Common C-ITS Service Definitions

Version 1.3

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	Constructed this document based on the integral individual documents of the services 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 service description of RWW 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. Only the table of contents has been adjusted accordingly.	Draft
1.01	19.03.2018	Revision of complete document following the comments received on OHLN for and in the WG2 meeting, all major changes discussed and agreed, minor comments integrated in the document and presented in an additional TF2 Telco, no open questions remained. (All comments addressed and commented 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. And as also agreed upon during WG2 meeting 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 fit within the current lay out.. Also, as agreed upon during the before mentioned WG2 meeting, the previous service section “Other Hazardous Location Notifications” (OHLN) has been changed into “Hazardous Location Notifications” (HLN). When writing this version of the documents, it was tried to avoid the use of gender specific language. Nonetheless, it might occur that in some sections it was not successfully yet, 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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Introduction

In this document the C-Roads Platform describes in a functional way the implemented services and use cases in the various C-Roads projects and pilots. These functional descriptions are the result of the harmonisation efforts that take place within TF2 (Service Harmonisation) and the alignment with the work of C-Roads TF3 where the harmonisation of the message profiles for the specific services and use cases takes place.

In this context we make use of the following terminology:

- Service: clustering of use cases based on a common denominator, for example being an objective like 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 present within a static snapshot) considering (driving) function-related goals and values.
- Scenario: describes temporal development in a sequence of situations (e.g. initial and after) based on events and actions. It is story telling.
- Actors: are external (human) entities that interact with the system. The system affects and is affected by the behaviour of actors, therefore these relations 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 is a new use case.
- The same information need in a different context is 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 in the high level technical descriptions. This document contains no high level technical descriptions as these are functional 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 in the use case name. Similarly, services should be defined carefully and economical as the 1..n relation with use cases may lead to a nearly infinite number of services.

The following format is used to describe the services:

Service introduction	
Summary	Here we provide a summary of the service (one or two lines)
Background	Here we describe the motivation/rationale of the service
Objective	Here we describe the intended outcome of the service
Expected benefits	Here we describe the added value and actor benefits of the service
Use Cases	Here we give a list 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	Here we provide a summary of the use cases (one or two lines)
Background	Here we describe the motivation/rationale of the use case
Objective	Here we describe the intended outcome of the use case
Desired behaviour	Here we describe the behaviour of the system and the intended behaviour of users
Expected benefits	Here we described the added value and actor benefits
Use case description	
Situation	Here we describe one or more situations relevant to the use case
Logic of transmission	Here we describe the transmission logic (I2V, V2V, V2I, V2I2V… + broadcast / unicast / multicast)
Actors and relations	Here we list all relevant actors and their relation/interaction to 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	Here we describe the story of the use case based on a sequence of situations (e.g. initial and after), events and actions. With illustration. Sender and receiver should be addressed, in stakeholder neutral manner.
Display / alert principle	Here we describe triggering conditions and what is displayed to the user and when.
Functional Constraints / dependencies	Here we describe functional constraints and dependencies that are requirements (if any) related to e.g. business, security, telecommunications, privacy, legal, human behaviour, etc.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	Here, the specific settings of the profiled message sets in the C-Roads TF3 document “Infrastructure Functions and Specifications” are described.

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

Service	Use Case
In Vehicle Signage	Dynamic Speed Limit Information (IVS-DSLI)
	Embedded VMS “Free Text” (IVS-EVFT)
	Other Signage Information (IVS-OSI)
Other Hazardous Location Notification	Accident Zone (OHLN-AZ)
	Traffic Jam Ahead (OHLN-TJA)
	Stationary vehicle (OHLN - SV)
	Weather Condition Warning (OHLN-WCW)
	Temporarily slippery road (OHLN-TSR)
	Animal or person on the road (OHLN-APR)
	Obstacle on the road (OHLN-OR)
Road Works Warning	Lane Closure (RWW – LC)
	Road Closure (RWW – RC)
	Road Works – Mobile (RWW-RM)
Signalized Intersections	Green Light Optimal Speed Advisory (SI-GLOSA)
	Public Transport Prioritization (SI-PTP)

