



# **C-ITS SERVICE AND USE CASE DEFINITIONS VERSION 2.3.0**

C-Roads Platform

Working Group 2 Technical Aspects

Taskforce 2 Service Harmonisation

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## Publication History

Version	Date	Description, updates and changes	Status
1.0	19.02.2018	This document integrates the individual document specifications of the services for In-Vehicle Signage (IVS 1.07), Other Hazardous Locations Notifications (OHLN v1.08) and Road Works Warning (RWW 1.06). The use case overview in the RWW service description was adjusted as the mentioned use cases 4-7 are not part of this document but potential candidates for further releases. No other changes were made to the content of the working documents used in the service working groups, the complete text was copied into this document for each specific service. The table of contents has been adjusted accordingly.	Draft
1.1	22.03.2018	Last smaller editorial issues	Final
1.2	12.06.2018	Included service descriptions for TLM/RLT v1.91. As agreed during the WG2 meeting of 29/30 May 2018 in Vienna the TLM/RLT service section is renamed into "Signalised Intersections". Some minor editorial changes were made to make it conform with the current layout.  Also, as agreed during the same WG2 meeting, the former service section "Other Hazardous Location Notifications" (OHLN) has been changed to "Hazardous Location Notifications" (HLN). This version of the document, the use of gender specific language is avoided. Nonetheless, further review and modification may be required; this will be taken into account for the next release 1.3.	Final
1.3	02.10.2018	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".  Based on SC meeting of 02-10-2018: Release 1.3 is accepted for C-ROADS deployment by 14 member states: Austria, Belgium/Flanders, Belgium/Wallonia, Czech Republic, Denmark, France, Germany, Hungary, Italy, Netherlands, Norway, Portugal, Slovenia, Sweden and United Kingdom. Release 1.3 is not accepted by Finland and Spain.	Final

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1.4	19.12.2018	<p>This release has the following changes with respect to v1.3:</p> <ul style="list-style-type: none"> <li>○ Incorporation of revised paragraph 4.2.2 based on the decision during the SC meeting of 11-12-2018 on the acceptance of the change request on R1.3. (the original paragraph 4.2.2 Signalised Intersections - Public Transport Prioritization, see for details "<i>C_Roads_WG2_TF2_TLM RLT Change Request on R1.3 after WG2 Budapest.doc</i>").</li> <li>○ Incorporation of new paragraphs based the acceptance of new use cases (see for more details: "<i>C_Roads_WG2_TF2_New Use Cases Release 1.4 (A) - after WG2 Budapest.doc</i>"). This meant the new paragraphs 1.2.3 IVS-Dynamic Lane Management, 4.2.3 SI - Signal Phase and Timing Information, 4.2.4 SI - Imminent Signal Violation Warning and 4.2.5 SI - Emergency Vehicle Priority. Some minor editorial changes were made as well as changes due to the inclusion of the new content (paragraph headers, number).</li> </ul>	Final
1.5	11.07.2019	<ul style="list-style-type: none"> <li>○ This release has the following changes with respect to v1.4, agreed upon during the SCOM meeting of July 2, 2019.</li> <li>○ Incorporation of agreed change request for IVS-EVFT use case from Slovenia.</li> <li>○ Incorporation of new paragraphs based the acceptance of the new use cases (see for more details: "<i>C_Roads_WG2_TF2_Service Descriptions SCOM 2019-06-21 After WG2 Prague meeting Clean</i>"): new paragraphs 2.2.8, 2.2.9; an improved RWW service description 3.1; new paragraphs 3.2.4, 3.2.5, 3.2.6; the inclusion of a new service PVD paragraph 5.1, 5.2.1 and 5.2.2; and the inclusion of an Annex belonging to PVD.</li> <li>○ Some minor editorial changes were made as well as some changes due to the inclusion of the new content (paragraph headers, number).</li> </ul>	Final

