Use Case Introduction IVS-DLM	
Summary	The use case is to inform road users of the status of the lanes (open/closed, normal, high occupancy vehicle (HOV) lane, bus lane or rush hour) of a road.
Background	Dynamic lanes support sustainable mobility. This use case enables the road operator to optimize the management of the lane(s) knowing the real-time traffic characteristics. Currently, the dynamic use of lanes need to be clearly identified in the field by signalization, for instance with lane control signs located on (mobile) gantries. With this use case, it would be possible to easier apply/implement the use of dynamic lanes on the networks. The current description of this use case describes the situation with physical lane control signs present and represented in a digital way.
Objective	To inform the road user of a (dynamic) lane status, and notify the road user if their vehicle is allowed to use specific lanes or not.
Desired behaviour	• Road users adapt their driving behaviour / position on the road according to the information. • Only authorized vehicles use the available/reserved lane(s)
Expected benefits	• Better awareness for the road user of the available lanes • Improved safety
Use case description	
Situation	In European countries different variable or dynamic message sign (VMS) systems are deployed on parts of the highway. The VMS systems can also be used to inform drivers on the actual status of dynamic lanes (see example in Figure 2-4).  *Figure 2: Example of status of dynamic lanes*

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	 *Figure 3: Example of status of dynamic lanes*  In *Figure 4: Example of status of dynamic lanes (using hard shoulder lane)* This situation status information of the dynamic lanes on a variable message system can also be provided in car using the Dynamic Lane Management use case.
Logic of transmission	I2V broadcast
Actors and relations	• Road user: receives Dynamic Lane Management information in their vehicle. • Road operator: provides information on dynamic road signage. • Service provider: disseminates Dynamic Lane Management information, to road users.

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Scenario	<u>Scenario 1 – Regular Driving Lanes</u> While driving on a highway, vehicle drivers receive prevailing Dynamic Lane Management information on the regular driving lanes in their vehicle. <u>Scenario 2 – Hard Shoulder Running</u> While driving on a highway, vehicle drivers receive actual prevailing Dynamic Lane Management information on use of a hard shoulder as a driving lane (rush hour lanes) in their vehicle
Display / alert principle	The information needs to be displayed to the driver early enough (but not too early with respect to the configuration of the actual lane control signals) and in the appropriate location.
Functional constraints / dependencies	Dynamic Lane Management information shall be displayed to the road user and shall be consistent with the actual dynamic lane control traffic signs on the road.
Interoperability requirements	
Message profile requirements	The IVIM message for IVS-DLM is profiled in chapter 3.2.2 of the *C-ITS Infrastructure Functions and Specifications* document. For this use case the following additional remarks are applicable: 1) Road sign codes: the road sign codes according to ISO14823:2017 are applicable. 2) For dynamic lane management several pictogram codes for the traffic sign are used with: a) countryCode: ISO 3166-1 code for countries, e.g. BE for Belgium b) serviceCategoryCode: 13 (1: Traffic Sign, 3: Informative) c) pictogramCategoryCode: i. 659 - Lane closed ii. 660 - Lane free iii. 661 - Clear lane to left iv. 662 - Clear lane to right v. 663 - End of all restrictions by electronic signs d) No attributes Note: other electronic signs may be used if relevant in the specific country. The corresponding serviceCategoryCode and pictogramCode of ISO 14823:2017 will be used, if available.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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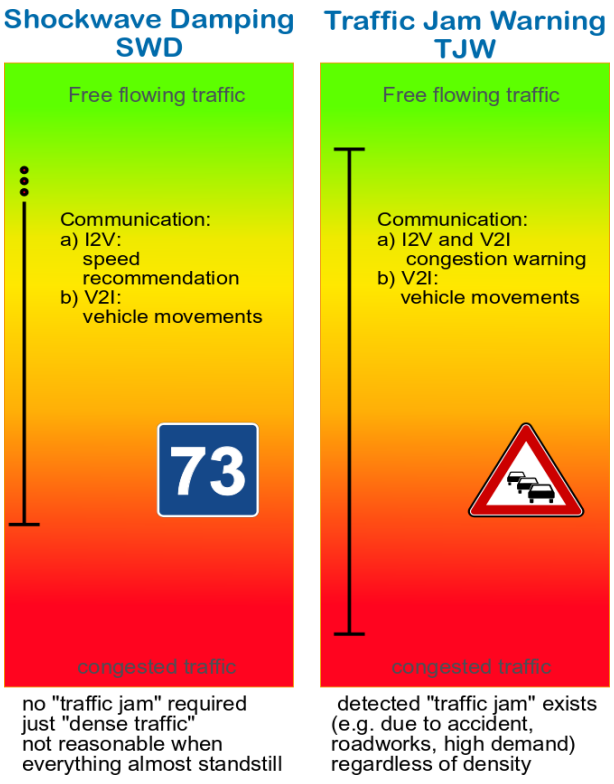
1.2.4 IVS - Shock Wave Damping (IVS-SWD)

Use Case introduction IVS-SWD	
Type of road network	Road with separate carriageways (non-urban) including entrance and exit segments
Type of vehicle	All
Summary	Providing I2V in-car information to avoid emerging or ideally even accomplish the elimination of shockwave situation in highway traffic.
Background	Shockwaves can occur in dense traffic when on some highway points the vehicles are driving relatively close to each other and/or change their speed or driving lane abruptly. In addition, it can be a result of a temporary overload on a highway ramp. In such situations, a braking action by a single vehicle may lead to a disturbance on the ongoing lanes that propagates or even amplifies in upstream direction, ultimately bringing the upstream vehicles to a full stop. In traffic jams, shockwaves can propagate during vehicles constantly alternate between 'free flow' and 'congested' traffic.
Objective	UC SWD is aimed at damping or dissolving shockwaves on the roadmap with help of C-ITS concepts. Therefore - the main goal is - to lessen or prevent shockwaves and to avoid occurrence of a traffic jam (TJ). If nevertheless the TJ takes place, the Use Case (UC) - Traffic Jam ahead Warning (TJW) becomes relevant.  no "traffic jam" required just "dense traffic" not reasonable when everything almost standstill detected "traffic jam" exists (e.g. due to accident, roadworks, high demand) regardless of density
Desired behaviour	**The road operator**: A shockwave damping situation is detected by the traffic operations centre. The operator can take necessary actions.

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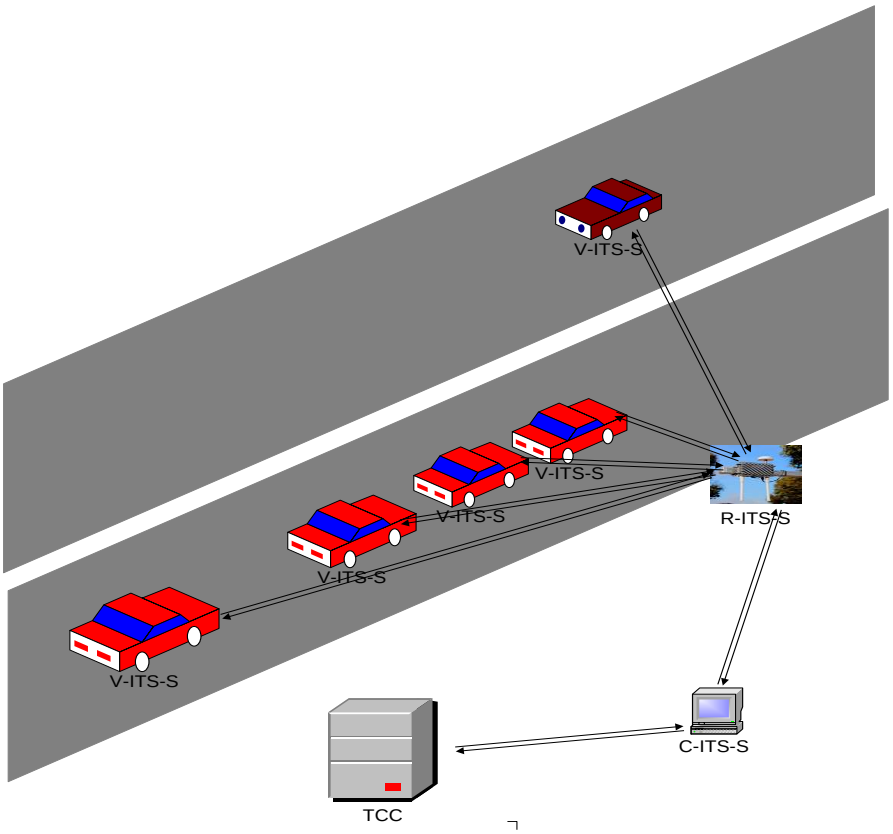
	The road user: adapts his/her driving behaviour/speed compliant to the applicable driving regulations and any advice or guidance provided.
Expected benefits	Homogenous traffic flow without traffic jams/congestions leads to: • Economic benefits: saving resources, money and time, achievement of maximum road capacity utilization. • Social benefits: traffic safety, reduced incidents. • Personal benefits: more comfortable driving. • Environment benefits: reduced CO_2 emissions and environmental pollution.
Use case description	
Situation	1. A vehicle brakes abruptly in dense traffic -> upstream traffic is affected -> shockwave situation occurs -> ITS system tries to regulate situation 2. A slow vehicle changes lane in dense traffic -> upstream traffic is affected -> shockwave occurs -> ITS system tries to regulate situation 3. Temporary overload on a highway ramp takes place -> upstream traffic is affected -> shockwave situation occurs -> ITS system tries to regulate situation
Logic of transmission	V2I – broadcast I2V- broadcast  There are three main data streams: Data stream 1: On the roadside, ITS communication technology (e.g. ETSI ITS G5 or Cellular) is used to receive vehicle information on ITS Roadside Station (R-ITS-S) and to send information from R-ITS-S directly to vehicles equipped with compatible ITS Vehicle Stations (V-ITS-S). a) *Uplink data*: V-ITS-S->R-ITS-S

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	Vehicles send data such as: • speed • position • other Probe Vehicle Data (PVD) raw data (e.g. brake state) b) *Downlink data:* R-ITS-S->V-ITS-S • Regulatory speed limit (if exists) • Speed recommendation generated on C-ITS-S • Driving lane information Data stream 2: Communication between R-ITS-S and ITS Central Station (C-ITS-S) a) *Uplink data*: R-ITS-S -> C-ITS-S R-ITS-S sends data such as: • PVD aggregated data • Control flow data b) *Downlink data:* C-ITS-S->R-ITS-S C-ITS-S sends data such as: • existing speed limit information • speed recommendation as a result of performing SWD algorithm • driving lane information Data stream 3: Communication between C-ITS-S and Traffic Control Centre (TCC) *Downlink data*: TCC -> C-ITS-S • conventional sensor data (cross-section measurement data) • VMS data (if available)
Actors and relations	• **In-vehicle system**: receives SWD related input information, speed recommendation. Automatically adapts car driving behaviour to the scenario or/and forwards warning information to HMI. • **Road user:** receives SWD related information, speed recommendation on the in-vehicle display. Adapts his/her driving behaviour to the scenario. • **Road operator**: Registers (if exist) shown at C-ITS-S HMI shockwave information. • **Service provider**: disseminates SWD related information, to/from vehicles/drivers. • **End user**: experiences a more harmonised traffic flow and less congestion.
Scenario	**Pre-Operation:** • System Start and Initialisation, • Road segment configuration. **Operation:** • Cooperative Vehicles send PVD raw data. • Existing highway infrastructure sends sensor and VMS data to TCC. • R-ITS-S and TCC prepare and send data to SWD module on C-ITS-S. SWD module analyses input data and generate dependent on road situation following control output.

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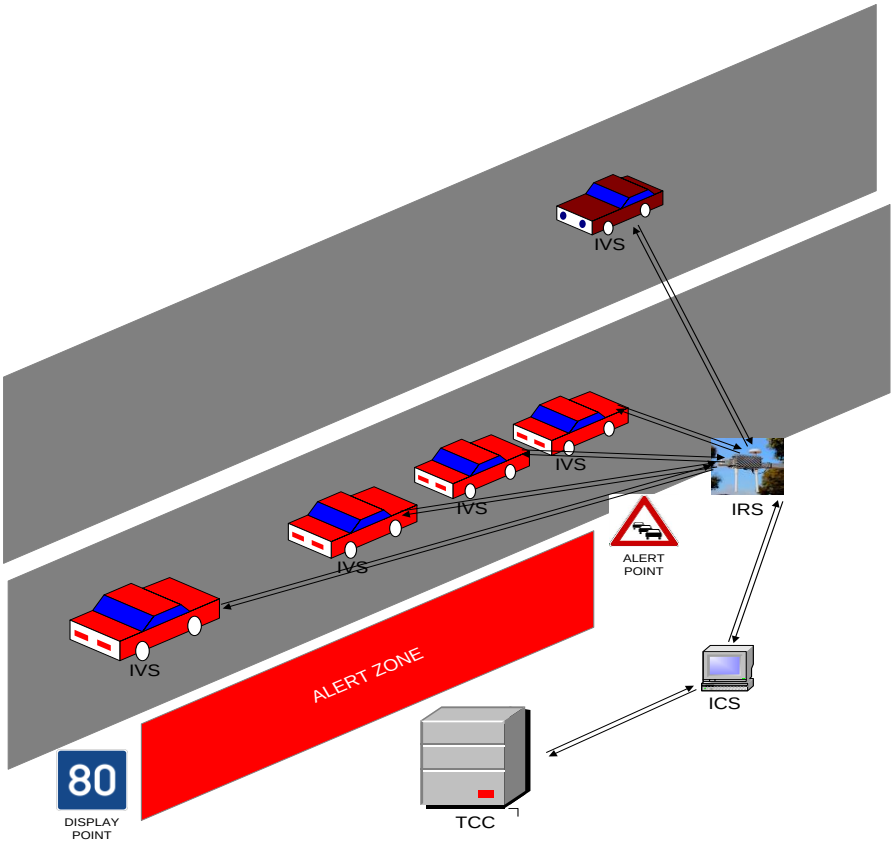
	Depending on situation: - Low probability of shockwave: • normal traffic flow - no action - High probability/occurrence of shockwave: • C-ITS-S sends relevant speed recommendations to R-ITS stations allocated in shockwave affected segment of the highway. • R-ITS stations disseminate ITS SWD messages • V-ITS-S analyses and prepares information for end user (ACC, car driver). - Traffic jam took place: • Remark: Use Case HLN-TJA can be activated. **Post-Operation:** • End user (car driver, ACC) takes relevant actions • Shockwave is mitigated. • Traffic flow is harmonised.
Display / Alert principle	Triggering condition is – shockwave situation recognition on C-ITS-S. Displayed Information - Speed recommendation on V-ITS-S display or ACC activation on car control system. 
Functional Constraints / Dependencies	Advisory speeds should match or be lower than the legal speed limit (static and dynamic speed limits).