1 In Vehicle Signage (IVS)

1.1 IVS: Service introduction

Service introduction	
Summary	In Vehicle Signage (IVS) is an information service to inform road users on actual, static or dynamic (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 as indicated on physical road signs along the road and on additional virtual information (virtual VMS or free text). IVS might use the option to 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. VMS systems are used today by road operators to send operational, tactical or strategic information to road users. Different types of 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 for road signage by providing signage information directly in the vehicle where it can potentially be displayed throughout its entire validity. This will severely reduce observation problems attributed to physical signage like e.g. limited line of sight, obstructions of any kind, limited attention by drivers during passage of signage • Display in own or preferred language potentially
Expected benefits	• In Vehicle Signage allows the driver to be informed earlier and more complete 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) what might result in less distraction.
Use Cases	IVS consists of several use cases where also VMS, VTP or VDS are used: • In Vehicle Signage: Dynamic speed limit information • In Vehicle Signage: Embedded VMS • In Vehicle Signage: Other signage information Other In Vehicle Signage Use Cases are under review and might be added in next releases.

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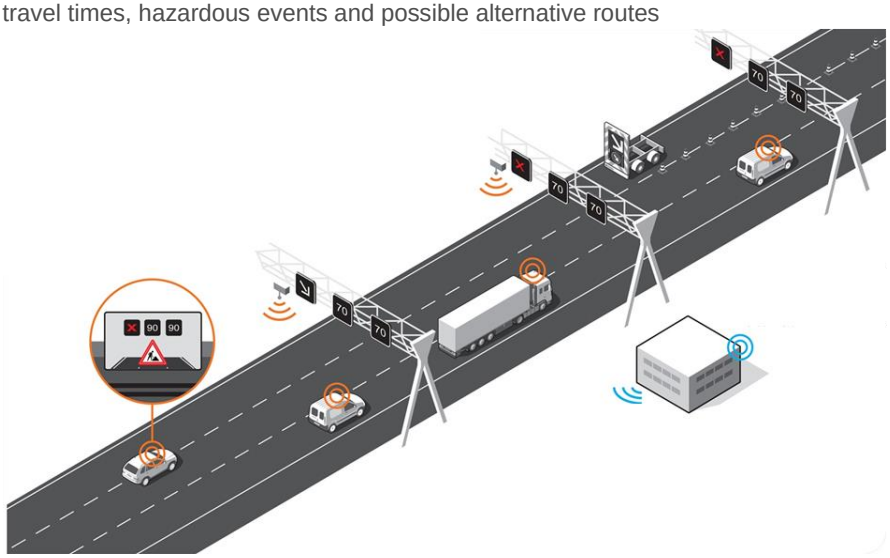
1.2 IVS: Use Cases

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

Use case introduction	
Summary	The road users receive in-car 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 more quickly and avoid speeding.
Objective	The aim is to inform the road users about the currently valid dynamic speed limit set by the road operator visualized by variable message signs (VMS).
Desired behaviour	The road users adapt their driving behaviour compliant to the applicable driving speed limit. In the future the information may be used by Advanced Driver Assisted Systems for 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 to enforce traffic regulations (like e.g. speed 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 transmits information on the currently valid speed limit continuously, as set by the road operator because of e.g. roadworks, incidents, traffic jams.
Logic of transmission	I2V Broadcast

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Actors and relations	• Road operator: The source of any 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 designers 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 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	• The Traffic Control Centre (TCC) sends a message with the dynamic speed limit for every lane. The speed limit can be targeted to a specific vehicle type (for e.g. Heavy Goods Vehicles). • The message is received in the vehicle and displayed to the driver if relevant to that road user. • The road user can adapt his speed.
Display / alert principle	• IVS information shall be displayed to the road user and shall be consistent with the currently valid dynamic traffic signs. • The information needs to be displayed to the driver early enough and in the right location.
Functional constraints / dependencies **Relation to C-Roads C-ITS Infrastructure Functions and Specifications**	• 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 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. • The IVI message for IVS-DSLI is profiled in the 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 of the speed limit 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 most of time it is absent.