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1.6	04.02.2020	<ul style="list-style-type: none"> <li>○ This release has the following changes with respect to v1.5, agreed upon during the SCOM meeting of December 17, 2019.</li> <li>○ Incorporation of the English proofreading improvements (<i>C_Roads_WG2_TF2_Service Descriptions v1.5 - English Proofreading 0.3 after WG2</i>)</li> <li>○ Incorporation of the SI improvements (<i>C_Roads_WG2_TF2_Service Descriptions v1.5 - SI improvements 0.3 After WG2 meeting</i>)</li> <li>○ Incorporation of the 6 accepted new Use Cases: <ul style="list-style-type: none"> <li>○ <i>C_Roads_WG2_TF2_HLN UBR I2V v0.6</i></li> <li>○ <i>C_Roads_WG2_TF2_HLN-AWWD v0.10</i></li> <li>○ <i>C_Roads_WG2_TF2_HLN-PTVC v0.3</i></li> <li>○ <i>C_Roads_WG2_TF2_HLN-PTVS v0.3</i></li> <li>○ <i>C_Roads_WG2_TF2_SWD v1.0.13</i></li> <li>○ <i>C-Roads_WG2_TF2_HLN-EVI v0.6</i></li> </ul> </li> <li>○ Some minor editorial changes were made as well as some changes due to the inclusion of the new content (paragraph headers, number).</li> </ul>	Final
1.7.0	24.06.2020	<ul style="list-style-type: none"> <li>○ 1.7.0.WG.5 accepted by the SCOM on 24.06.2020.</li> <li>○ Incorporated agreed upon additional segments: Acronym List and New Introduction chapter. The numbering of the chapters has changed due to this inclusion.</li> <li>○ No new use cases were added to the document</li> </ul>	Final
1.8.0	03.02.2021	<ul style="list-style-type: none"> <li>○ Inserted the outcome of the common resolution meetings and the WG2 meeting of November into the document.</li> <li>○ No new use cases added in this release</li> <li>○ Added the input from TF1, TF3, TF4 and TF5 to the interoperability requirements per use case. The TF5 addition also covers a more detailed description of the Test and Validation Requirements in the generic format description.</li> <li>○ Also changed the numbering of the document due to the decision of WG2 in November to number this December release 1.8 instead of 2.0.</li> </ul>	Final

Version	Date	Description, updates and changes	Status
2.0.0	09.07.2021	<ul style="list-style-type: none"> <li>○ Reviewed Interoperability requirements for HLN and IVIM use cases were added based on the discussions with C2C-CC.</li> <li>○ Improvements based on the change request from Austria were discussed and agreed upon improvements and corrections of errors were incorporated.</li> <li>○ The IVS recategorization and new descriptions are now an integral part of this document and replace the previous descriptions for IVS. The content was added from: <ul style="list-style-type: none"> <li>○ <i>C_Roads_WG2_TF2_IVS_Traffic Signs Free Text.SC.2 Comment resolution</i></li> </ul> </li> <li>○ The SI service and use cases and HLN-ROVA and HLN-EVA were removed due to the intent of WG2 with this release. As soon as the remaining issues are solved, this service and these use cases will be added again.</li> <li>○ A new service (Automated Vehicle Guidance) and use cases (SAE Level Guidance and Platoon Support Information) are added. The content was added from: <ul style="list-style-type: none"> <li>○ <i>C_Roads_WG2_TF2_Automated_Vehicle_Guidance_consolidated_SCOM</i></li> </ul> </li> </ul>	Final
2.0.2	21.01.2022	<ul style="list-style-type: none"> <li>○ References updated</li> </ul>	Final
2.0.3	01.04.2022	<ul style="list-style-type: none"> <li>○ Additional input from TF5 on IVS test cases included</li> <li>○ Improvements in the functional descriptions as well as in the interoperability requirements based on the improved [C-Roads MSP].</li> <li>○ Included the content of the by the SCOM (23.03.2022) accepted documents: <ul style="list-style-type: none"> <li>○ <i>C_Roads_WG2_TF2_Signalised Intersections Reintroduction.SC.2</i></li> <li>○ <i>C_Roads_WG2_TF2_Emergency Prioritised Vehicle Approaching_SC.10</i></li> <li>○ <i>C_Roads_WG2_TF2_Emergency_and_Recovery_Vehicle_in_Intervention.SC.6</i></li> </ul> </li> <li>○ As decided by the SCOM, removed the content of the HLN-EVI and RWW-ROVI use cases as these are now covered by the content of: <ul style="list-style-type: none"> <li>○ <i>C_Roads_WG2_TF2_Emergency_and_Recovery_Vehicle_in_Intervention.SC.6</i></li> </ul> </li> <li>○ Some references needed to be updated due to the change of paragraph numbering in the respective documentation</li> </ul>	Final