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	The coverage of users participating should be large enough to have a real impact. Note: Data form existing physical cross measure sections lowers the level for necessary coverage.
Interoperability requirements	
Message profile requirements	• The IVI Message for SWD is profiled in chapter 3.2.2 of the *C-ITS-Infrastructure Functions and Specifications* document. • For this use case ISO 14823 DF is set with serviceCategoryCode = informative (13), nature = 8, serialNumber = 87 • vehicleCharacteristics are not used • applicableLanes are used only if applicable to specific lanes Such complex scenario as SWD can use other signage or information to influence the traffic. Examples are lane advice, time headways, release of hard shoulder, or Sign-distanceBetweenVehicles (EN ISO 14823).
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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1.2.5 IVS - Other Signage Information (IVS-OSI)

Use case introduction IVS-OSI	
Summary	The aim of this use case is to display signage information to road users other than the speed limit and free text information presented in previous use cases, e.g. bans on overtaking. The information will either reproduce what is displayed at a physical VMS (e.g. variable text panel) or display a completely new message that does not mirror a physical VMS (a virtual VMS).
Background	This use case is meant to inform drivers via in-car information systems about static and dynamic traffic regulations and traffic advice as indicated on either physical road signs along the road or the notion of virtual VMS i.e. where a physical VMS is not present. Today, VMS systems are used by road operators to send operational, tactical or strategic information to road users. Different types of systems are used, with both static pictograms and text and variable pictograms and text on: • Variable Message Signs (VMS) • Variable Text Panels (VTP) • Variable Direction Signs (VDS)
Objective	To improve traffic safety by using additional means and communication channels to inform drivers about traffic regulations and traffic advice otherwise provided via conventional signage
Desired behaviour	The vehicle driver adapts his/her driving behaviour compliant to the applicable driving regulations and any advice or guidance provided. In the future, the information may be used by Advanced Driver Assistance Systems for supported and automated driving.
Expected benefits	• The primary expected impact is more attentive driving by providing actual and continuous information on road signage (e.g. prohibition to overtake for trucks), which improves traffic safety as it reduces (the severity of) accidents and reduces congestion. • Other benefits presenting information in the language as selected by the driver, or to present only information relevant for vehicle type (e.g. restrictions for trucks).
Use case description	
Situation	This use case contains currently valid and continuous information on, e.g.: ○ Speed advice: in-car information on the current speed advice, based on a specific traffic situation along the route. The speed advice can be used to: ○ Reduce the growth of a (potential) traffic jam detected in the downstream direction ○ Reduce a (potential) traffic jam detected in the downstream direction ○ Detected hazardous situation (e.g. weather (rain, fog, wind), road status (slippery road, hole, object on road) or approaching emergency vehicle; ○ Overtaking prohibition: in-vehicle information on actual overtaking prohibition, especially for trucks ○ In-vehicle information about potentially dangerous situations and road construction / road works

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	○   *Figure 5 and 6 Examples of Other Signage Information*
Logic of transmission	I2V Broadcast
Actors and relations	• Road user: receives IVS information, warnings and/or guidance on the in-vehicle display. • Road operator: provides information on (dynamic) road signage • Service provider: disseminates the IVS information to the road user. If the IVS information is disseminated using a direct communication link between road operator and road user, the road operator acts as the service provider. If communication is using an external communication network, either the operator of that network or the service recipient (car manufacturer) itself becomes service provider.
Use Case Scenario	While driving on a highway, vehicle drivers receive currently valid IVS related information, warnings and/or guidance directly in their vehicle. This may include an advice to reduce speed, change lanes, conform to regulations or warnings of other kinds.
Display / alert principle	Other signage information shall be displayed to the road user and shall be consistent with the actual dynamic traffic signs. If presented, the information needs to be displayed to the driver early enough and in an appropriate location.
Functional constraints / dependencies	• How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information may be translated to the preferred language of the driver. • The information presented by means of I2V is not legally binding: Information should be handled as 'convenience information' and presented accordingly to the road user, as currently done within navigation systems. presented accordingly to

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	the road user, as currently done within navigation systems.
Interoperability requirements	
Message profile requirements	• The IVI message for IVS-OSI is profiled in chapter 3.2.2 of the *C-ITS Infrastructure Functions and Specifications* document. • With respect to “End of the restriction”: serviceCategoryCode = informative (13), nature = 6, serial number = 63 for ‘end of all restrictions by electronic signs’ may be used to if this electronic sign is shown. This ending message might be redundant to the end point of the relevance zone of the initial IVI message. • vehicleCharacteristics are not used as clearance consigns are applicable to all vehicles. • applicableLanes is used and each lane of the road shall be described. • extraText is not used.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2 Hazardous Locations Notification (HLN)

2.1 HLN: Service introduction

Service introduction HLN	
Summary	This C-ITS service describes an I2V warning message related to one or a series of potentially hazardous events on the road, where the approaching road users get information and therefore warning about the location and type of hazard they are approaching and – if available – also the duration of the event.
Background	Hazardous locations/situations create a risk for road users potentially causing (more) accidents resulting in injuries/fatalities. This C-ITS service has the potential to directly inform involved and relevant road users so they can adapt their driving behaviour accordingly.
Objective	To inform road users of hazardous locations on their route in order to enhance overall road safety by providing in-vehicle information about hazards, including the location and type of hazard, possibly also the remaining distance to the location, the duration of the events creating the hazard and lane and speed advice.
Expected benefits	More attentive driving while approaching and passing a hazardous location. Minimize risk of collisions/accidents resulting in less incidents / injuries / fatalities amongst road users.
Use Cases	The events and therefore the use cases of the C-ITS service group HLN –Hazardous Location Notifications can be, for example, the following warnings as use cases: • Accident Zone, (Abbreviation: HLN – AZ) • Traffic Jam Ahead, (HLN – TJA) • Stationary Vehicle, (HLN –SV) • Weather Condition Warning, (HLN – WCW) • Temporarily Slippery Road (I2V), (HLN – TSR) • Animal or Person on the Road (I2V), (HLN – APR) • Obstacle on the Road (I2V), (HLN – OR) • Emergency Vehicle Approaching, (HLN-EVA) • Emergency Vehicle in Intervention (HLN-EVI) • Railway Level Crossing, (HLN-RLX) • Unsecured Blockage of a Road (HLN-UBR) • Alert Wrong Way Driving (HLN-AWWD) • Public Transport Vehicle Crossing (HLN-PTVC) • Public Transport Vehicle at a Stop (HLN-PTVS) Other HLN use case descriptions are under review and may be added in future releases.

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2.2 HLN: Use Cases

2.2.1 HLN - Accident Zone (HLN-AZ)

Use case introduction HLN-AZ	
Summary	The road operator detects that an accident has happened on the network and broadcasts the information to road users who can benefit from this information.
Background	This use case is about exchanging information about accident zones between infrastructure and vehicles and describes the following scenario: • Sending event information from the TCC to the vehicles This scenario (TCC to vehicles) deals with the available infrastructure content (mainly the kind of events which are available in the TCC) and how this content / these events can be mapped into coded accident information.
Objective	To warn road users of accident zones ahead and around their position in order to enhance overall road safety.
Desired behaviour	Precisely and correctly inform drivers to adapt their driving behaviour (e.g. reduce the approaching speed, drive more cautiously , etc.) before and whilst passing of the accident zone.
Expected benefits	• Enhanced road safety for the society and lower numbers of persons killed or injured by traffic accidents • Lower numbers of incidents and secondary damages following a dangerous situation on the road for road operators and drivers • Higher quality of traffic information services for service providers • More relaxed/comfortable driving for drivers
Use case description	
Situation	The driver gets informed about an accident zone in their vicinity, and according to their driving direction and validity is informed about the warning message. .
Logic of transmission	I2V broadcast
Actors and relations	• **Road operator:** provides information about the accident zone detected on the road network mentioned in the use cases specifications and distributes respective warnings as C-ITS messages • **Service provider:** distributes C-ITS messages actively and dynamically to the subscribers (end users) • **Road user**: The road user is informed about the accident zone ahead on their route by their chosen channel of information.
Use case scenario	• An accident is detected and confirmed in the TCC, the warning message is coded according to the specified definition and send via defined channels to a ITS station which broadcasts the information. • The road operator generates the event information within the TCC and distributes it via various channels with one message ID to vehicles - e.g. I2V broadcast • The service provider collects and distributes the AZ C-ITS message from his active users in the area. • The road user is informed ahead of the accident zone.

Display / alert principle	Sending event information from the road operators back-office systems in the TCC to a C-ITS system which then creates and broadcasts C-ITS messages based on that content (I2V broadcast). When the road user approaches an accident zone, the vehicle receives C-ITS messages which allow the driver to adjust behaviour (e.g. speed and position) on the road to reduce risk. The information can then be displayed on the In-Vehicle HMI early enough and should be only moderately intrusive (at the manufacturer's decision).
Functional constraints / dependencies	• The information quality of the "Accident Zone" use case mostly depends on the accurate detection of the event and the confirmation level / maturity of the information in the back-office systems / TCC of road operators. • For service providers the overall speed and latency in message generation and transmission as well as the selection of the geographical dissemination area, including a single warning message ID, is a major dependency to implement this use case successfully. • Various sensor measurements and procedures for traffic detection are needed in the back-office systems of the road operators in order to generate accurate information for the "Accident Zone" use case. Therefore, restrictions towards the availability of the service according to the limitations of the sensors used for events detection could apply.
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-AZ is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 2 (accident) and subCauseCode is between 0 and 7 except 6 (vehicle; which is implicit for an accident).
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.2 HLN - Traffic Jam Ahead (HLN-TJA)

Use case introduction HLN-TJA	
Summary	A road operator detects a traffic jam, and sends the information to the road user (mentioning the position, the length of the traffic jam and the section/ lanes concerned if the information is available).
Background	With C-ITS, the availability and the precision of the traffic jam ahead warning is better than conventional means, and therefore drivers are warned with higher information quality, including the accuracy of the road segments, possibly lanes involved and the vehicle speeds.
Objective	The objective of this use case is to inform about a queue but more importantly to inform about a potentially dangerous end of queue. The drivers can modify their driving approach (speed, lanes) towards the end of the queue. The precision of the end of queue is usually very low. This use case could help to improve it since it can be signalled by vehicles encountering it, if they are adapting their speed and/or vehicle trajectory nearby the end of traffic jam zone.
Desired behaviour	• Well informed drivers adapting their driving behaviour (e.g. reduce their approaching speed, before arriving at the end point of the traffic jam and while passing it). • Precisely and correctly informed drivers also drive more cautiously or concentrated nearby the end of traffic jam area. • The constant speed adaptation of single vehicles when approaching the end of queue area has also an impact on the overall traffic flow.
Expected benefits	More homogenous traffic flows with less congestion, caused by accidents, leading to: • Economic benefits: saving resources, money and time for all stakeholders • Social benefits: traffic safety, reduced number of incidents • Personal benefits: more comfortable driving. • Environment benefits: reduced CO2 emissions and environmental pollution.
Use case description	
Situation	I2V • the traffic jam could be on one specific lane (e.g. at an exit of a motorway) of a motorway section or • on the whole section The TJA warning message for the respective lane or road section is sent out to end users approaching the traffic jam area on various channels of information, but with one message identity.
Logic of transmission	I2V
Actors and relations	• The road operator discovers and confirms TJA situations and forwards them to the C-ITS System • The operator in the TCC or (one or several) equipped vehicles breaking is/are the sender of the TJA warning • Service provider: disseminates TJA related information, to/from vehicles/drivers • End receiver is the mobile C-ITS station in the vehicle (and in the future possibly ACC system) or the driver • Sources of information can be: ○ Cameras (incident detection ones as well)

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	○ traffic loops ○ Operating agents/road operator equipped patrol vehicles ○ Other vehicles which have detected the danger The TJA warning message for the respective lane of the vehicle or road section is sent out to end users approaching the area.
Use case scenario	I2V 1. The operator in the TCC gets informed about a traffic jam on the road network ○ He puts the information in his TCC, confirms it with its length and/or lane and the message is then broadcasted to the road users 2. The vehicles nearby the traffic jam area receive the information and display it to their drivers. 3. The driver adapts driving behaviour. 4. In future the in-vehicle TCC-ACC system could follow the warning message related advice directly 5. The road operator can have a system to automatically update the length and/or lane of the traffic jam, and communicates the end of the traffic jam area, when regular travelling speed is confirmed.
Display principle / alert logic	• The in-vehicle information should be adapted to the relative position between the vehicle and the TJA warning positions. • The display could be different according the position of the receiving vehicles or not even happen if the other vehicle is too close to the end of queue. • The in-vehicle information could inform the driver that TCC-ACC is active and working according to the driver's set of preferences. • The user is provided with related information, displayed on the dashboard. Layout and sequence of presentation is left to specific implementation.
Functional constraints / Dependencies	• The precision of the information of the end of queue from the road operator can be low depending on the systems to update them and the available information sources used by the road operator, e.g. if these are single sensor networks like loop detectors, the highest precision will be the road section length between two installed loop detectors, which would mean low quality of localization of the end of the queue. • The equipped vehicles as probe data (or source of information) could enhance the quality of localization and improve awareness of drivers which are approaching the traffic jam zone. For high accuracy of this use case it needs to have a high percentage of equipped vehicles included in the message generation at the end of the traffic jam area.
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-TJA is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 27 (dangerous end of queue) and subCauseCode is 0 (unavailable). For conveying information about the whole length of the queue, causeCode 1 (traffic congestion) and subCauseCode 0 is used.
Security and data protection requirements	
Communication technology requirements	
Test and validation	

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requirements	

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2.2.3 HLN - Stationary vehicle (HLN - SV)

Use case introduction HLN-SV	
Type of road network	All road networks, forwarding mainly on motorways
Type of vehicle	All vehicles
Summary	• Stationary Vehicle(s) service warn approaching drivers about stationary/broken down vehicles ahead, which may represent obstacles in the road. It is a preventive safety service, as drivers will have advanced notice and more time to prepare for the hazard. • The road operator could have an event management system and insert also a conventional (non-C-ITS) vehicle broken down, and trigger an I2V message to warn other vehicle drivers. • In line with the ETSI ITS standard, this service could rely on V2V ITS G5 communication, and in particular, on the messages broadcast by the stationary vehicle and processed/filtered by nearby receiving vehicles. • An interesting variant of use case, which adds to the quality of the information, is when the stationary vehicle information is also processed by a nearby roadside unit and then, to further distribute the same warning via the roadside infrastructure, other RSU´s connected via the road operator distribute the SV warning via resending it.
Background	• While the C-ITS platform presents a single entry for this use case, ETSI TR 102 638 V1.1.1 [2] includes two distinct use cases: Slow vehicle warning as a use case of cooperative awareness application, and stationary vehicle as a use case of road hazard warning application. • The Stationary Vehicle warning is achieved through a DENM message (event notification) by the sender vehicle application which, based on the vehicle state (broken, stopped with emergency lights on, etc.) which broadcasts to nearby vehicles a notification with a specific Stationary Vehicle cause code. • The variant of I2V information about stationary vehicle was tested concerning the I2V part, i.e. infrastructure informs vehicles of a stationary vehicle. • So far, no thorough and operative scenario demonstration has been done, where stationary vehicle, roadside unit(s) and incoming vehicles share all the same hazard in a fully cooperative manner, so that as many interested vehicles as possible are informed.
Objective	To avoid collisions (mostly rear-end) with stationary vehicles on the road and enhance road safety.
Desired behaviour	• The vehicle driver adapts their driving behaviour, slowing down or changing lane. • Because the I2V warning is targeted and accurate from the event management system of the road operator the reliability is high and improves the driver attention near to these traffic situations or areas. • In the future the information may be used by Advanced Driver Assistance Systems for supported and automated driving. In addition, the driver awareness is raised to the possible presence of vulnerable road user(s) (VRU) on the road.
Expected benefits	• As reported in the Study of the Deployment of C-ITS in Europe [1] summarizes, main benefit is expected on road safety, minimal impact expected in traffic efficiency and fuel consumption. • Concerning safety, this service helps to prevent dangerous manoeuvres, giving

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	drivers advanced notice and more time to prepare for the hazard and take appropriate countermeasures also for possible vulnerable road users nearby.
Situation	Road operators event management system forwarded to C-ITS a Stationary Vehicle(s) is expected to inform road users of stationary vehicle in front.
Logic of transmission	I2V, (with V2I combined with V2V broadcast as additional input source);
Actors and relations	**Road operators**: (to detect within their event management systems slowly moving or broken-down vehicles) verify and forward C-ITS messages via different communication channels with one warning message ID **Road users:** as one information source and end user of SV warning message, **Service providers**: distributing positions of stationary vehicles via different networks to their users approaching the event position of the warning Sources of information can be: • Cameras (incident detection ones as well) • Operating agents/RO equipped patrol vehicles • Other C-ITS-equipped vehicles which have detected the danger.
Use Case Scenario	I2V Scenario: • A conventional (non-C-ITS) vehicle or a C-ITS equipped vehicle is or stopped and the road operator has determined it as such • the road operator generates an appropriate warning message that is sent I2V via the C-ITS System in the relevant zone • approaching vehicles receive the warning and drivers adapt their behaviour.
Display principle / Alert logic	• The user is provided with related information, displayed on the dashboard. Layout and sequence of presentation is left to OEM-specific implementation. • The display to the driver needs to be early enough to adapt their vehicle's speed but not too early that the alert is forgotten. The alert can be repeated when nearer to the position of the event.
Functional constraints / Dependencies	The document ETSI TS 101 638 V1.1.1 defines the requirements For stationary vehicle warning, functional requirements are ○ *Capability for a vehicle, from detecting a dangerous stationary vehicle, to broadcast e.g. in V2X DENM its current stationary situation or position.* ○ *Capability for concerned vehicles (on the same road, and same heading of the stationary vehicle) to receive and process e.g. the V2X DENM's* A stationary vehicle use case is achievable if the receiving vehicle software can warn the driver based on absolute/relative speed thresholds (such as, e.g. in forward collision warning). For stationary vehicle warning, non-functional requirements are ○ *Minimum frequency of the periodic message: 10 Hz.* ○ *Latency time less than 100 ms.* For generating the vehicle-based warning in the same way for a fast detection of slow or stationary vehicles at the Roadside a common implementation of the triggering conditions in the vehicles is requested.