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

Use case introduction	
Summary	The goal of this use case is to display to the road user in-car 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 (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 the panel is visible to the road user. • 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: due to the extended communication with the road user compared to just viewing the text panel while driving by, there is more time to read and comprehend the information that is shown directly in the vehicle
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 his/her driving behaviour compliant to the applicable driving regulations and any advice or guidance provided.
Expected benefits	• Traffic management: the use case allows to improve traffic management (regulation, smart routing, etc.), because information can potentially be broadcasted 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 regulation information, the virtual VMS allows to display 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 • Etc.

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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 designers 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 an information to road users. The virtual VMS is a possible means, as well as physical VMS, radio, the internet, etc. • The road operator sends the information via all or selected information channels • Vehicles receive the information, and display it to the drivers, at the moment and in the location defined by the road operator. The priority of the IVS messages sent by the road operator to display is defined by the road operator.
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 right 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.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The IVI message for IVS-EVFT is profiled in the 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 by lane(s) is not displayable.

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1.2.3 IVS - Other Signage Information (IVS-OSI)

Use case introduction	
Summary	The aim of the 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 or lane advice / closures. The information will either reproduce what is displayed at a physical VMS (e.g. Variable Text Panel) or display a completely new message (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 based on information in the TCC (virtual VMS) VMS systems are used today 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 Assisted Systems for automated and autonomous 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 ○ Solve 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-car information on actual overtaking prohibition, especially for trucks ○ Lane advice or information about closed driving lanes (e.g. below) ○ In-vehicle information about potentially dangerous situations and

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	road construction / road works ○ See examples below ○  
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 info 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 the vehicle. This may include an advice to reduce speed, change lanes, apply 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 the right 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 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.

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	presented accordingly to the road user, as currently done within navigation systems.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	The IVI message for IVS-OSI is profiled in the chapter 3.2.2 of the *C-ITS Infrastructure Functions and Specifications* document. For this use-case in a dynamic lane management standard context (clear to left or right) : • ISO14823 DF is set with serviceCategoryCode = informative ; nature = 6 ; serialnumber = 59 (for lane closed), 60 (for lane free), 61 (for clear lane to left) or 62 (for clear lane to right). • 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.

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2 Hazardous Locations Notification (HLN)

2.1 HLN: Service introduction

Service introduction	
Summary	This C-ITS service describes an I2V warning message related to a series of potentially hazardous events on the road, where the approaching road users gets 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 the involved and relevant road users so they can adopt their driving behaviour accordingly.
Objective	Inform road users of hazardous locations on their way in order to enhance overall road safety by providing in-car information about these 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 to 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 e.g. the following warnings as use cases: • Accident Zone, (Abbreviation: HLN – AZ) • Traffic Jam Ahead, (Abbreviation: HLN – TJA) • Stationary Vehicle, (Abbreviation: HLN –SV) • Weather Condition Warning, (Abbreviation: HLN – WCW) • Temporarily Slippery Road,(I2V), (Abbreviation: HLN – TSR) • Animal or Person on the Road (I2V), (Abbreviation: HLN – APR) • Obstacle on the Road (I2V), (Abbreviation: HLN – OR) Further use case descriptions like Truck Queues, (Abbreviation: HLN – TQ), Railway Level Crossing, (Abbreviation: HLN – RLX), Wrong Way Driver (Abbreviation: HLN – WWD), or form emergency corridor (Abbreviation: HLN – FEC) –are under investigation and might be added in next C-Roads releases.

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2.2 HLN: Use Cases

2.2.1 HLN: Accident Zone (HLN-AZ)

Use case introduction Accident Zone	
Summary	The road operator detects that an accident has happened on the network and broadcasts the information to road users that 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 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	Warn road users of accident zones ahead and around their position in order to enhance overall road safety.
Desired behaviour	Precisely and correctly informed drivers adapt their driving behaviour (e.g. reduce the approaching speed, drive more cautiously or concentrated...) before and during the 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 his vicinity, and according to his driving direction and validity he is informed about the warning message. .
Logic of transmission	I2V broadcast
Actors and relations	• **Road operator:** provides information about the accident zone detected on its 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 his way by his selected channel of information.
Use Case Scenario	• An accident is detected and confirmed in 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. • The road operator generates the event information within the TCC and distributes it via various channels with one message ID to the vehicles - e.g. I2V broadcast • The service provider collects and distributes the AZ C-ITS message from

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	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, he receives C-ITS messages which allow him to adjust his behaviour (e.g. speed and position) on the road to prevent any danger. The information can then be displayed on the 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 proper 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 backend system of the road operators in order to generate proper 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.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for HLN-AZ is profiled in the 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 2 (accident) and subCauseCode is between 0 and 7 except 6 (vehicle ; which is implicit for an accident).

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2.2.2 HLN – Traffic Jam Ahead (HLN-TJA)

Use case introduction: Traffic Jam Ahead warning	
Summary	Within his TCC a road operator detects a traffic jam, and sends the information to the road user (mentioning the positions, 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 potential dangerous end of queue. The driver can change his driving approach adapting his speed, and driving approach to the end of jam area. The precision of the end of queue is usually very low. This use-case could help to improve it since it can be signalized by vehicles encountering it, if they are adapting their speed and/or vehicle trajectory nearby the end of traffic jam zone.
Desired behaviour	• Precisely and correctly informed drivers adapt their driving behaviour (e.g. reduce the 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	Homogenous traffic flow with less congestions caused by accidents leads 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 send 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 and in the future possibly ACC system) or the driver

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	• Sources of information can be:
	  ○ Cameras (incident detection ones as well)
	  ○ traffic loops
	  ○ Operating agents/RO 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 send out to end users approaching the area.

Use Case Scenario	I2V 1. The operator in the TCC gets informed about a traffic jam on his 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 his 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 drivers set of preferences. • The user is provided with related information, displayed on the dashboard. Layout and sequence of presentation is left to OEM-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.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for HLN-TJA is profiled in the 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 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.

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2.2.3 HLN - Stationary vehicle (HLN - SV)

HLN – UC - SV Stationary vehicle	
Type of road network	All road networks, forwarding mainly on motorways
Type of vehicle	All vehicles
Use case introduction	
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 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 broadcasted by the stationary vehicle and processed/filtered by the receiving vehicles nearby • 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 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.) broadcasts to incoming 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 his/her 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 Assisted Systems for automated and autonomous driving. In addition to that the driver shall pay particular attention to the possible presence of Vulnerable

	Road User (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 drivers 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 his speed but not too early that he forgets the alert, and 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 is capable of warning 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. 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 Signaling (RHS) application requirements specification [5] ETSI TS 101 638 V1.1.1
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for HLN-SV is profiled in the 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 0 (unavailable) or 2 (breakdown vehicle).

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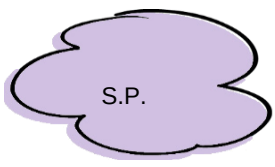
2.2.4 HLN - Weather Condition Warning (HLN-WCW)

HLN – UC WCW – Weather Condition Warning	
Type of road network	All road networks
Type of vehicle	All vehicles
Use case introduction	
Summary	Weather Conditions (WC) shows both static and dynamic information of weather conditions and road status in-car. 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 (WC) I2V service is meant to inform drivers via in-car information systems on static and expected information of weather conditions and road status along the road. Both advisory events are in scope of WC. The WC 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 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 Assisted Systems for automated and autonomous driving
Expected benefits	• The primary expected impact is more attentive driving by providing actual and continuous (expected) information on road conditions (e.g. grip, 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 e.g. fog (scenario 3).
Logic of transmission	I2V broadcast

<table>
<tr><td>Actors and relations</td><td>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</td></tr>
<tr><td>Use Case Scenario</td><td>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 send directly but after the TCC confirmed the data and the triggering conditions
  
Scenario 2: the vehicle gets the WCW message and ask´s 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.</td></tr>
</table>

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	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 [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. In particular it includes • *DENM transmission conditions.* • *Event triggering condition* • *Relevance area* • *Event termination condition* • *Use case specific data element values to be provided*
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for HLN-WCW is profiled in the 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 17 (extreme weather condition) or 19 (precipitation).