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	Sources of information: [1] Study of the Deployment of C-ITS in Europe: Final Report, pp 158-160, 2016, includes references to the EU projects here mentioned [2] ETSI TR 102 638 V1.1.1 (2009) for the two use cases as seen by ETSI and related requirements [3] C-ITS Platform final report, includes WC within the day 1 services [4] ETSI TS 101 539-1-V1.1.1 Road Hazard Signalling (RHS) application requirements specification [5] ETSI TS 101 638 V1.1.1
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-SV is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS ~~Infrastructure Functions and Specifications~~Message Profiles and Parameters 1.7.0* document. • For this use case, causeCode is 94 (stationary vehicle) and subCauseCode is 0 (unavailable) or 2 (breakdown vehicle). • stationType: 15 (roadSideUnit) • eventHistory: Unfortunately a range of specific uses in the general DENM table, which are believed all not applicable to stationaryVehicle, proposal to state 'not used' • eventSpeed: 'standstill' • eventPositionHeading: 'not used' • 'alacarte': 'not used'
Security and data protection requirements	The requirements of the C-Roads *C-ITS Security Requirements and Specifications 1.7.0* apply to this use case For this use case the required SSP must be present in the certificate used to sign messages containing the DENM cause code "stationary vehicle", see chapter xyz.123 . of the *C-ITS Security Requirements and Specifications 1.7.0.*
Communication technology requirements	If this use case is implemented with ITS G5 the requirements of the following documents apply: • *C-ITS Roadside ITS G5 System Profile 1.7.0* • *C-ITS Mobile Roadside ITS G5 System Profile 1.7.0* Additional specific requirements from TF3 to be determined/received If the implementation of this use case is IP based the requirements of the following document apply: • *C-ITS IP Based Interface Profile 1.7.0* Additional specific requirements from TF4 to be determined/received
Test and validation requirements	List of applicable Generic Test Cases: 1. ITS-G5 only: • TC_CROADS_Generic_ITSG5_DENM_Position_01 • TC_CROADS_Generic_ITSG5_DENM_Traces_02 • TC_CROADS_GENERIC_ITSG5-DENM_TIMING_03 • TC_CROADS_GENERIC_ITSG5-DENM_CANCEL_UPDATE_04 2. Hybrid (cellular only):

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	• TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01 • TC_CROADS_Generic_HYBRID_DENM_Traces_02 • TC_CROADS_GENERIC_HYBRID-DENM_Timing_03 • TC_CROADS_GENERIC_HYBRID-DENM_Cancel_Update_04 List of applicable Specific Test Cases: 1. ITS-G5 only: • TC_CROADS_HLN-SV_ITSG5-DENM_Lanes_08 • TC_CROADS_HLN-SV_Hybrid_DENM_Causecodes_13 2. Hybrid (cellular only): • TC_CROADS_HLN-SV_Hybrid_DENM_Lanes_08 • TC_CROADS_HLN-SV_ITS-G5_DENM_Causecodes_13 For the specific TCs TC_CROADS_HLN-SV_ITSG5-DENM_Lanes_08 and TC_CROADS_HLN-SV_Hybrid_DENM_Lanes_08, the Lane Number needs to be handled by the road's infrastructure.

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2.2.4 HLN - Weather Condition Warning (HLN-WCW)

Use case introduction HLN-WCW	
Type of road network	All road networks
Type of vehicle	All vehicles
Summary	Weather Conditions Warning (WCW) use case shows both static and dynamic information of weather conditions and road status in-vehicle. As reported in the Study of the Deployment of C-ITS in Europe: Final Report, this service provides *(...)accurate and up-to-date local weather information. Drivers are informed about dangerous weather conditions ahead, especially where the danger is difficult to perceive visually, such as black ice or strong gusts of wind.* *Vehicles are sent information from roadside units warning the driver of dangerous, or changeable weather conditions. Alternatively, the messages may be transmitted via the cellular network. This service is applicable to all roads and vehicle types.* [1]
Background	With reference the Commission Delegated Regulation (EU) 886/2013, weather condition is within the minimum set of road safety-related traffic information services free of charge to users on the European Roads (Article 3, category (h)). Article 2 defines exceptional weather conditions as *unusual, severe or unseasonal weather conditions which might affect safe driving* [2]. The Weather Conditions Warning (WCW) I2V service is intended to inform drivers via in-vehicle information systems of static and expected information of weather conditions and road status along the road. Both advisory events are in scope of WCW. WCW information is provided by means of Infrastructure-to-Vehicle (I2V) communication, referring to a sub use case of Hazardous Location Notifications, as in ETSI TR 102 638 V1.1.1 [3] and coherently in the C-ITS Platform final report [4].
Objective	To improve traffic safety via additional means of C-ITS messages to inform drivers in a more accurate way about weather conditions and road status information.
Desired behaviour	• The vehicle driver adapts their driving behaviour compliant to the applicable driving regulations and any advice or guidance provided. • In the future the information may be used by Advanced Driver Assistance Systems for supported and automated driving.
Expected benefits	• The primary expected impact is more attentive driving by providing actual and continuous (expected) information on road conditions (e.g. poor road traction conditions, visibility, wind, rainfall etc.) and, which improves traffic safety as it reduces (the numbers and the severity of) accidents. • A topic of future day 2 C-ITS services can be to evaluate, the applicability of this concept to Autonomous Driving functions.
Situation	WCW is expected to inform drivers of current and/or expected information related to precipitation or extreme weather conditions (scenario 1), or low visibility ranges due to, for example, fog (scenario 3).
Logic of transmission	I2V broadcast

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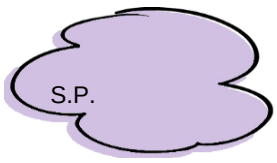
Actors and relations	The actors are: road operator, (e.g. Weather Information) service provider, end user, vehicle driver or vulnerable road users. **Road operator:** validates warning, issues triggering information via different communication channels with one message ID **Service provider:** collects and ensures triggering information is correct, triggers I2V warning, and/or aggregates information in cloud service. **Weather information provider:** shares real-time information with the road operator, or TCC **End User:** receives the warning via the on-board unit and/or receives notification that the automatic vehicle control is taking adverse weather conditions into account. **Vehicle driver:** is informed about dangerous weather conditions ahead in time to adapt the driving behaviour **Vulnerable road users**, or special vehicle categories (e.g. PTW) could receive adapted WCW messages Additional Information sources for the use case could be as follows: • Roadside sensors/weather forecasts provide weather data. • C-ITS vehicles
Use Case Scenario	I2V The operator in the TCC gets informed about extreme weather conditions (and the consequences: e.g. low visibility,) on his network He puts the information together, confirms it in his TCC and the WCW message is then distributed via different communication channels and broadcasted to the road users The vehicles receive the information and display it to the driver. The driver adapts his behaviour. Additional scenarios can be implemented as follows: Scenario 1: data are sent directly but after the TCC confirmed the data and the triggering conditions   Scenario 2: the vehicle gets the WCW message and asks to the Service Provider (linked to TCC) for a confirmation of the data already on-board, and displays the message in time to react.   The event is cleared by the respective actors involved in each scenario by the end of lifetime with a next update. The sources of information for this use case are the following: [1] "Study of the Deployment of C-ITS in Europe : Final Report, pp 158-160, 2016, includes references to the EU projects mentioned

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	[2] Commission Delegated Regulation (EU) No 886/2013 of 15 May 2013, for definition of weather warning [3] ETSI TR 102 638 V1.1.1 (2009), for Hazardous location notifications [4] C-ITS Platform final report, includes WC within the day 1 services [5] ETSI TS 101 539 1, reports WC requirements [6] ETSI-EN-302-637-3-V1.2.2 (2014-11), specifies the data structure
Display principle / alert logic	• The user is provided with related information, displayed on the dashboard. Layout is left to OEM-specific implementation. • The WCW message is displayed early enough for the driver to be able to adapt the driving behaviour, and at the same time not too distant from the affected road segment. • The distribution of this warning message to end users can be wider than the single road segment or area affected.
Functional constraints / dependencies	The document ETSI TS 101 539 1 defines Adverse Weather condition specific functional requirements, as part of Road Hazard Signalling (RHS), clause 6.3.6. It includes: • *DENM transmission conditions.* • *Event triggering condition* • *Relevance area* • *Event termination condition* • *Use case specific data element values to be provided*
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-WCW is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 17 (extreme weather condition) or 19 (precipitation).
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.5 HLN - Temporarily slippery road (HLN-TSR)

Use case introduction HLN-TSR	
Type of road network	**All**
Type of vehicle	**All**
Summary	A road operator knows that a section of a road (or a single lane or point) is temporarily slippery and sends thus information to the road user, or/and a vehicle detects that it is slipping and broadcasts an alert message to other vehicles. The combination of these two information sources within a C-ITS system makes it possible to generate much better information quality and accuracy compared to both single sources used up to now.
Background	• Today information about slippery road sections is very limited, and this information is provided only by VMS. • With C-ITS, the availability is better, the coverage and the information quality is much improved using a I2V and V2V C-ITS System which complement each other. • This use case could decrease the risks of accidents by broadcasting this information more largely and reach the end user in many more driving situations than today.
Objective	The objective of this use case is to increase the awareness of drivers about dangerous slippery sections to make the drivers adapt their speed and trajectory to the situation.
Desired behaviour	• Increased driver attention • Adaptation of the driving speed • Change of lanes (if needed) • Rerouting (e.g. for HGV or specific vehicle categories)
Expected benefits	• Reducing the risk of accidents • Improved traffic management
Situation	• Depending on the cause of the slippery section, this use case can concern both directions of roads, even for dual carriageways. • Dealing with this information can be different for HGV or passenger vehicles since HGV might even adapt their itinerary completely. • Natural causes and/or spillage of various materials on the road are possible reasons for this risky situation and the warning generation: - oil, chemical fluids etc. - rolling elements (e.g. bottles, golf balls, fruits,) - black ice or water • - etc.
Logic of transmission	I2V Broadcast; V2V logic Broadcast
Actors and relations	• **Road operator** generates the warning in the TCC and sends it to the C-ITS systems and various communication channels with one message ID • **Service provider** forward the warning messages to their users, and contribute to the detection of slippery road segments. • **End-user** is the driver, for detected slippery segments by the vehicle sensors he is also the generator of the data / information.

	• Or sender is the vehicle detecting the slippery road • End user are all vehicles around or ahead of the slippery road segment. Other sources of this information can be • Cameras • Phone call of a witness • Operating agents • C-ITS equipped vehicles with sensors which have detected the danger
Use Case Scenario	I2V • The operator in the TCC gets informed about a section that is slippery on the road network • The TCC operator puts information into the TCC systems and the message is then broadcasted to the road users by the C-ITS system and by various communication channels with one message ID • The vehicles receive the information and display it to the driver. • The drivers adapts their behaviour.
Display principle / Alert logic	• The user is provided with related information, displayed on the dashboard. Layout is left to OEM-specific implementation. • The alert needs to be early enough for the driver to adapt their speed without stress, but not too early so that the driver does not forget about the alert.
Functional constraints / Dependencies	• The vehicles might have to deal with two different sources of information for this use case: e.g. from other vehicles and from the TCC. Both information could inform about a similar event but not exactly with the same warning message, therefore the vehicle will have to deal with the priority between both messages. • For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully, and to deliver high quality warning messages to the TCC. • Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators in order to generate the information about all the slippery road segment locations for this use case. Therefore, restrictions of the service-availability could apply. • The Information quality of this use case temporarily slippery road depends mainly from the detection of the event “temporarily slippery road” and the confirmation/ maturity of the information.
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-TSR is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications document*. • For this use case, causeCode is 6 (adhesion) and subCauseCode is between 0 and 9.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.6 HLN - Animal or person on the road (HLN-APR)

Use case introduction HLN-APR	
Type of road network	All
Type of vehicle	All
Summary	• A road operator knows that one or several animal(s) is(are) present on the road network and broadcasts the information to road users, or • A driver detects one or several animals on the road and signals that information via his HMI, broadcasting a message to road users, or both situations or warnings are combined.
Background	• Today, this information is typically provided only by the VMS or radio. • With C-ITS, the availability is better. The update of the information can also be improved (moving animal). • Wandering animals are not easily detectable. Such a use case can be an added information for the road users.
Objective	The objective of this use case is to alert a road user of a potential danger. Since there is usually no automatic detection, and the animal can be moving quite fast the accuracy of the localization is not very high. Hence, the road user needs to increase his driver attention.
Desired behaviour	• Increased driver attention • Adaptation of driving speed • Change of itinerary (e.g. because of a flock of animals in mountains)
Expected benefits	• Reducing the risk of accidents • Improved traffic management
Situation	• The starting situation of this use case can be several situations like a vehicle breakdown, an accident or a person taking a call, for which persons or also animals are on a part of the road network, and their movements are a dangerous situation for all involved in the area. The dangerous situations like - persons present or - a flock, or group of animals need to be detected, and the warnings created and distributed to all possible road users involved. • According to the type of the road (and the speed limit consequently), the danger can be more or less important. A flock of animals in the mountains can be quite frequent for example.
Logic of transmission	I2V Logic Broadcast
Actors and relations	I2V Sender is a road operator in the TCC End-receiver is the road user Sources of information can be: • Cameras

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	• Phone call of a witness • Operating agents or • Other C-ITS equipped vehicles which have detected the danger with various – C-ITS messages as follows:
Use case scenario	I2V: • The operator in the TCC gets informed about the presence of one or several persons or animal(s) on his network. • The TCC operator puts the information in the TCC systems and the message is then broadcasted by the C-ITS system on various communication channels with one message ID to the road users • The vehicles receive the information and display it to the driver. • The drivers adapt their behaviour.
Display principle / alert logic	• The display to the driver needs to be early enough to adapt their speed or itinerary (in case of a flock for example). However, since the driver should not forget about the alert, it could be repeated closer to the location. • The information could be displayed differently according to the type of the road. • HMI Layout and the sequence of presentation is left to OEM-specific implementation.
Functional constraints / dependencies	• For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully. • Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators in order to generate the information about persons/ animals detected on road segment locations for this use case. Therefore, restrictions of the service-availability could apply. • The Information quality of this use case depends mainly from the detection of the event “animals or persons on the road” and the confirmation/ maturity of the information. • The localisation can be very imprecise. And the information cannot always be verified by the road operator.
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-APR is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 11 (animal on the road) or 12 (human presence on the road).
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.7 HLN - Obstacle on the road (HLN-OR)

Use case introduction HLN-OR	
Type of road network	All
Type of vehicle	All vehicles
Summary	A road operator knows that there is one or several obstacles on one or several lanes of his network and broadcasts the information to road users. However, traffic can still pass the obstacles (not a blockage).
Background	Today, this information is typically provided only by the VMS or radio. With C-ITS, the availability is better.
Objective	The objective of this use case is to alert a road user of a potential danger. Since there is no automatic detection, the accuracy of the localization is not very high. Hence, the road user needs to increase driver attention.
Desired behaviour	• Increased attention • Adaptation of the speed • Change of lanes (if needed)
Expected benefits	• Reducing the risk of accidents • Improved traffic management for road operators
Situation	The obstacles can be small and not harmful and still be dangerous since they can surprise the driver, who could brake or show unpredictable behaviour if not alerted. There can also be big obstacles, such as lost furniture for example from a HGV, etc., that could result in the closure of a lane.
Logic of transmission	I2V Broadcast, V2V Broadcast
Actors and relations	(I2V) Sender is a road operator in the TCC End-receiver is the driver Sources of information can be: • Cameras • Phone call of a witness • Operating agents or • Other vehicles which have detected the danger and vehicle C-ITS messages as possible source of information
Use case scenario	I2V: • The operator in the TCC gets informed about the presence of one or several obstacle(s) on his network. • The TCC operator puts the information in the TCC system and the message is then broadcast by the C-ITS system on various communication channels with one message ID to the road users. • The vehicles receive the information and display it to the driver. • The drivers adapt their behaviour.
Display principle /	• The displayed warning to the driver needs to be early enough to adapt their speed

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alert logic	or even their itinerary. However, since the driver should not forget about the alert, it could be repeated closer to the location. • The information could be displayed differently according to the type of the road. • HMI layout and the sequence of presentation is left to OEM-specific implementation.
Functional constraints / dependencies	• For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully. • Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators in order to generate the information about persons/ animals detected on road segment locations for this use case. Therefore, restrictions of the service-availability could apply. • The Information quality of this use case depends mainly from the detection of the event “animals or persons on the road” and the confirmation/ maturity of the information. • Due to the dynamic event the localisation can be very imprecise. And the information cannot always be verified by the road operator.
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-OR is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 10 (obstacle on the road) and subCauseCode is between 0 and 5 (6 and 7 are not used).
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.8 HLN - Emergency Vehicle Approaching (HLN-EVA)

Use case introduction HLN-EVA	
Summary	The emergency vehicle is equipped with the necessary technology for a vehicle-to-vehicle (V2V) communication to send appropriate messages and alert the road users in advance.
Background	Obstructions in connection with emergency vehicles often occur due to road users, which receive the information about an approaching emergency at very short notice. Limited visibility, for example due to bad weather conditions, reinforces the critical situation. Additionally, a high driving speed difference between the emergency vehicle and the road users while an emergency increases the risk of accidents.
Objective	The objective is to reduce the number of accidents in connection with emergency vehicles. Safety of the personnel and road users can be increased. Additionally, the travel time for the emergency vehicle can be reduced by fostering the formation of an emergency corridor in advance.
Desired behaviour	The informed road users adapt their driving behaviour accordingly. The road user can adapt the vehicle speed and the usage of the lane conforming to the information.
Expected benefits	• More attentive driving while an emergency vehicle is approaching. • Minimize risks to collisions and accidents. • Faster formation of the emergency corridor and therefore reduced travel time for the emergency vehicle due to a proper emergency corridor. • Avoidance of congestion
Use case description	
Situation	• The emergency vehicle, which can be approaching from behind, or stand still nearby the accident in front of the traveller, sends appropriate messages to the road users. • The road user is precisely informed about the emergency vehicle.
Logic of transmission	Vev2V Broadcast[1]
Actors and relations	• **Emergency vehicle**: sends appropriate messages to the environment for the road users to receive. • **Road user**: receives message sent by the emergency vehicle. The road user is informed about the situation and can act accordingly.
Scenario	The emergency vehicle is sending appropriate messages to the road users nearby: (1) The road users receive the information about the approaching emergency vehicle from behind and can adapt their driving behaviour accordingly. (2) The road users receive the information about an emergency vehicle in front and can adapt their driving behaviour accordingly. (3) The road users receive information about a stationary emergency vehicle, which for example, guards against an accident, and adjusts their driving behaviour and speed accordingly.
Display / alert principle	(1) The emergency vehicle sends appropriate messages to the road users nearby as soon as the light bar is active.