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2.2.5 HLN - Temporarily slippery road (HLN-TSR)

HLN – UC – TSR temporarily slippery road,(I2V)	
Type of road network	**All**
Type of vehicle	**All**
Use case introduction	
Summary	A road operator know 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 it 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 him adapt his 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

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	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 his network • He puts the information in his TCC 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 driver adapts his 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 his 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.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for HLN-TSR is profiled in the 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 6 (adhesion) and subCauseCode is between 0 and 9.

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

HLN – UC - APR animal or person on the road (I2V),	
Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	• A road operator knows that one or several animal(s) is(are) present on his network and broadcasts the information to road users, or • A driver detects one or several animals on the road and signals it via his HMI, broadcasting a message to road users, or both situations or warnings are combined..
Background	• Today, this information is 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 precision of the localization is not very high. Hence, the road user needs to increase his driver attention.
Desired behaviour	• Increased driver attention • Adaptation of the 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 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 :

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	• Cameras • 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. • He puts the information in his TCC 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 his speed or even his itinerary (in case of a flock for example). However, since he 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.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for HLN-APR is profiled in the 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 11 (animal on the road) or 12 (human presence on the road).

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

HLN – UC – OR obstacle on the road (I2V)	
Type of road network	All
Type of vehicle	All vehicles
Use case introduction	
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 go through (not a blockage).
Background	Today, this information is 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 precision of the localization is not very high. Hence, the road user needs to increase his 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 if not alerted. There can also be big obstacles, 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 • Others 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. • He puts the information in his TCC 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 driver adapts his behaviour.
Display principle / Alert logic	• The displayed warning to the driver needs to be early enough to adapt his speed or even his itinerary. However, since he should not forget about the

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	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.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for HLN-OR is profiled in the 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 10 (obstacle on the road) and subCauseCode is between 0 and 5 (6 and 7 are not used).

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3 Road Works Warning (RWW)

3.1 RWW: Service introduction

Service introduction – Road Works Warning	
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. • In the next release of the document, new use cases could be added for specific situations. For example, when a vehicle with a dangerous trajectory / speed approaches road works, a warning could be sent to the driver of the approaching vehicle and to workers.
Background	Road works usually affect the road layout and 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 the length of the roadwork.
Objective	More attentive and adjusted driving while approaching and passing a work zone 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, 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 safety-objects 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) Further use case descriptions are under investigation and might be added in next C-Roads releases, like: • Alert operator vehicle approaching / in intervention / in patrol, • Winter maintenance (Salting, snow removal), • Vehicle dangerously approaching road works: warning to the approaching vehicle, Vehicle dangerously approaching road works: warning to workers

3.2 RWW: Use Cases

3.2.1 RWW: Lane closure (and other restrictions) (RWW – LC)

RWW – LC: Lane Closure and other restrictions	
Type of road network	All
Type of vehicle	All
Use case introduction	
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 Center, 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 a RWW site needs to be taken care of.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for RWW-LC is profiled in the chapter 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.

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3.2.2 RWW - Road Closure (RWW – RC)

RWW – CR: Planned road (or carriageway) closure	
Type of road network	**All**
Type of vehicle	**All**
Use case introduction	
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 driver adapts his 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
Relation to C-Roads C-ITS Infrastructure	• The DENM message for RWW-RC is profiled in the chapter 3.2.1.1 and 3.2.1.2 of the C-ITS Infrastructure Functions and Specifications document.

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Functions and Specifications	• For this use-case, causeCode is 3 (roadworks) and subCauseCode is 1.

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3.2.3 RWW – Road Works – Mobile (RWW-RM)

RWW – M : Planned road works – mobile (e.g. cutting the grass or renewing the lane markings)	
Type of road network	**All**
Type of vehicle	**All**
Use case introduction	
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 (stand alone 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 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.
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The DENM message for RWW-RM is profiled in the chapter 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.