[1]Vev2V = Emergency Vehicle to Vehicle

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	(2) As soon as the light bar is off the emergency vehicle stops sending DENMs. (3) If the hand break is pulled, the emergency vehicle sends a DENM with the information that a stationary emergency vehicle is on the road. (4) The road user receives the information about the approaching emergency vehicle. (5) The road user adapts their driving behaviour accordingly.
Functional constraints / dependencies	This use case has been described and harmonized with just limited input from the stakeholder group of emergency responders. Their representation in C-Roads is only very limited. A broader consultation on an EU level with these stakeholders could lead to improvements to this use case.
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-EVA is profiled in chapters 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document: • CauseCode: 95 • SubCauseCode: 1 • RelevanceTrafficDirection: allTrafficDirection
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.9 HLN - Emergency Vehicle in Intervention (HLN-EVI)

Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	The task of the Emergency Vehicle in Intervention (EVI) is to warn drivers about the location (e.g. a traffic accident, rescue and recovery work) of an emergency vehicle in intervention so the drivers will be able to adjust their speed or lane position on the road. The equipped emergency vehicle is sending a warning message when the vehicle is stationary with an activated light bar and being stationary for more than the defined time period. Only the emergency vehicle equipped with the certified C-ITS unit is allowed to send the message.
Background	The place of accident or another type of intervention can be located at unclear sections of the road and could surprise or confuse drivers arriving to the section of the road and could complicate passing the intervention location. This could lead to another accident and could pose a serious danger for the participants of the former accident, drivers and rescue workers.
Objective	Ensure that drivers are informed in a timely manner through C-ITS messages about the place of intervention ahead so it is possible to adjust their speed and distance to lower the risk of other complications or accident. Ensure more attentive driving while approaching and passing the area of an accident by providing in-car information and warnings about the type of rescue and recovery work.
Desired behaviour	• Increased driver attention • Adaptation of the driving speed • Adaptation of the driving trajectory by living space to the emergency vehicle • Providing in-car information and warnings about rescue and position.
Expected benefits	• Reducing the risk of accident with emergency vehicles • Avoid follow up accidents and possible additional confusion on the road • Increased driving comfort • Increasing safety of operation for all participants. • Increased safety of emergency vehicle crews
Use case description	
Situation	If a stationary emergency vehicle stands near the location of the accident or another type of intervention where the rescuers are working. When other drivers are approaching the place of intervention and are in relevant zone they are notified through an application installed in car or mobile device about the position and distance from the intervention. Drivers can adjust their speed and position on the road for easy passing by.
Logic of transmission	$V_{ev}2V$[2], I2V
Actors and relations	• **Road user** receives information on the in-vehicle display about emergency vehicle activity on the road, its distance and exact position, the driver is also notified about rescue and recovery work and the respective traffic limitations he will experience on his way. • **Vehicle emergency driver** uses EVI service “Emergency Vehicle Intervention ” for warning other drivers about the place and position of accident ahead or on another type of intervention on the road when approaching the accident spot also send an information about distance, direction and lane position of emergency vehicle.

[2] $V_{ev}2V$ = Emergency vehicle to vehicle

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	• **Road operator** provides information about the emergency vehicle intervention detected on its network mentioned in the use cases specifications and distributes respective warnings as C-ITS messages to all vehicles approaching the respective road segments involved.
Scenario	**V_{ev}2V** • The equipped emergency vehicle arrives at the incident place • The unit starts to transmit the message when light bars of the vehicle is activated and the vehicle is stationary at least for a predefined time or the warning is activated manually via a HMI device. • Vehicles in the relevance zone receive the message and drivers adapt their behaviour. **I2V** • The road operator generates the event information within the TCC • The correct warning message is coded according to the specified definition and send via defined channels to a roadside ITS station which broadcasts the information • Vehicles in the relevance zone receive the message and drivers adapt their behaviour.
Display / alert principle	• The warning for the driver needs to be displayed early enough for him/her to adapt to cautious driving. However, since he/she should not forget about the alert, it could be repeated closer to the location. • The location information needs to be accurate on road and lane level and related to the physical location of the actual rescue or recovery work. • The warnings may include the type of dangers, distance to the emergency vehicle and lane position. • Instructions may include to change lanes, to prepare for a steering manoeuvre, breaking etc.
Functional Constraints / dependencies	• For road operators the detection quality of the accident and the linked traffic conditions are of high importance to be able to warn precisely and generate a correct message for this use case. • For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully. • The link of this use case with other C-ITS messages need to be carefully taken into account when implementing the warning priorities for mobile units. E.g. on its way towards the location, the equipped emergency vehicle could use the HLN:EVA (Emergency Vehicle Approaching) use case.
Interoperability requirements	
Message profile requirements	• The DENM message for EVI is profiled in chapter 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use-case, causeCode is 15 (rescueAndRecoveryWorkInProgress) and subCauseCode is 1 (emergencyVehicles) • The difference between Vev2V and I2V messages with EVI is just the stationType in DENMs. In case of Vev2V „specialVehicles“ is used and for the I2V it is filled „roadSideUnit“. The other difference can be informationQuality in case the event is set up manually by an operator via GUI.
Security and data protection requirements	
Communication technology requirements	

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Test and validation requirements	

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2.2.10 HLN - Railway Level Crossing (HLN-RLX)

Use case introduction HLN-RLX	
Summary	The railway infrastructure manager or a service provider informs the driver about the presence of a railway level crossing and its type/parameters/status. This use case covers both protected level crossings along with unprotected ones. The messaging to drivers and the information provided is addressed, too.
Background	Very serious accidents, sometimes with a high number of fatalities, occur at railway level crossings. These accidents are often caused by a road vehicle driver overlooking the warning lights of the signalling system and failing to stop in front of the crossing. Even at level crossings with barriers, serious accidents occur due to reluctance of drivers to stop before the barriers are down and, in addition, tendencies of drivers to bypass half barriers during active warning (waiting) phase at a crossing (so called S-manoeuvre). Accidents are also frequent on railway crossings without any signalling protection systems. It needs to be noted that railway level crossings principally differ from road intersections in that the train has always priority and cannot be stopped suddenly and that light warning principles of signalling systems on crossings differ from those on road intersections. Also different legal bodies are responsible for road and railway in Europe (with a few exceptions).
Objective	The driver gets warned about the presence of a railway level crossing to raise his/her attention when approaching it. Special warning is also shown to the driver when the signalling system (when available) detects approaching train. Other use cases and scenarios of light railway crossings involving traffic lights in urban environments with equipment at the crossing can be part of the intersection safety use cases.
Desired behaviour	• Increased driver attention • Adaptation of the driving speed in the vicinity of railway crossing and when passing the crossing according to national speed limits • Stopping the vehicle in front of the crossing if the crossing is in a warning state • Waiting for the train to pass the level crossing
Expected benefits	• Reducing the risk of accident between road and railway vehicles • Reducing the risk of road vehicle accidents in the vicinity of railway level crossings • Increased driving comfort
Use case description	
Situation	A vehicle is approaching a railway level crossing which may be equipped with a signalling system with warning lights and barriers, without barriers, or with a warning cross only. In due time and location the driver is informed about the presence of the railway crossing, and, if warning is active, about the current status of the crossing.
Logic of transmission	I2V broadcast • locally to both sides of the level crossing, covering all roads leading to the level crossing and denoting the boundaries, or stopping points, of the crossing • over the network to various communication channels
Actors and relations	• **Railway infrastructure manager** is responsible that the signalling system generates warnings locally at the railway crossing and distributes respective warnings directly (with low latency) as C-ITS messages to all drivers approaching the crossing or via alternate communication channels.. *In addition, the **railway infrastructure manager** provides this information to the TCC in order to be published by the road operator to other users like navigation information providers,*

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	etc. • **Service provider** receives the warning messages from the railway infrastructure manager and provides them to the end users. He can also maintain (static) database of railway crossings and generate messages based on that (without the information about the state of the crossing). • **End-user** receives the warnings in the vicinity of the railway crossing.
Scenario	**I2V** 1. Basic warning: • Information about the location of the level crossing including the national ID, the type of the level crossing, the number of rail tracks, its length, width, height and other optional information like recommended/maximum passing speed for road vehicles, is available in the railway system. • The information is periodically sent out by the C-ITS system at the crossing directly on various communication channels with one message ID to the road users. • Inclusion of optional information is dependent on the rules of the respective railway infrastructure manager • The vehicle receives the information and displays it to the driver. • The drivers adapt their behaviour 2. Approaching train: • If the approaching train is detected (by the signalling system), C-ITS system will automatically and continuously broadcast/distribute C-ITS message with a special warning about the warning state active at the crossing, including optional information like estimated time to the end of the warning state, direction of the approaching train(s), etc. directly or on alternate communication channels with one message ID to the road users. • Inclusion of optional information is dependent on the rules of the respective railway infrastructure manager • The vehicle receives the information and displays it to the driver. • The drivers adapt their behaviour 3. Railway crossing out of order: • If the railway crossing signalling system is malfunctioning or out of order and such event is detected by the signalling system itself or remotely by the Railway infrastructure manager's means, or if fully closed for traffic, respective warning information is continuously sent out by the C-ITS system on various channels with one message ID to the road users. In case of malfunctioning, which can be demonstrated to the driver in several different ways, it is recommended to send only "long-term warning state" information as the driver may not comprehend precisely the meaning and react in a wrong way. • The vehicle receives the information and displays it to the driver. • The drivers adapt their behaviour
Display / alert principle	• The warning to the driver needs to be displayed early enough and with adequate priority for the driver to adapt his driving. However, since the driver should not forget about the alert, it could be repeated closer to the location. • The user is provided with related information. Layout and sequence of presentation is left to OEM-specific implementation.
Functional constraints / dependencies	Due to strict safety requirements on railway and the danger that the C-ITS system, which is not fail-safe, might, by its failure, send an information valid for another time instant, **no 'positive' information should be sent to the driver and also should not be implemented in the OBU, i.e. informing that the railway crossing is open (no train approaching)**. Only neutral (railway crossing is ahead) and 'negative' (signalling system is broken down or railway crossing closed/train is approaching) information should be given.
Interoperability requirements	

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Message profile requirements	The most suitable type of C-ITS message for this use case is DENM for the status (opened, closed, breakdown, unguarded, ...) and IVI for the restriction and other information (length, width, height, weight, irregular ground, etc.). In addition, a SPAT/MAP can be added relatively to a traffic light, if relevant e.g. in urban area or at freight railway sidings. For the RLX status, currently only the scenario of a risk of collision can be handled by the standard. • The DENM message for HLN-RLX is profiled in the chapter 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document: • CauseCode: 97 • SubCauseCode: 2 It will be used on the following situations: Train is approaching or the signalling system is broken down.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.11 HLN - Unsecured Blockage of a Road (HLN-UBR)

Use case introduction HLN-UBR	
Type of road network	**All**
Type of vehicle	**All**
Summary	An operator in the TCC gets the information that there is a blockage of a road. Till the time that operating agents arrive to the site to protect and manage it, the operator sends a warning message to road users. A blockage means that there is no traffic going through the road segment and passing it by on a single or several lanes., The complete road is blocked (not an obstacle on one or more lanes).
Background	Today, this information is provided only by the VMS or the radio. With C-ITS, the availability of information is better. In mountainous regions for example, where there are a lot of kilometres be driven before road operators reach a site , providing such warning information to drivers before the road operator arrives to the site can be essential.
Objective	The objective of this use-case is two-fold: • For vehicles that are very close to the blockage: to alert them about a danger ahead • For vehicles much more upstream, to allow them to reroute early enough This use case concerns one whole road, or one direction of a dual carriage way.
Desired behaviour	• Increased vigilance of the approaching drivers • Adaptation of the speed • Rerouting if blocked road is far away and rerouting possible for the targeted destination
Expected benefits	• Reducing the risk of accidents • Improved traffic management • Reduce the number of drivers impacted by the road blockage
Use case description	
Situation	• a vehicle close to the blockage is warned of the dangerous situation ahead • a more upstream vehicle is informed to adapt the driving route Causes of blockage: • rocks falling • accidents of HGV • water flood • etc. This use case does not include a single broken down vehicle, or a vehicle blocking a single lane of a dual carriage way road.
Logic of transmission	I2V Broadcast
Actors and relations	• Sender is an operator in the TCC • End-receiver is the driver in the vehicle • Sources of information can be: ◦ Other vehicles which have detected the danger ◦ Cameras ◦ Phone call of a witness ◦ etc.
Scenario	1. The operator in the TCC gets informed about a section of road that is blocked

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	2. He puts the information in his TCC and the message is then broadcasted to the road users 3. The vehicles receive the information and display it to the driver. 4. The driver adapts his behaviour, depending from the distance and driving situation compared to the accident location 5. When the operating agents arrive on site, the blockage becomes managed, and additional use cases activated. 6. This C-ITS message will be terminated and enhanced with more accurate information and use cases.
Display / alert principle	The information to the driver needs to be send in time and the display to the driver needs to be early enough to adapt his speed or even his itinerary. However, since he should not forget about the alert, it could be repeated closer to the location. The message of this use case should be enhanced when road operator vehicles get on the blocked road segment and terminated the warning message.
Functional Constraints / dependencies	The information quality of this use case depends highly from the information source and the detection quality of the information, but as a first warning it is for sure useful to enhance aware driving.
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-PTVS is profiled in chapter 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, for now, causeCode is 10 (Hazardous location - Obstacle on the road) and subCauseCode is 7 (waitingVehicles). *Hence, a C-Roads follow up action with ETSI is planned to provide a more adequate solution on the CC and sCC.*
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.12 HLN - Alert Wrong Way Driving (HLN-AWWD)

Use case introduction HLN - AWWD	
Type of road network	Road with separate carriageways (non-urban) including entrance and exit segments.
Type of vehicle	All
Summary	This Use case is to warn a driver that he could encounter a vehicle that is driving in the wrong way. It is not the primary aim of this use case to alert the wrong-way driver that he is on the wrong way. This V2V use case could be added in the future to the warning sequence if detection quality and confirmed status of information is improved. Hence, the following description is valid only for right lane driving countries, in e.g. UK the lane situation would be mirrored, but the resulting danger for all vehicles involved similarly high.
Background	Today, the information about a wrong-way driver exists, but is only broadcasted by radio and/or VMS. The detection rate, time and accuracy of information is initially low, even if the wrong way driver alert is activated. Because of the high relative vehicle speeds involved between the approaching vehicles on the same lane, this generates always a highly risky situation on the road motorway network. For these reasons the application of a collaborative C-ITS service were vehicles and infrastructure cooperate to quickly detect, and immediately warn nearby vehicles and drivers reaching the “warning zone” could be of high positive impact for road safety. As the wrong way drivers occur at varying network positions, including motorway entrances and exits the main limitation of current technologies is the low quality and slow detection of the vehicle involved, this can be improved by applying C-ITS and combining I2V and V2V applications.
Objective	The objective is to encourage the driver to adapt his driving lane, speed and his behaviour, in case of a wrong-way driver to minimise his risk. The aim is not to alert the wrong-way driver that he is on the wrong way. This can be an optional V2V message and possibly even an in vehicle detection application in the future. This would lead to enhanced road safety through the prevention of high speed, and therefore very risky, road accidents on motorways by faster detection and more precise location of the wrong way driver and activate a detailed warning sequence to all nearby and approaching drivers.
Desired behaviour	Vehicle drivers receiving this information: • can adapt their speed and / or trajectory by driving at the most right (and mostly slowly travelling vehicles compared to left lanes on motorways, which are used to overtake or higher speed cruises) • and can put themselves in a safe place (rest area, motorway interchange, etc) • Pay more attention to their direct traffic surroundings
Expected benefits	The added value of this use case is that potential directly involved drivers are informed faster and more accurately. Moreover, the service aims to inform more drivers than currently (not all drivers listen to the radio). This leads to: • Increased road safety by less accidents due to wrong way driving and less “horrible driving situations” for drivers involved in such a situation even without a direct accident. • Reduce the number of follow up accidents by detecting high risk situations

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	linked to wrong way drivers fast and efficiently and distribute the correct and precise warning sequence of messages to all drivers approaching the risky area of driving.
Use case description	
Situation	The wrong way driving alert could be triggered by several situations: • On a motorway, a vehicle takes a slip road (entrance or exit segment) in the wrong way, or turns back in the toll station / rest area and drives the motorway in the wrong driving direction. • On a ring road with separate carriageways, the situation can be the same, but with slip roads / exits more regular. Because the wrong way driver is entering the motorway* segment he mostly uses the most left lane*, which is for the correct drivers the one with the highest travelling speed*. **In the urban environment, the use case is currently not regularly reported even if evidence shows that it could also be relevant, but is rarely detected. (Urban use case could be added in the future).* ***This described traffic situation is valid only for right lane driving countries, in e.g. UK the lane situation would be mirrored, but the resulting danger for all vehicles involved similarly high.* For the wrong way driving alert the following phases of the use case should be defined depending on the confirmed status of information of the road operator, possibly the warning sequence in a single case can also consist of more than two, but linked use case phases as follows. Phase 1 and 3 always apply. The WWD alert could be extended with Phase 2 if more specific information becomes available. Phase 1 - Warning all approaching drivers to the risky area or segment of the transport network at early indications of a wrong way driver present. The WWD - alert informs drivers to drive carefully and slowly and only on the right lane and not to overtake (and therefore use the most left lane of the motorway) on both directions of the motorway. Phase 2 - If the wrong way driver position, heading and lane is confirmed, alert all drivers approaching this respective road segment to drive carefully and switch lanes to drive on the right lanes. And at the same time alert drivers on the opposite driving direction of the motorway that the WWD alert has been clarified and regular traffic conditions have been resumed. Phase 3 - After clearance of the complete warning case inform all drivers involved that regular traffic condition have been resumed.
Logic of transmission	I2V Broadcast
Actors and relations	**Vehicle driver:** the end-users of this service are drivers in their vehicle, exposed to the wrong way driving vehicle in their direction and in the opposite direction of driving at the beginning of the WWD-alert. Following the confirmation of WWD position, heading and driving direction including the lane only the vehicle drivers on the carriageway approaching the RWW are informed, the other driving direction gets a de-escalation or warning cancellation. **Road operator:** the sender of the message is an operator in the TCC, using various detection sources of the wrong way driving vehicle e.g.: ○ Automated wrong-way detector ○ Camera's ○ Phone call (field operator, police, drivers, radio).

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	○ Other C-ITS equipped vehicles **Service providers:** providing the message to the involved drivers and contributing the fast and precise detection of WWD cases by sending their WWD cases from vehicles to the involved road operators / public.
Scenario	1. An operator in the TCC is alerted of the presence of a wrong way driving vehicle on a motorway segment. 2. Phase 1: The TCC broadcast the information for the relevant road segments for both directions. The subject of the message is "wrong-way driver on your way". No detailed recommendations will be given initially. It informs drivers only to drive slowly and not to overtake. 3. Vehicles receive the information. 4. If the information is relevant for a vehicle (driver), the information is displayed to the driver with a high priority. 5. Phase 2: Wrong way driver details (driving position, speed, heading, driving lane) are confirmed by a second source of information to the road operator in the TMC. 6. Vehicles involved receive the driving direction dependent updated information. 7. Updated information (for same traffic event and message) is displayed to the driver with a high priority. 8. A message cancellation is transmitted after clearance of the WWD alert. Hence, if the detailed information does not become available, steps 5-7 will not be applicable. The use case could in the future also be extended in urban road networks, where drivers are driving against the allowed driving direction of a single direction road, which is also mainly a V2V use case. In a later stage of C-ITS deployment this could be enhanced by (an advanced vehicle detection application) warning the wrong way driver to stop immediately at the safe border of his current driving lane (and not to try to turn, deviate or perform other driving actions).
Display / alert principle	There are two main display possibilities: • A moderately intrusive alert to encourage the driver to adapt his behaviour (change lane to right as precaution) without risk of an overreaction. (this can be related to phase 1) • An intrusive alert to encourage the driver to adapt his behaviour in case of urgency. (this can be related to phase 2). In both cases, the alert should be done enough in advance to give the drivers the time to adapt their driving behaviour, possibly vehicle speed and lane advice.
Functional Constraints / dependencies	• For this particular use-case, the validity duration and the dissemination area of the information will need to be determined and ascertained for every phase of the use case and the respective status and quality of the available information about the wrong way driver in the TMC. . • The information will not be precise enough to manage an imminent emergency. This use case would benefit from a future extension with V2V messages between vehicles and of an in vehicle application for all C-ITS Vehicles involved. (also ego vehicle detection) This use case would benefit a lot if all C-ITS vehicles have a robust WWD-Detection logic on board for the EGO vehicle and for other vehicles in the surrounding traffic environment. Additionally if the WWD use case is active a specific V2V message forwarding in the opposite direction of the WWD would enhance the message distribution and to the correct drivers group (approaching the risky situation with the WWD.)

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Interoperability requirements	
Message profile requirements	• The DENM message for HLN use-cases are profiled in the *C-ITS Infrastructure Functions and Specifications* document (chapter 3.2.1.1 and 3.2.1.3). • For this use-case, causeCode is 14 (wrongWayDriving) and subCauseCode is 2 (wrongDirection). **The relevance zone of the event** is a linear which starts upstream the last known position of the WW Driving vehicle and ends downstream this last know position. Upstream and downstream have to be understand as the correct driving direction of the infrastructure concerned (and not in reference to the driving direction of the WW driver). This linear of relevance is the eventHistory of the DENM. This results in that the WW Driving vehicle is somewhere, along the eventHistory, between the eventPosition and the last point of the eventHistory. In case the WW Driver position is well known, the eventHistory can be shortened by the road operator. Anyway, the start of this linear event (i.e eventPosition) could be set by the road operator before the previous road connector. So that receiver-vehicles can choose to leave the carriageway to avoid any risk of accident with the WW driver.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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2.2.13 HLN - Public Transport Vehicle Crossing (HLN-PTVC)

Use case introduction HLN – PTVC	
Type of road network	Road, urban road
Type of vehicle	All vehicles
Summary	Vehicle is approaching a location of a high risk of collision with PT vehicles. The driver is informed about this situation via in-car information and warning.
Background	Mainly in the cities, there are many places where tram tracks cross a road for other vehicles and these places are not equipped with traffic lights. Mainly during the turning manoeuvre, the driver doesn't expect to cross with tram tracks which often leads to the accident with trams.   Other dangerous situations include where buses merge from a bus priority lane into the mixed traffic lane. Most drivers are unaware that they have to give priority to buses, as a consequence this leads to conflict and accidents. 
Objective	The driver gets warned about the presence of locations with a risk of collision with PT vehicle, i.e. where tram tracks cross a road (or in the connection from reserved lane). The aim of the service is raising the driver's attention and reminding him/her to "Give priority!" when approaching the location.
Desired behaviour	• Increased driver attention • Adaptation of the driving speed
Expected benefits	• Reducing the risk of accident with PT vehicles • Increased driving comfort

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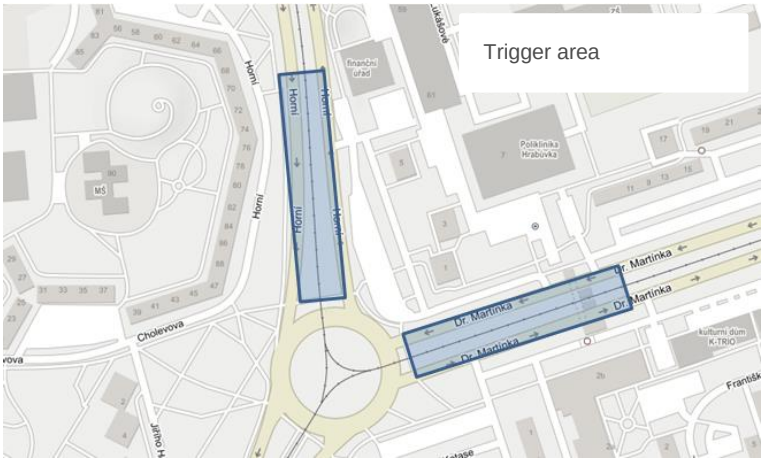
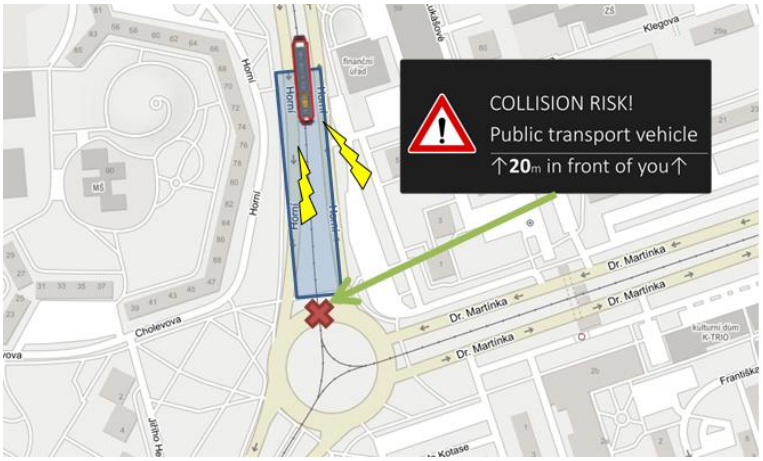
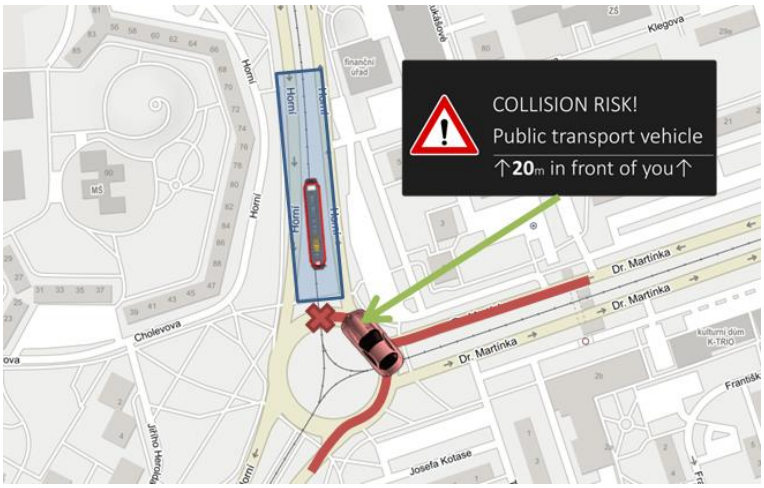
Use case description

Situation	Vehicle is approaching a location with a high risk of collision with PT vehicles. All these dangerous locations are known, pre-selected and saved in the database. In the same time, the PT vehicle enters the trigger area of this location and begins to generate and transmit prepared warning message. The database of the dangerous locations and related pre-prepared warning messages are saved in the vehicle's OBU.







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Logic of transmission	V_{PT}2V
Actors and relations	• **Public transport operator** is the origin of the information of the message. The direct source are OBUs in their vehicles. • **End-user** receives the warnings in the vicinity PT vehicle crossing.
Scenario	• The PT vehicle enters a trigger area of a dangerous location. • Warning message about a potential collision is generated and transmitted by an OBU in the PT vehicle. • Transfer of information into vehicles equipped with an OBU. • The vehicle receives the information and displays it to the driver. • The driver adapts his/her behaviour.
Display / alert principle	• The warning to the driver needs to be displayed early enough for him/her to adapt his driving. However, since he/she should not forget about the alert, it could be repeated closer to the location.
Functional constraints / dependencies	• The (location) information of the trigger area should be accurate, detailed and up-to-date. • The approaching PT vehicle should broadcast its position with certain accuracy and in a timely manner
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-PTVC is profiled in chapter 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use-case, causeCode is 97 (collision risk) and subCauseCode is 2 (crossing collision risk) + stationType is 6 (bus) or 11 (tram) → indicator of PT vehicles
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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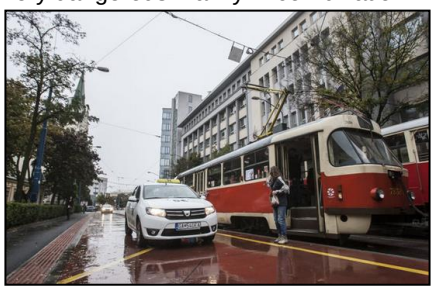
2.2.14 HLN - Public Transport Vehicle at a Stop (HLN-PTVS)

Use case introduction HLN-PTVS	
Type of road network	Road, urban road
Type of vehicle	All vehicles
Summary	Providing in-car information and warning about public transport vehicle at a stop.
Background	The public transport vehicles stopping in some types of stops create an obstacle on the road. These situations happen mainly in the stops on the road lane or stops where passengers get off directly on the road. In these locations, approaching vehicle could collide with the stationary public transport vehicle or even the passengers. These locations can be very dangerous mainly in combination with bad weather conditions.  
Objective	The driver gets warned about the presence of a public transport vehicle at the stop to raise his/her attention when approaching it by providing in-car information and warnings about this situation. During the getting on/off to public transport, the passengers often don't pay much attention. Due to the warning, the driver can be prepared for unexpected pedestrian behaviour.
Desired behaviour	• Increased driver attention • Adaptation of the driving speed in the vicinity of the stop (stopping the vehicle behind the stationary PT vehicle) • Readiness for unexpected pedestrian behaviour
Expected benefits	• Reducing the risk of accident with PT vehicles • Reducing the risk of road vehicle accidents in the vicinity of PT stops • Increased driving comfort
Use case description	
Situation	Vehicle is approaching a PT stop (e.g. stop on the road lane) where the PT vehicle is standing and passengers are getting on/off the vehicle in a hurry. The driver is informed about this situation.
Logic of transmission	$V_{PT}2V$
Actors and relations	• **Public transport operator** is the origin of the information of the message. The direct source are OBUs in their vehicles. • **End-user** receives the warnings in the vicinity PT vehicle at a stop.
Scenario	• The PT vehicle stops at a stop. • Warning messages begin to be generated by the PT vehicle's OBU. • Transfer of information into vehicles equipped with OBU. • The vehicle receives the information and displays it to the driver. • The driver adapts his/her behaviour.
Display / alert	• The warning to the driver needs to be displayed early enough for him/her to adapt

principle	his driving. • The user is provided with related information. Layout and sequence of presentation are left to OEM-specific implementation.
Functional constraints / dependencies	The broadcasted position of the PT vehicle and the exact lane it is located should be sufficiently accurate. The broadcasted info that the PT vehicle is coming to a stop should be communicated timely enough to leave time for surrounding vehicles to be aware and react. -
Interoperability requirements	
Message profile requirements	• The DENM message for HLN-PTVS is profiled in chapter 3.2.1.1 and 3.2.1.3 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use-case, causeCode is 94 (stationary vehicle) and subCauseCode is 4 (publicTransportStop) • ValidityDuration should be quite short and corresponding to the mean time of a stop.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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3 Road Works Warning (RWW)

3.1 RWW: Service introduction

Service introduction – RWW	
Summary	With this service, warnings will be provided to road users about road works, which can be mobile or static, short-term or long-term. Road works is seen as all type of road operations by the road operator including operations involving road operator vehicles.
Background	Road works usually affect the road layout and often the driving regulations. Despite dedicated signage prior to road work zones, such changed conditions frequently come as a surprise to road users. This may lead to unsafe situations and sometimes even accidents, which involve both road users and workers (i.e. changes to the road layout and applicable driving regulations). Moreover, the attention of the driver can fade with regular or longer road works. Road operators' vehicles are not emergency vehicles and are not as equipped as police, firefighting and rescue service vehicles for example. Use cases involving road operator vehicles (e.g. salting, ploughing, bypassing towards incident, protecting accident zone, vehicle recovery by road operator) support the safety of the involved road operators and road users.
Objective	More attentive and adjusted driving while approaching and passing a work zone or road operator vehicles in operation by providing in-car information and warnings about road works, changes to the road layout and applicable driving regulations.
Expected benefits	• The primary expected impact is more attentive driving while approaching and passing a work zone or road operator vehicles in operation, helping to avoid sudden braking or steering / swerving manoeuvres, thereby improving traffic safety as it reduces (the severity of) accidents. • RWW aims at reducing the number of collisions with road vehicle safety-objects and road operator vehicles near road works. RWW will inform the road user when approaching a work zone and will simultaneously provide information on the changes in the road layout. • Better flow • Less accidents
Use cases	1. Lane closure (and other restrictions) (RWW – LC) 2. Road Closure (RWW – PC) 3. Road Works – Mobile (RWW-RM) 4. Winter Maintenance (RWW-WM) 5. Road Operator Vehicle in Intervention (RWW-ROVI) 6. Road Operator Vehicle Approaching (RWW-ROVA) Other RWW use cases are under review and may be added in future releases.