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4 Signalized Intersections (SI)

4.1 SI: Service Introduction

Service introduction: Signalized Intersections	
Summary	The service is to provide information to road users for a safe and efficient crossing of a signalised intersection. 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 accelleration. 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 improve traffic safety due to reduced red light violation and lower risk of collision when passing the intersection. Primarily expected from the emergency approaching/prioritisation use case, is a shorter travel time for emergency vehicles (EVs), but also less collision risk with, and reduced negative impact to individual traffic. For public transport 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	Traffic Light Manoevre (TLM) & Road and Lane Topology (RLT) use cases: 1. Green Light Optimal Speed Advisory *2. Time-To-Green Advisory (future release)* *3. Signal Violation Warning (future release)* *4. Safe Intersection Crossing (future release)* Traffic Light Control (TLC) use cases: 1. Public Transport Prioritization *2. Traffic Signal Priority For Other Vehicles (heavy goods / emissions, etc.) (future release)* 3. *Emergency Vehicle Priority (future release)*

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4.2 SI: Use Cases

4.2.1 SI: Green Light Optimal Speed Advisory (GLOSA)

Use case introduction	
Summary	The service is to provide speed advice to road users approaching and passing traffic light controlled intersections.
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	Situation 1 (single intersection): 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. Situation 2 (sequence of intersections): 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 influences the validity of the speed advisory information.. • Road operator: ensures coordination of traffic light controlled intersections and provide 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.

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Use Case Scenario	Scenario 1a (vehicle calculates speed advice): 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 a 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 outweighs 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

Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• The SPATEM and MAPEM messages for SI-GLOSA are profiled in the 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.

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4.2.2 SI: Public Transport Prioritization

Use case introduction	
Summary	The use case is to give priority to public transport vehicles over individual vehicles at signalized intersections for assuring on time transportation schedule (e.g. bus, tram).
Background	To make public transport more punctual and comfortable prioritization system for public transport at signalized traffic intersections is necessary. Also to make the use of public transport more attractive to the public.
Objective	Interaction between public transport vehicle and traffic light controller (either local or central) to reduce the delay of public transport vehicles at signalized intersections, thereby improve the efficiency of public transport operations.
Desired behaviour	Public transport (e.g. busses, trams) drive through an intersection without stopping on "red light" or waiting for "green light" and crossing the intersection without any delays. The traffic light controller adapts its signal phases to give priority to the public transport vehicle. The public transport vehicle can pass the signalized intersection with minimum delay.
Expected benefits	The following benefits are expected: • Minimum delay for public transport vehicles at signalised intersections • Less emissions from public transport vehicles • Improved punctuality due to reduced disturbance on branch lines • Increased attractiveness of public transport due to improved comfort • Improved efficiency of public transport operations (e.g. same service quality with less vehicles or higher frequency with equivalent fleet) • Improved choice of suppliers for public transport operators or public authorities dueto standardized V2X solution for public transport prioritization systems.
Use case description	
Situation	A V2X equipped public transport vehicle approaches a signalized intersection which is serviced with a public transport prioritization system.
Logic of transmission	V2I and I2V transmission.
Actors and relations (in no particular order)	• Public transport 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 • Public transport operator: determines if the public transport vehicle is in time or delayed
Use Case Scenario	The public transport vehicle transmits a prioritization request. The public transport prioritization system processes the request and either accepts (e.g. the vehicle is behind schedule) or rejects (e.g. other priorities are granted) the request, then gives feedback to the public transport vehicle. If the request is accepted, e.g. "red phases" may be shortened and "green phases" extended, thus the bus gets "green light" with minimum delay at the stop line.

	After successful driving through the intersection, the traffic light controller switches back to normal operation.
Display principle / Alert logic	The driver of the public transport vehicle receives on an in-vehicle display information about the 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. 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 public transport vehicles shall be ensured. • Policy on public transport prioritization shall be defined, e.g. the level of priority, which public transport lines, what locations, etc. • The priority request shall be provide in time to allow the public transport prioritization system to react on the request. • 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
Relation to C-Roads C-ITS Infrastructure Functions and Specifications	• Not defined yet in the C-ITS Infrastructure Functions and Specifications document.

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