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3.2 RWW: Use Cases

3.2.1 RWW - Lane closure (and other restrictions) (RWW-LC)

Use case introduction RWW-LC	
Type of road network	All
Type of vehicle	All
Summary	• The road user receives information about the closure of part of a lane, whole lane or several lanes (including hard shoulder), but without the road closure. • The closure is due to a static road works site. • In this use case, alternate mode and road closure are excluded.
Background / added values	Currently, many road users enter the road works sites or strike the protection equipment of the site, sometimes causing victims. Information sufficiently in advance would prevent this type of situation by adapting the behaviour of the road user.
Objective	• The objective is to allow road users to anticipate the closure of lanes due to a road works site on the road ahead and to adapt their speed and lane on the road. • The objective is not to signal a road closure and therefore no alternative route will be transmitted, even if a warning message could be sent. It is also not the objective to signal to the user that he/she is likely to have to stop, as in the case of an alternate mode.
Desired behaviour	• Increased vigilance • Adaptation of the speed • Change of lanes (if needed)
Expected benefits	• Reduce the risk and number of accidents and dangerous situations for road users and workers. • Informing the road user about a risk of discomfort on the road (slowing down, manoeuvring) • Improved traffic management due to less traffic relevant events on the road
Use case description	
Situation	• Roadworks equipped with warning beacons / temporary road signs / illuminated lights arrows, on a road with separate carriageways or on a dual carriageway. • Carriageway crossover (in a divided highway. situation where vehicles need to use the contraflow carriageway because their own carriageway is closed) • Lane closure by sign gantries (line control system) • Lane closure by warning trailer equipped with RSU (short term roadworks)
Logic of transmission	I2V Broadcast
Actors and relations	• **The Road operator** is the origin of the information of the message. It can be the Traffic Operations Centre, or a road operator vehicle if no connection to the central station (“stand alone mode”). • **The road user** approaching the area is the end-user of this service (receives the information/message). • **Service provider:** the road works planner of the road operator, a management system or the RSU on the trailer (in case of the “stand – alone mode”).

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Use case scenarios	1. Static planned roadworks (TOC Triggered): a. The road operator programs static and planned (or ad hoc) road works in its Traffic Management System (TMS). The information contains all the elements that could be used to describe the work site (start / end position of the work site, duration) precisely. Additional information could be added, such as the speed limit of each affected section. Some data could be provided to the TOC by the trailers or road operator (vehicle) of the roadwork. b. The message is then broadcasted to the road users c. The road user receives the information and processes it. 2. Stand-Alone Mode a. A trailer is used for a short-term or long-term roadwork, but without a connection to the TOC (no connection available). b. The message is then broadcasted to the road users without additional information from the TOC. c. The road user receives the information and processes it. 3. Augmented (Stand-alone then TOC Triggered): a. A trailer is used for a short-term or long-term roadwork (e.g. broken road surface after an accident). b. Firstly, the message is then broadcasted to the road users without additional information from the TOC. c. Then, the TCC can send messages from the TOC. The message can be sent with additional information from the TOC. d. The road user receives the information and processes it.
Display / alert logic	• When the road user arrives near the work zone site, he receives information to allow him to adjust his speed and position on the road to prevent dangerous situations. The information needs to be displayed on the HMI early enough, and is moderately intrusive (at the manufacturer's decision).
Functional constraints / dependencies	• It must be assured that information generated via different messages/ information networks can be linked by the receiver to the same roadworks event. • The validation process of transmitted information (quality) against the physical layout of an RWW site needs to be taken care of.
Interoperability requirements	
Message profile requirements	• The DENM message for RWW-LC is profiled in chapters 3.2.1.1 and 3.2.1.2 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 3 (roadworks) and subCauseCode is 0 or 4.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

3.2.2 RWW - Road Closure (RWW – RC)

Use case introduction RWW-RC	
Type of road network	**All**
Type of vehicle	**All**
Summary	The road user receives information about a road closure due to a set of static roadworks. The closure is temporary.
Background	• When road users are stuck without being informed on the situation, they can become anxious and they may do dangerous U-turns or use an inappropriate lane (e.g. hard shoulder). Providing that kind of information can prevent these situations, bringing more safety and comfort to road users. • There is an added value in this use case if the information is accurately linked with re-routing information.
Objective	• To allow the driver to anticipate the closure of a road so he can choose an alternate route. • This anticipation can be geographical or temporal.
Desired behaviour	• The drivers adapt their route.
Expected benefits	• Safety (avoid dangerous behaviour, e.g. U-turns) • Improved traffic management • Improved comfort for road users
Use case description	
Situation	• On a dual carriageway: one direction is closed, without carriageway crossover. • On a two-way carriageway: the whole road is closed (therefore without alternate). • In both case: a deviation is indicated near the closure.
Logic of transmission	I2V Logic Broadcast
Actors and relations	• **The Road operator** is the sender of the message. Can be in contact with the other road operators in order to implement a smart deviation itinerary. • **The Road user** is the end-user of the service (receiver of the closure information). • **The service provider** can be the road operator. •
Use case scenario	**TOC triggered only.** • The road operator programs static and planned road works in its Traffic Management System (TMS). • This information contains all the elements that can be used to precisely describe the work site (start / end position of the closure, duration) and potential alternative routes (may be different by type of road user or destination). • The message is then broadcasted to the road users approaching the road closure, so that users can adapt their itinerary. • The information is received in the vehicle and displayed to the driver.
Display principle / alert logic	• Little intrusive alert in the case of a significant temporal anticipation; a little more intrusive in case of a shorter anticipation time. • The display of alternate routes is to be considered.
Functional constraints / dependencies	• Management of planned events to be sent to road users. • Prior the standards decision, some checks would be necessary: ▪ Update of the Message Set and Triggering Conditions for Road Works Warning Service which also includes LT-RWW ▪ Work plan proposal, including IVI, MAP and several stakeholder perspectives

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Interoperability requirements	
Message profile requirements	• The DENM message for RWW-RC is profiled in chapters 3.2.1.1 and 3.2.1.2 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 3 (roadworks) and subCauseCode is 1.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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3.2.3 RWW – Road Works Mobile (RWW-RM)

Use case introduction RWW – RM	
Type of road network	**All**
Type of vehicle	**All**
Summary	The road user receives information about a zone on the road that contains, at some point, the neutralization of part of a lane or a lane closure (but without road closure) due to a planned mobile work site.
Background	Currently, many road users enter the road works sites or strike the protection equipment of the site, sometimes causing victims. An alert sufficiently in advance would prevent this type of situation by adapting the behaviour of the driver. The risk is even more important with mobile work site that are “lighter” in terms of protection and signalling, since moving.
Objective	The objective of this use case is to inform a road user of a mobile work zone where he will encounter operating agents in the zone. However, roadwork equipment / workers might not be present / visible on the whole section.
Desired behaviour	• Increased vigilance • Adaptation of the speed • Change of lanes (if needed)
Expected benefits	• Reduce the risk of accidents (for users, road agents) • Informing the road user about a risk of discomfort on the road (slowing down, manoeuvring) • Improved traffic management
Use case description	
Situation	• Mowing • road markings • fixing restraint systems • phyto-sanitary treatments • sweeping, road cleaning, • etc.…
Logic of transmission	I2V Broadcast
Actors and relations	• **The Road operator** is the sender of the message. It can be the TCC (TCC triggered mode) or the operator vehicle (standalone mode) • **The Road user** approaching the area is the end-user of this service (receives the message). • **Information service provider:** the road works planner of the road operator.
Use case scenario	**1. TOC triggered:** 1. The road operator programs mobile and planned road works in its Traffic Management System (TMS). The information contains all the elements that can be used to precisely describe the work zone (start / end position of the work zone, duration). This zone will not be entirely used by the operating agents; they will set markings around the actual work site within this zone. 2. Additional information can be added, such as the speed limit of each neutralized portion. 3. The message is then broadcasted to the road users. 4. The vehicle receives the information, processes it, and displays it to the driver. 2. **Stand-alone Mode** 1. The message is sent by a mobile RSU mounted on a road operator vehicle (e.g. trailer) without a connection to a central station

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	2. The message contains a basic set of information (event speed, position, arrow position) 3. There is no additional information from a management system 4. The message is then broadcasted to the road users. 5. The vehicle receives the information, processes it, and displays it to the driver **3. Augmented (Stand-alone then TOC Triggered):** 1. The message is broadcasted to the road users by a mobile RSU mounted on a road operator vehicle (e.g. trailer), firstly without additional information from the TOC 2. The message contains a basic set of information (event speed, position, arrow position) 3. Then, the TOC can send messages with additional information. 4. The vehicle receives the information, processes it, and displays it to the driver
Display principle / alert logic	When the road user arrives near the planned work zone, the road user receives an alert to allow him to adjust his speed and position on the pavement. The alert needs to be displayed on the HMI early enough, and is moderately intrusive (at the manufacturer's discretion).

Functional constraints / dependencies	• Prior the standards decision, some checks would be necessary:
	  ○ Update of the Message Set and Triggering Conditions for Road Works Warning Service which now also includes LT-RWW (all based on DENM only)
	  ○ Work plan proposal, including IVI, MAP and several stakeholder perspectives
	• The road operator vehicle on site, if equipped, might broadcast a message signalling a mobile work site as well. The HMI might need to handle those two messages. The priority shall be given to the information given by the vehicle on site.

Interoperability requirements	
Message profile requirements	• The DENM message for RWW-RM is profiled in chapters 3.2.1.1 and 3.2.1.2 of the *C-ITS Infrastructure Functions and Specifications* document. • For this use case, causeCode is 3 (roadworks) and subCauseCode is 3.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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3.2.4 RWW - Winter Maintenance (RWW-WM)

Use case introduction RWW-WM	
Summary	The winter maintenance vehicle, equipped with the necessary technology for a road operator vehicle-to-vehicle (Vro2V) communication, sends a message signalling their activity (salting and/or snow/ice removal). The alerted road user can adapt its driving behaviour accordingly.
Background	Winter maintenance vehicles are much slower and, in some countries, it is forbidden to overtake them when in operation. Even if most of the drivers are driving slowly because of the potential slippery road conditions, bad visibility can lead to not seeing exactly where the winter maintenance vehicles are on the road. Then this use case can support the prevention of collisions between winter maintenance vehicles and road users. It can also help sending information about a possible spill of salt for road users driving in the opposite direction of the road (bi-directional roads) or passing by the winter maintenance vehicle (where allowed).
Objective	The objective of this use case is to alert road users that will encounter an operating winter maintenance vehicle so that they can adapt their driving behaviour accordingly. This use case is also relevant for road users in the opposite direction because the salting and/or snow removal operations could have an impact for them as well, especially in the case of bidirectional roads.
Desired behaviour	• Increased vigilance • Adaptation of speed
Expected benefits	• Reducing the risk of accidents for road users and winter maintenance crews • Improved winter maintenance interventions efficiency
Use case description	
Situation	In case of winter maintenance vehicle in operation (salting and/or ploughing): A road user is arriving behind one (or several) winter maintenance vehicle(s) in intervention. The road users can adapt their driving behaviour accordingly on the basis of the information received in advance. In some countries, the road user knows then (or is warned) that he cannot overtake the winter maintenance vehicle(s). In case of circulating winter maintenance vehicle (not in operation): A road user is arriving behind this larger than usual vehicle (because of the snowplough). The road user can adapt their driving and their overtaking taking the information of a large vehicle into account
Logic of transmission	Vro2V Logic Broadcast[3]
Actors and relations	• The **winter maintenance vehicle** (through the on-board unit) is the sender of the information/warning • The **road user** approaching the relevant area is the end user of this service (receives the message).
Scenario	Scenario (1) A winter maintenance vehicle is on the road and the salting process is activated. If

[3]Vro2V = Road operator vehicle to vehicle

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	connected directly to the salting equipment, the In-Vehicle System sends a message to inform road users of the salting process; otherwise, the activation can be done manually. Scenario (2) A winter maintenance vehicle is on the road and the snow removal process is activated. Additionally, the salting process can be activated. If connected directly to the snow plough equipment, the In-Vehicle System sends a message to inform road users of the snow removal process; otherwise, the activation can be done manually. Scenario (3) A winter maintenance vehicle with large dimensions is on the road and the light bar is switched on. If connected directly to the light bar or the beacon, the In-Vehicle System sends a message to inform road users of the winter maintenance vehicle; otherwise, the activation can be done manually. The road users nearby the winter maintenance vehicle receive the message(s) and the messages are displayed to the road user when appropriate.
Display / alert principle	The display logic might be different if the message is received by a road user behind the winter maintenance vehicle or next to it (or on the other side of the road). For the reason that in some countries the road users are not allowed to overtake a winter maintenance vehicle, a reminder of not overtaking the winter maintenance vehicle as displayed in the road user's vehicle could be interesting.
Functional constraints / dependencies	This message could be also accompanied by a message sent by the TCC signalling a zone of winter maintenance (using VMS for example). The receiving systems will have to deal with the priority or redundancy of both messages.
Interoperability requirements	
Message profile requirements	• The DENM message for RWW-WM is profiled in chapters 3.2.1.1 and 3.2.1.2 of the *C-ITS Infrastructure Functions and Specifications* document. • CauseCode: 26 (slow vehicle), subCauseCode: 8 (salting vehicle); 6 (snow plough); • CauseCode: 3 (roadworks) subCauseCode: 6 (winter service) • relevanceTrafficDirection: allTrafficDirection If multiple events happen in parallel, e. g. salting and snow ploughing, the major incident should be alerted, in the example the snow plough.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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3.2.5 RWW - Road Operator Vehicle in Intervention (RWW-ROVI)

Use case introduction RWW-ROVI	
Summary	An operating agent in his vehicle stops in front of an accident/incident to protect the obstacles or is currently setting the equipment (lane delineation) to protect a site (in case of roadworks for example).
Background	Currently, many road users hit the protection equipment of road works or incident/accident sites, sometimes causing victims. An alert sufficiently in advance would prevent this type of situation by adapting the behaviour of the road user. The risk is even more important with accidents where road users usually slow down / stop to look at.
Objective	The objective of this use-case is to alert a road user that an operating agent is intervening on a site so that the driver can adapt his behaviour. This can be either a stop during a patrol tour to take a picture/fix equipment, or actual intervening to protect road users that might have stopped, either on the road or on the hard shoulder.
Desired behaviour	• Increased vigilance • Adaptation of the speed • Change of lanes (if needed)
Expected benefits	• Reducing the risk of accidents (for users, road agents) • Informing the road user about a risk of discomfort on the road (slowing down, manoeuvring) • Improved traffic management
Use case description	
Situation	• accident • incident (stopped vehicle on the road, obstacle) • stop during a patrol tour • lane delineation • moving the warning trailers • etc.
Logic of transmission	Vro2V Broadcast[4]
Actors and relations	• **Road Operator**: The sender is an operating agent in his vehicle (through the OBU), or the vehicle itself (if automatic detection). • The **road user** – receivers of the messages are road users around the event.

[4]Vro2V = Road operator vehicle to vehicle

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Scenario	Scenario (1) Intervention in case of accident/incident: An operator detects/gets alerted of an accident/incident on the road and asks the operating agents (via their hierarchy) that there is a need to go and protects the site. Scenario (2) Intervention while patrolling: While patrolling, an operating agent detects an event on the road (pothole, obstacle, broken restraint system, etc.) and needs to protect the site or correct the situation. Scenario (3) Intervention in case of lane delineation: Road work is planned and lane delineation needs to be done (or removed). Next for all the scenario's: The operator agent in its vehicle stops to protect the event and/or starts delineating and sends a message in Vro2V indicating its position. The triggering conditions are manual if the warning arrows are not connected, automatic if connected.
Display / alert principle	Vehicles approaching the intervention site receive the message, process it and display the information to the road user. When the road user arrives near the intervention site, the road user receives an alert to allow to adjust its speed and position on the pavement. The alert needs to be displayed on the HMI early enough, and is moderately intrusive (at the manufacturer's discretion).
Functional constraints / dependencies	Another message could be sent by the TCC providing information on the actual event protected by the operating event (I2V Broadcast). Two messages could be then sent. See if it is possible to link the events dynamically. In case of a big accident / incident with a lot of intervention vehicles, a problem could be that a lot of messages would be sent.
Interoperability requirements	
Message profile requirements	• The DENM message for RWW-ROVI is profiled in chapters 3.2.1.1 and 3.2.1.2 of the *C-ITS Infrastructure Functions and Specifications* document. • CauseCode: 15 (rescue and recovery work in progress) • SubCauseCode: 0 • RelevanceTrafficDirection: upstream for dual carriageway roads; AllTrafficDirection for other roads
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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3.2.6 RWW - Road Operator Vehicle Approaching (RWW-ROVA)

Use case introduction RWW-ROVA	
Summary	A road operating agent in his intervention vehicle needs to access urgently an incident area to protect it. The agent requests to road users that they facilitate the agent's way on the road, broadcasting a message.
Background	Road operators' vehicles are not emergency vehicles and are not as equipped as police or firemen vehicles for example. Thus, they are not always visible by the road users when they try to go through or bypass a bottleneck for example. This use case can make sure the road user is alerted by their presence and facilitates its progression.
Objective	The objective is to alert a road user that a road operator intervention vehicle is passing by or trying to pass and that the road user can facilitate this.
Desired behaviour	When the road user receives the alert, the desired behaviour is that the road user checks where the road operator vehicle is and makes sure the road operator can bypass easily. The road user can change lanes, move aside, or else.
Expected benefits	• Faster arrival to the incident/accident site to improve road safety of such zones • Reduction of risks taken by road operating agents to reach those accident sites • Improvement of traffic management
Use case description	
Situation	• Situation of bottleneck: the road operating vehicle can for example bypass using the hard shoulder, or in between lanes • Free flow traffic
Logic of transmission	Vro2V Broadcast[5]
Actors and relations	• The sender is an operating agent in its vehicle. • The end – receivers are **road users** in their vehicles that the operating agent is trying to overtake/bypass. • The road operating agent in its vehicle is the source of information
Scenario	1. The operating agent needs to go and protect an incident / accident zone on the road network 2. While the operating agent is on the network trying to reach his destination, the agent broadcasts a message to road users that the agent is trying to bypass/overtake. 3. The road user receives the information and is alerted. 4. The road users facilitate the trajectory of the road operator vehicle.
Display / alert principle	This use case is one that needs to alert the road user from an event that is happening behind him. The alert logic should make sure that the road user gets the message without distracting its driving. It is at the OEM discretion: can be a display on the HMI, a sound, or a flash on the mirrors for example.

[5]Vro2V = Road operator vehicle to vehicle

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Functional constraints / dependencies	This use case being a message from behind the road user, the main constraint will be to alert the driver without distracting his driving. This type of messages should only be allowed to specific vehicles (operating vehicle).
Interoperability requirements	
Message profile requirements	• The DENM message for RWW-ROVA is profiled in chapters 3.2.1.1 and 3.2.1.2 of the *C-ITS Infrastructure Functions and Specifications* document. • CauseCode: 95 • SubCauseCode: 0 • RelevanceTrafficDirection: downstream
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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4 Signalized Intersections (SI)

4.1 SI: Service Introduction

Service introduction: Signalized Intersections	
Summary	This service will provide information to road users, and vehicle data to traffic light controllers, for a safe and efficient approach and crossing of a signalised intersection(s)The implementation of the infrastructure-based intersection use cases will increase the safety and traffic flow efficiency and minimize environmental pollution at a signalised intersection.
Background	Traffic intersections can be complex traffic environments, where traffic flows can be affected negatively by various traffic aspects. Additionally, intersections are also areas with higher risks for accidents, because of conflicting traffic streams. Also emissions are higher due to stops and acceleration. For these reasons C-ITS services that allow a smooth passing of one or more intersections with a constant speed for a large number of road users decrease negative effects of urban traffic.
Objective	More attentive driving while approaching and passing an intersection by providing in-car information, speed advice and priority to designated vehicles (e.g. public transport, emergency vehicles, heavy goods vehicles, etc.) for better energy efficiency and improved road safety. Enhanced safety for emergency vehicles as conflicting traffic streams can be stopped and drivers can cross with less risk.
Expected benefits	The primary expected benefits are enhanced energy efficiency due to smoother driving and improved traffic flows and therefore lower emissions when vehicles pass intersections. Another expected benefit is to improve traffic safety due to reduced red light violation and lower risk of collision when passing the intersection. Primarily expected from the emergency vehicle prioritisation use case, is a shorter travel time for emergency vehicles (EVs) and less collision risk. For traffic light prioritisation, the expected benefits are also shorter travel times and compared to existing systems, reduced impact to individual vehicles. Moreover, it provides a more uniform and economical solution to the public transport operator compared to current complex installations.
Use cases	The following use cases are included in this release: 1. Signal Phase and Timing Information 2. Green Light Optimal Speed Advisory 3. Imminent Signal Violation Warning 4. Traffic Light Prioritisation 5. Emergency Vehicle Priority

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4.2 SI: Use Cases

4.2.1 SI - Signal Phase and Timing Information (SI-SPTI)

Use case introduction SI-SPTI	
Summary	This service will provide information to road users approaching and passing traffic light controlled intersections, on the current phase as well as upcoming phase(s) and the moment these are expected to start and end.
Background	Intersections cause delay and stops thereby negatively affecting environmental pollution and traffic safety. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights can be given to road users to optimize their driving and to overcome the inefficiencies.
Objective	Enable road users to adapt their behaviour due to left time untill the next phase of the upcoming traffic light to minimise sudden stops, deceleration and acceleration (delay), resulting in better safety, throughput and sustainability.
Desired behaviour	Road users can adapt their speed while approaching a signalised intersection, or when stopped at a red phase, they can turn off their engine.
Expected benefits	The expected benefit is increased awareness of traffic lights and their phase changes and more efficient and effective driving behaviour while approaching or waiting at traffic light controlled intersections with reduced stops, thus reduces emissions, anger and aggressiveness, and increases safety.
Use case description	
Situation	A V2X equipped vehicle approaches an I2V enabled signalised intersection, which transmits periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead.
Logic of transmission	I2V broadcast
Actors and relations (in no particular order)	• Road user: receives phase and timing information and adapts his or her behaviour according to this information. • Road operator: ensures coordination of traffic light controlled intersections and provides access to signal phase and timing data. • Road authority: defines policy and traffic light infrastructure (i.e. traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology). • Data provider: processes the signal phase and timing data. • Service provider: disseminates phase and timing information to traffic participants.
Use case scenario	Scenario 1: Vehicle approaches a green traffic light The I2V enabled signalized intersection transmits periodically and in real time the current green phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle approaching the intersection, aware of its own location, velocity, and speed limit receives the messages and extracts the relevant time to red information. Scenario 2: Vehicle approaches a red traffic light The I2V enabled signalized intersection transmits periodically and in real time the current red phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle approaching the intersection, aware of its own location, velocity, and speed limit receives the messages and extracts the relevant time to green information. Scenario 3: Vehicle is stopped at red traffic light The I2V enabled signalized intersection transmits periodically and in real time the current red phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle extracts the relevant time to green information.
Display principle / alert logic	The phase and timing information needs to be provided to the road user on an HMI early enough, and be moderately intrusive. The notification could be, for example, a traffic light symbol, countdown timer, sand glass, alert to turn off the engine or an alert to prepare for green. The presentation of signal phase and timing on the HMI should be done in a way that

	discourages drivers from increasing their speed beyond the speed limit or to depart before the start of the green phase
Functional constraints / dependencies	• Current phase state and timing of upcoming phase changes from the signalized intersection shall be sufficiently accurate and reliable to ensure high quality information. • The signal state as indicated by the physical signal heads shall always outweigh the information provided in the vehicle. • Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance.
Interoperability requirements	
Message profile requirements	The SPATEM and MAPEM messages for SI-SPTI are profiled in chapter 3.2.3 of the C-ITS Infrastructure Functions and Specifications document.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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4.2.2 SI - Green Light Optimal Speed Advisory (SI-GLOSA)

Use case introduction SI-GLOSA	
Summary	This service will provide speed advice information to road users for a safe and efficient approach and crossing of a signalised intersection(s)
Background	Intersections cause delay and stops thereby negatively affecting environmental pollution and traffic safety. At signalised intersections actual and/or predicted information on the phases and timing of traffic lights as well as speed advisory can be given to road users to optimize their driving and to overcome the inefficiencies.
Objective	To calculate a speed advice for one or multiple intersections which enables road users to adapt their approach speed and to pass one or more signal-controlled intersections in an energy efficient manner (e.g. by minimizing stops, acceleration and deceleration), safely and sustainably.
Desired behaviour	Road users comply with the speed advice and adapt their speed while approaching, stopping and/or passing a signalised intersection or driving through a sequence of traffic light controlled intersections.
Expected benefits	The expected benefit is a smoother driving behaviour while approaching and driving through a sequence of traffic light controlled intersections, which reduces stops, reduces emissions and increases safety.
Use case description	
Situation	<u>Situation 1 (single intersection):</u> A V2X equipped vehicle approaches a *single* I2V enabled signalized intersection, which transmits periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead. <u>Situation 2 (sequence of intersections):</u> A V2X equipped vehicle approaches a *sequence* of I2V enabled traffic light controlled intersections, which transmit periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection(s) ahead.
Logic of transmission	I2V transmission
Actors and relations (in no particular order)	• Road user: receives speed advisory information and adapts his or her behaviour according to this information.. • Road operator: ensures coordination of traffic light controlled intersections, and provides access to signal phase and timing data. • Road authority: defines policy and traffic light infrastructure (i.e. traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology). • Data provider: processes the signal phase and timing data. Service provider: calculates speed advisory and disseminates the speed advisory information to traffic participants.
Use case scenario	<u>Scenario 1a (vehicle calculates speed advice):</u> The I2V enabled signalized intersection transmits periodically and in real time the current phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the

	messages and calculates the optimal speed advice for approaching the intersection. Scenario 1b (infrastructure calculates speed advice): The I2V enabled signalized intersection calculates and transmits periodically and in real time advisory speed information for multiple road segments of the approach of the intersection. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and extracts the optimal speed advice for approaching the intersection. Scenario 2 (green wave speed advice): A sequence of I2V enabled traffic light controlled, synchronized intersections transmit a pre-defined/planned green wave speed advice. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and extracts the green wave speed for passing the intersections.
Display principle / alert logic	The speed advisory information needs to be provided to the road user on an HMI early enough, is moderately intrusive, and could be anything from a speed value, a speed range, a driving indication like slow down, or something else.
Functional constraints / dependencies	• Current phase state and timing of upcoming phase changes from the signalized intersection shall be sufficiently accurate and reliable to ensure high quality speed advisory. • The signal state as indicated by the physical signal heads always outweigh the information provided in the vehicle. • Traffic conditions, e.g. queues or traffic jams, affect the validity of speed advisory information and therefore shall be considered. • Speed advisory shall never exceed the legal speed limit. • Public Transport Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance. ETSI TS 103 301, Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services, V1.2.1
Interoperability requirements	

Message profile requirements	• The SPATEM and MAPEM messages for SI-GLOSA are profiled in chapter 3.2.3 of the *C-ITS Infrastructure Functions and Specifications* document.
	• For this use case:
	  ○ MAPEM defines intersections (not roadsegments)
	  ○ MAPData / intersections / intersectionGeometry / speedLimits (when available), SPAT / intersections / intersectionState / states / state-time-speed / MovementEvent / timing and SPAT / intersections / intersectionState / states / maneuverAssistList / ConnectionManeuverAssist / queueLength (when available) are key information to deliver a good speed advisory.

Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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4.2.3 SI - Imminent Signal Violation Warning (SI-ISVW)

Use case introduction IS-ISVW	
Summary	This service will provide imminent signal violation warnings to road users approaching traffic light controlled intersections.
Background	Signalised intersections can be complex traffic environments, and occasionally road users do not stop for a red traffic light, intentionally or unintentionally. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights, as well as imminent signal violation warnings, can be given to road users to increase their awareness of red traffic lights and avoid red light violation.
Objective	To reduce the likelihood and severity of collisions and injuries at signalized intersections by warning the driver that he is potentially violating a red intersection signal.
Desired behaviour	Road users react to the imminent red light violation warning, stopping their vehicle in time to avoid red light violation or reducing their speed to minimise the impact of the red light violation.
Expected benefits	The primary expected benefits are increased awareness of signal phases and their timing, less red light violations and thereby less collisions at signalised intersections
Use case description	
Situation	A V2X equipped vehicle approaches an I2V enabled signalised intersection, which transmits periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead.
Logic of transmission	I2V broadcast
Actors and relations	• Road user: receives imminent red light violation warning and adapts his or her behaviour according to this information. • Road operator: provides access to signal phase and timing data. • Road authority: defines policy and traffic light infrastructure (i.e. traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology). • Data provider: processes the signal phase and timing data. • Service provider: disseminates imminent red light violation warnings to traffic participants.
Use case scenario	The I2V enabled signalised intersection transmits periodically and in real time the current phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and calculates if red light violation is imminent.
Display principle / alert logic	The imminent red light violation warning needs to be provided to the road user on an HMI early enough and is intrusive (e.g. supported acoustically).
Functional constraints / dependencies	• Current phase state and timing of upcoming phase changes from the signalized intersection shall be sufficiently accurate and reliable to ensure high quality red light violation warnings. • The time critical nature of this use case requires for a sufficiently low latency system implementation. • The signal state as indicated by the physical signal heads always outweigh the information provided in the vehicle. • Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance. • If red light violation is inevitable, another use case comes in play which ensures that other road users are warned for the presence of a red light violator at the signalised intersection.
Interoperability requirements	
Message profile requirements	• The SPATEM and MAPEM messages for SI-ISVW are profiled in chapter 3.2.3 of the *C-ITS Infrastructure Functions and Specifications* document.

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Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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4.2.4 SI - Traffic Light Prioritisation (SI-TLP)

Use case introduction SI-TLP	
Summary	This service will give priority to designated vehicles (e.g. public transport, heavy goods vehicles, etc.) over individual vehicles at signalized intersections for assuring on time transportation schedule (e.g. bus, tram) and/or minimise emissions.
Background	To assure punctual transportation and minimise emissions, a prioritization system for designated vehicles at signalized traffic intersections is necessary. The prioritization system will also make the use of public transport more comfortable and attractive to the public.
Objective	Interaction between designated vehicle and traffic light controller (either local or central) to reduce the delay of designated vehicles at signalized intersections, thereby improve the efficiency of vehicle operations.
Desired behaviour	Designated vehicles (e.g. buses, trams, trucks) drive through an intersection without stopping on "red light" or waiting for "green light" and cross the intersection without any delays. The traffic light controller adapts its signal phases to give priority to the designated vehicle. The designated vehicle can pass the signalized intersection with minimum delay.
Expected benefits	The following benefits are expected: • Minimum delay for designated vehicles at signalised intersections • Less emissions from designated vehicles • Improved punctuality due to reduced disturbance on branch lines • Increased attractiveness of public transport due to improved comfort • Improved efficiency of vehicle operations (e.g. same service quality with less vehicles or higher frequency with equivalent fleet) • Improved choice of suppliers for fleet operators or public authorities due to standardized V2X solution for designated vehicle prioritization systems.
Use case description	
Situation	A V2X equipped priority eligible vehicle approaches a signalized intersection which is serviced with a prioritization system.
Logic of transmission	V2I and I2V transmission
Actors and relations	• Priority eligible vehicle: transmits the priority request, receives priority status information and benefits from the priority • Road authority: sets the priority policy • Road operator: processes the priority request and implements the priority policy • Fleet operator: determines if the designated vehicle is in time or delayed
Use case scenario	The designated vehicle transmits a prioritisation request. The prioritization system processes the request and either accepts (e.g. the vehicle is behind schedule and/or eligible to get priority) or rejects (e.g. other priorities are granted) the request, then gives feedback to the designated vehicle. If the request is accepted, e.g. "red phases" may be shortened and "green phases" extended, thus the vehicle gets "green light" with minimum delay at the stop line. After the vehicle has successfully

	driven through the intersection, the traffic light controller switches back to normal operation
Display principle / alert logic	The driver of the designated vehicle receives on an in-vehicle display information about the prioritisation status, early enough and in a moderately intrusive manner (at the vehicle manufacturer's and/or service provider's decision). For example, if the request is accepted or rejected. In addition, time to green information may be presented to the driver.
Functional constraints / dependencies	• The stationID of the vehicle shall not change during processing of a prioritization request. • Authentication and authorization of designated priority vehicles shall be ensured. • Policy on vehicle prioritization shall be defined, e.g. the level of priority, which vehicles and/or lines the priority applies to, the locations in which priority is available, etc. • The priority request shall be provided in time to allow the prioritization system to react on the request. • Traffic Light Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance. • ETSI TS 103 301, Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services, V1.2.1
Interoperability requirements	
Message profile requirements	• The SSEM and SREM messages for SI-TLP are profiled in chapter 3.2.4 of the *C-ITS Infrastructure Functions and Specifications* document.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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4.2.5 SI - Emergency Vehicle Priority (SI-EVP)

Use case introduction SI-EVP	
Summary	This service will actively contribute to the phase control of an equipped intersection to aid the passage of emergency vehicles (EV). It will also provide the prioritisation status to other users approaching and passing traffic light controlled intersections.
Background	Traffic light prioritisation for EVs can be distinctly different from normal traffic light prioritisation. Depending on intersection geometry, lanes other than those that the EV intends to use may be cleared, offering the EV an easier approach to and passage through the intersection. Moreover, drivers of other vehicles are often not aware that they can pass through a red light if an emergency vehicle (with sirens and light bar enabled) is approaching and there is no other way to clear a path. This results in drivers blocking the path of the emergency vehicle until the light turns green.
Objective	Interaction between emergency(s) vehicle and traffic light controller(s) (either local or central) to reduce the time taken for emergency vehicles to cross signalised intersections and increase the safety of these crossings.
Desired behaviour	The traffic light control adapts its signal phases to give priority to the emergency vehicle, allowing the EV to pass the signalised intersection safely and with minimum delay. The EV driver responds to the information on the prioritisation status (e.g. active and accepted) and if needed adjusts the EV path to the lane which will be cleared by the traffic light controller.
Expected benefits	Primarily expected benefits are a shorter travel time for emergency vehicles and less collision risk. Additional benefit is the increased flexibility to alter the priority lane/signal and use different routes.
Use case description	
Situation	A V2X equipped EV approaches an I2V enabled signalised intersection that is serviced by an EV prioritisation system. The EV transmits periodically and in real time the current position and the certified right of a prioritised passing at the intersection ahead.
Logic of transmission	V2I and I2V broadcast
Actors and relations (in no particular order)	• Emergency vehicle: transmits the priority request, receives priority status information and gets prioritised passing at the intersection. • Road operator: processes the priority request and implements the priority policy at the traffic light controlled intersection. • Road authority: defines policy and traffic light infrastructure (i.e. assigns authorisation and acceptance of certification for EV prioritisation).
Scenario	The V2X equipped vehicle approaching the intersection, sends periodically and in real time the current position and the operational state. The I2V enabled signalized intersection receives the prioritisation request and checks its validity. Dependent on the position, the heading and the distance to the intersection the traffic light phases are controlled in a way that, at first, conflicting traffic streams are stopped, then under regard of minimum inter green times, all or selected lanes of the ingress approach of the EV get a green light and are cleared. Based on the prioritisation status information, the EV passes the intersection using the cleared lane(s). After detecting that the EV has successfully passed the intersection, the intersection control switches back to normal operation (i.e. starting with green for conflicting lanes with high traffic).
Display principle /	The driver of the emergency vehicle receives on an in-vehicle display information about the

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alert logic	prioritization status, early enough and in a moderately intrusive manner (at the vehicle manufacturer's and/or service provider's decision). For example, if the request is accepted or rejected and what lane(s) will be cleared. A combination with the signal phase and timing service can give additional comfort.
Functional constraints / dependencies	• The stationID of the emergency vehicle shall not change during processing of a prioritization request. • Authentication and authorization of emergency vehicles shall be ensured. • Policy on emergency prioritization shall be defined, e.g. the level of priority, what locations, which lanes to clear, etc. • The priority request shall be provided in time to allow the prioritization system to react on the request. • Traffic Light Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance.
Interoperability requirements	
Message profile requirements	• The SREM and SSEM message for SI-EVP are profiled in chapter 3.2.4 of the *C-ITS Infrastructure Functions and Specifications* document.
Security and data protection requirements	
Communication technology requirements	
Test and validation requirements	

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5 Probe Vehicle Data (PVD)

5.1 Probe Vehicle Data service introduction

Service introduction PVD	
Summary	The Probe Vehicle Data (PVD) is a service in which vehicle or road user data is collected by the road operator or service provider.
Background	• Modern vehicles know at any time their own position, speed and direction, vehicle type, length, … • Moreover, thanks to their sensors / embedded technologies, they also know specific events affecting the driving experience (windscreen wiper status, ABS, ESP, collision sensors, etc.). • These data could be used by the road operator to get a more comprehensive knowledge of its network (especially in areas not equipped with other sensors, such as loop detectors). • These data could also be used to enhance the road operator's knowledge of events, complementing cameras, patrol and other existing sources.
Objective	The objective of the service is to collect data from vehicles and/or from road users • to improve knowledge of traffic conditions, traffic flow and events; • to improve knowledge of road and weather conditions; • to improve or enable traffic management (and hereby improve traffic efficiency and safety); • to improve or enable I2V use cases; • to improve existing management strategies (e. g. through information, harmonisation of traffic flow); • for statistical and modelling purposes;
Expected benefits	• Improvement of traffic conditions, network management and event management (improve traffic safety and efficiency) • Improvement of road network and event impact knowledge • Improvement of road and weather condition knowledge • Improvement and evaluation of traffic management strategies • Faster, more accurate and more efficient event detection and qualification • Enabling or improving C-ITS services: ◦ Location-based provisioning of C-ITS messages/services by service providers ◦ (Centralised) collision risk warning or signal violation warning ◦ Optimisation of signalized intersections ◦ (Dangerous) End of queue warning ◦ Extreme weather warning ◦ Travel time estimation and information ◦ Hazardous Location Notification • A possible cost reduction of the installation/maintenance of detection infrastructure.
Use cases	1. Vehicle Data Collection (PVD-VDC) 2. Event Data Collection (PVD-EDC) *An important remark must be made on the current description. It must be taken into account that the current description reflects the starting point for the road operators and that these descriptions probably will be improved/enhanced after discussions with e.g.*

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	C2C-CC.

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5.2 PVD Use Cases

5.2.1 PVD - Vehicle Data Collection (PVD-VDC)

Use case introduction PVD – VDC	
Type of road network	All
Type of vehicle	All C-ITS equipped ones
Summary	Vehicle data is collected.
Background / added values	Vehicle data is a first hand or original source for traffic information for road operators. The data can be used to generate traffic information for road users, to enable traffic management by road operators and to provide services by service providers.
Objective	See PVD service introduction
Desired behaviour	
Expected benefits	See PVD service introduction
Situation	A vehicle automatically sends out its information to its service provider or broadcasts its information.
Logic of transmission	V2I
Actors and relations	• The **in-vehicle-system** sends vehicle data • The **road operator** collects and processes data and can exchange this information with other road operators and/or service providers • The **service provider**: collects and processes data and can exchange this information with other providers and/or road operators. • The **road user** is the data subject • The **Traffic Operations Centre** uses the data for traffic management
Scenario	1. The in-vehicle-system automatically generates and sends out information. 2. The R-ITS-S or the service provider samples or collects the data from the vehicles. This could be - the first received message + at fixed time intervals (e.g. 30s) - the first message received - when the vehicle is crossing one or more fixed locations (virtual loops) - at fixed time intervals - continuously 3. The R-ITS-S or service provider forwards vehicle data or information to the C-ITS-S or to other service providers. 4. The C-ITS-S forwards data or information to the TOC (or to other service providers). The data can be collected, filtered, cross-checked, aggregated and/or consolidated at each of the steps.

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Display principle / Alert logic	An indication of data transmission or consent status might be presented on the HMI. There are no other alerts or information presented on the vehicle's HMI.
Constraints / Dependencies	Data Processing has to be compliant with GDPR and local legislation (e.g. concerning data retention time). This document does not specify how to be compliant. That is up to the controllers and processors. Examples of ways to be compliant can be added to the Annexed Table. Possible harmonisation of the anonymisation of the stationID is to be discussed (retention time, level within architecture and methods). Linkability should be avoided. Geofiltering to roads can be needed, to limit the registration of vehicles on private property (e.g. home addresses). The PVD-VDC use case depends on the willingness of the actors to share data. Selling vehicle data can be part of a business model. Vehicle data can also be sensitive business info for service providers, since it can give insight into number of clients.
Relation to standards and data requirements	For communication over an ETSI ITS-G5 channel, vehicle data in the form of a ETSI EN 302 637-2 CA message shall be supported. The data which several Member States require for which types of processing has been tabled in the annex. The green fields indicate requirements, the orange fields indicate nice-to-have. This table could be used as a basis for discussing further harmonisation for data requirements between Member States, C2C, ….
Common Types of Vehicle Data Processing	
Introduction	Among the C-Roads road operators the following common types of data processing have been identified.
Aggregated vehicle data collection	This data processing creates data similar to and/or compatible with existing loop detectors or area sensors. The resulting data is used for traffic analyses and traffic modelling, traffic information and traffic regulation (e.g. speed advice/limit) The processed data contains or could contain - number of vehicles - average speeds (in time) - harmonic average speeds (in space) - (average) length - classification (data per class) - standard deviations - minimum and maximum speeds during a specified interval. Commonly used intervals are 1 minute, 5 minutes, 6 minutes, 1 hour
Vehicle detection	This processing detects or counts the presence of vehicles in specific areas. The resulting data is used in e.g. tunnels and parking areas.
Signal optimisation	The processing results in data to be used to optimize traffic signal timings. Applications include queue and delay measurement, signalised intersection manoeuvres analysis, verification of signal timings and sensor failings.
Event detection	This processing detects events or trends in the vehicle data resulting in queue, congestion or event information.

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	The processed data contains or could contain: - acceleration/deceleration - speed and direction - number of vehicles with headlights on - number of vehicles with daytime running lights on - number of vehicles with fog lights on - specific vehicle roles (for e.g. emergency vehicle warning) - positions of start and/or end of congested areas or queues - positions of stationary vehicles
Travel time	Vehicle data is processed on multiple locations to determine or estimate the travel time. The resulting data is used for traffic analyses and traffic modelling, traffic information. To be able to make the estimate, matches for vehicles on the different locations should be possible with sufficient confidence during a sufficiently large time interval.
Origin/destination	Vehicle data is processed on multiple locations to determine or estimate the origin-to-destination information. The resulting data is used for traffic analyses and traffic modelling, investment analysis, traffic information or traffic regulation. To be able to make the estimate, matches for vehicles on the different locations should be possible with sufficient confidence. Compared to “Travel time”, the time interval during which matches are needed are larger, because of the longer distances.
Performance indication	Vehicle data is processed into information of actual performance of roads or road systems compared to regular, expected or optimal performance

5.2.2 PVD - Event Data Collection (PVD-EDC)

Use case introduction PVD – EDC	
Type of road network	**All**
Type of vehicle	All C-ITS equipped ones
Summary	Events (either automatically detected by the vehicle's systems or either manually reported by road users) are collected.
Background / added values	• Thanks to their sensors / embedded technologies, vehicles know specific events affecting the driving experience (windscreen wiper status, ABS, ESP, collision sensors, etc.). • Some events cannot (yet) be detected automatically by the vehicle itself (e.g. Animal on the road, unmanaged blockage of a road, etc.) • Therefore, the road user himself could also be a source of information to detect some specific events and to warn the road operator or service provider. These data could be used to enhance the road operator or service provider's knowledge of events, complementing cameras, patrol and other existing sources. Additionally, a maintenance worker or road operator personnel can be seen as specific type of road users, who can detect and manually report events.
Objective	See PVD service introduction
Desired behaviour	• In the automatic detection case: No specific behaviour is expected from road users for whom the operation of the service is totally invisible. • In the manual declaration case: The ability of the road user to send information safely and quickly. • For the road operator, the collected data gives insight in the traffic situation and surroundings. These are used as input for monitoring & evaluation (e.g. for policy making) and other I2V use cases such as traffic condition warning, hazardous location notification and adverse weather condition.
Expected benefits	See PVD service introduction
Situation	A vehicle is driving along the road. A vehicle or a road user detects a specific event, and transmits a message.
Logic of transmission	V2I
Actors and relations	• **The in-vehicle system** is the source of the information or gathers together the information from the vehicle's sensors. • **The road user** is the data subject, who might need to give its consent regarding automatic sharing of their vehicle's data. The road user might be able to manually declare specific events or feedback via the HMI of the in-vehicle system. • **The road operator** collects and processes the data from vehicles. • **Service provider:** collects and processes data to provide services and can exchange this information with other providers and/or road operators. • The **Traffic Operations Centre** uses the data for traffic management and public communication.
Scenario	1. A) An in-vehicle system automatically detects an event B) The road user observes an event (or the absence of an event) and reports it via the HMI of the in-vehicle system. 2. The in-vehicle system sends a message.

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	3. Messages from vehicles are received by an R-ITS-S or service provider. Data can be anonymized, maybe aggregated, and transmitted to a central system. 4. The data can be collected, validated, aggregated, consolidated by the road operator or service provider. 5. Data are accessible in the Traffic Operations Centre or by the service provider. 6. This will allow it, in return, to provide information or services to vehicles or road users (I2V) Example how PVD-EDC can be used e.g. Detection of a vehicle at risk in a critical area: The road operator or service provider identifies and configures the dangerous locations within its areas (such as a railway crossing, a bridge or a tunnel). If certain messages (e.g. Broken Down Vehicle, Stationary Vehicle) are received by the Road Operator that concern these critical areas previously defined, the data should be processed accordingly. When the data comes from a dangerous location there can be a specific alert for the road operator. This will allow it, in return, to provide information or services to vehicles, other road users (I2V) but also to other operators (e.g. railway) to take appropriate actions.
Display principle / alert logic	When a road user manually reports specific events on the HMI or the in-vehicle system automatically declares an event, a confirmation of sending out the event can be presented on the vehicle's HMI.
Constraints / dependencies	See PVD-VDC Additionally: In the manual reporting case: the road user should be able to **safely** report the event on the HMI.
Relation to standards and C-Roads C-ITS Infrastructure Functions and Specifications	For communication over ETSI ITS-G5 channel, event data in the form of a ETSI EN 302 637-3 DEN message shall be supported. The data requirements have been tabled in the annex. In the annex, the (dark) green coloured fields indicate mandatory requirements, and the orange coloured fields indicate optional nice-to-have data. The difference between automatically detected or manually declared events is indicated by the InformationQuality data element.

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6 Annex PVD

6.1 Annex PVD-VDC

ETSI EN 302 637-3 DEN message		
	FR	
CauseCodeType / Container	Level of desire	Remarks FR
trafficCondition(1)	Not expected	
accident(2)	Really Needed	
roadworks(3)	Not expected	
adverseWeatherCondition-Adhesion(6)	Needed	
hazardousLocation-SurfaceCondition(9)	Needed	
hazardousLocation-ObstacleOnTheRoad(10)	Really needed	
hazardousLocation-AnimalOnTheRoad(11)	Needed	
humanPresenceOnTheRoad(12)	Needed	
wrongWayDriving(14)	Needed	Only if confidence on lane positioning is high.
rescueAndRecoveryWorkInProgress(15)	Not expected	
adverseWeatherCondition-ExtremeWeatherCondition(17)	Not expected	
adverseWeatherCondition-Visibility(18)	Needed	
adverseWeatherCondition-Precipitation(19)	Needed	
slowVehicle(26)	Not expected	
dangerousEndOfQueue(27)	Needed	
vehicleBreakdown(91)	Not expected	94/2 expected for vehicle breakdown
postCrash(92)	Not expected	
humanProblem(93)	Not expected	
stationaryVehicle(94)	Really needed	Especially for 94/2 (vehicle breakdown)
emergencyVehicleApproaching(95)	Not expected	V2V
hazardousLocation-DangerousCurve(96)	Not expected	
collisionRisk(97)	Not expected	
signalViolation(98)	Not expected	
dangerousSituation(99)	Needed	
RailwayLevelCrossing (100) (C-Roads FR project, this cause code is not in the standard yet.)	Not expected	I2V only
Probe vehicle data on detected events		
Probe vehicle data on manually declared events		
same information, but specific (lower?) information quality		

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6.2 Annex PVD-VDC

required for purpose/data processing

nice-to-have

ETSI EN 302 637-2 V1.3.2 (2014-11)

Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service

Annex B: Description for data elements and data frames

Member State / Pilot Site	C-Roads draft v0.8	C-Roads draft	NL			DE Hessia				DE Lower	FR					AT			C-Roads draft PVD
Services	Minimally common data requirements	Maximal data requirements	vehicle data aggregation	signal optimization	queue, event and congestion detection	emergency or maintenance vehicle warning	TrafficJam Warning	ShockWave Damping	vehicle data collection	general PVD requirements	aggregated vehicle data collection	vehicle detection	travel time,	origin/destination	general PVD	Aggregated vehicle data collection	Vehicle detection	travel time	(for reference)
B.0 General requirements																			
B.1 header													stationID fixed 1h	stationID fixed 2h					
B.2 cam																			
B.3 generationDeltaTime																			
B.4 camParameters																			
B.5 basicContainer																			
B.6 highFrequencyContainer																			
B.7 lowFrequencyContainer																			
B.8 specialVehicleContainer																			
B.9 basicVehicleContainerHighFrequency																			
B.10 basicVehicleContainerLowFrequency																			
B.11 publicTransportContainer																			
B.12 specialTransportContainer																			
B.13 dangerousGoodsContainer																			
B.14 roadWorksContainerBasic																			
B.15 rescueContainer																			
B.16 emergencyContainer																			
B.17 safetyCarContainer																			
B.18 stationType																			
B.19 referencePosition																			
B.20 performanceClass																			
B.21 heading																			
B.22 speed																			
B.23 vehicleRole																			
B.24 lanePosition																			
B.25 driveDirection																?	?		
B.26 longitudinalAcceleration																			
B.27 accelerationControl																			
B.28 lateralAcceleration																			
B.29 verticalAcceleration																			
B.30 embarkationStatus																			
B.31 curvature																			
B.32 curvatureCalculationMode																			
B.33 yawRate																			
B.34 steeringWheelAngle																			
B.35 vehicleLength																			
B.36 vehicleWidth																			
B.37 exteriorLights																			
B.38 pathHistory																			
B.39 ptActivation																			
B.40 specialTransportType																			
B.41 dangerousGoodsBasic																			
B.42 roadworksSubCauseCode																			
B.43 closedLanes																			
B.44 trafficRule																			
B.45 speedLimit																			
B.46 lightBarSirenInUse																			
B.47 incidentIndication																			
B.48 emergencyPriority																			
B.49 rsuContainerHighFrequency																			
B.50 protectedCommunicationZoneRSU																			
B.51 cenDsrcTollingZone																			
B.52 protectedZoneLatitude																			
B.53 protectedZoneLongitude																			
PVD Wishlist -additional data																			
windscreen wiper frequency																			
Anti-lock braking system																			
Electronic Stability Control																			
Traction control system																			
Temperature																			
Rain sensor																			
eCall																			
Photodetector																			
Air pressure in tyres																			
Emission sensor																			
Headway (un)managed																			