Version	Date	Description, updates and changes	Status
2.0.4	07.07.2022	<ul style="list-style-type: none"> <li>○ Replacement of the HLN-EPVA use case due to the I2V scenario addition with:</li> <li>○ <i>EPVA I2V addition.SCOM.3</i></li> <li>○ Updated test cases were added</li> </ul>	Final
2.0.5	26.10.2022	<ul style="list-style-type: none"> <li>○ Missing test cases for the HLN-EPVA use case were added</li> </ul>	Final
2.0.6	13.12.2022	Revision of use case description due to change requests <ul style="list-style-type: none"> <li>○ HLN-PTVC</li> <li>○ HLN-APR</li> <li>○ HLN-WCW</li> </ul> Added/replaced agreed upon definitions in Acronym list	Final
2.0.7	30.03.2023	Revision of the HLN and RWW use case specific interoperability requirements due to the DENM release 2 based on ' <i>C_Roads_WG2_TF2_Service and Use Case Definitions 2.0.6 Working Doc_TF3.SCOM.1</i> '  Replaced the PVD service and use case descriptions with the content of the by the SCOM approved ' <i>PVD use case description V0.20</i> ' document	Final
2.0.8	30.06.2023	HLN-AZ: Added description in the message profile requirements HLN-ERVI: Updated message management based on exchange with C2C-CC; Updated definition of "stationary vehicle" Update of message profile requirements for IVIM based use cases, based on the changes in the C-ITS Message Profiles document and the new requirement to use machine-readable message components as far as possible when encoding signs.	Final
2.0.9	21.09.2023	Incorporated the improvements reviewed WG2 (June and August 2023), incorporation on some change requests and some editorial issues (formatting, figure list). The accepted and revised test cases from release 2.0.8 were incorporated (DENM). Added also the Topology Information <sup>1</sup> service and its first use case Toll Station Approaching ( <i>C_Roads_WG2_TF2_TI Service + TSA Description.SCOM.3</i> )	Final

<sup>1</sup> In version 2.3.0 renamed into Navigation Guidance

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2.1.0	16.01.2024	<p>Incorporated the changes due to:</p> <ul style="list-style-type: none"> <li>○ HLN-RLX Change Request</li> <li>○ HLN-OR Change Request</li> <li>○ IVIM-based Use Case specific message profile requirements (IVS and AVG service)</li> <li>○ HLN-TJA error due to previous accepted change request</li> <li>○ RWW-WM error due to reference to wrong subCauseCode</li> </ul> <p>Also added the following use cases:</p> <ul style="list-style-type: none"> <li>○ “IVS-Smart Routing”<sup>2</sup> based on the integral version of ‘C-ROADS UC - Smart Routing SCOM.13.doc’</li> <li>○ “SI-Toll Station Crossing” based on the integral version of ‘C_Roads_WG2_TF2_Toll Station Crossing_SCOM.10.doc’</li> </ul>	Final
2.1.1	30.04.2024	<p>Incorporated the changes due to:</p> <ul style="list-style-type: none"> <li>○ Editorial change to IVS-SR (instead of IVS-SM)</li> <li>○ IVIM updates in IVS-TS, IVS-FT, AVG-SAELG and AVG-PSI (requirement on cancellation IVIM), IVS-SR: addition of disclaimer since MP requirements are outdated</li> </ul> <p>Also added the following service and use cases:</p> <ul style="list-style-type: none"> <li>○ The service description of Collective Perception and 2 use cases (Collective Perception on Motorways and Collective Perception on Urban Intersections) based on the integral version of “C_Roads_WG2_TF2_Collective_Perception_Service and UC.SCOM.7 Clean”</li> </ul>	Final

<sup>2</sup> In version 2.3.0 moved into Navigation Guidance

Version	Date	Description, updates and changes	Status
2.2.0	31.07.2024	<p>Incorporated changes due to:</p> <ul style="list-style-type: none"> <li>○ Changed name of sCC 5 from “trafficStationary” to “trafficJam” according to CDD v2.2.1.</li> <li>○ Added additional CC and sCC for HLN-TSR</li> <li>○ Removal of SSP per station type tables and addition of statement for which stations the respective SSPs shall be granted.</li> </ul> <p>Added the following service and use case:</p> <ul style="list-style-type: none"> <li>○ The service description of the Points of Interest service and 1 use case (Parking Information) based on the integral version of “C_Roads_WG2_TF2_Parking Information.SCOM.12”</li> </ul>	Final
2.2.1	31.12.2024	<p>Incorporated changes due to:</p> <ul style="list-style-type: none"> <li>○ Addition of the 5<sup>th</sup> scenario into the HLN-RLX use case and improved on some editorial issues</li> <li>○ Updating naming of causeCodes according to DENM release 2</li> <li>○ Addition of an extra entry in the SSP table for HLN-TSR for the respective causeCode.</li> </ul>	Final



Version	Date	Description, updates and changes	Status
2.3.0	06.05.2025	<p>Renamed the following service and use case:</p> <ul style="list-style-type: none"> <li>○ Topology Information into Navigation Guidance</li> <li>○ TI-TSA into NG-TSA</li> <li>○ IVS-SR into NG-SR</li> </ul> <p>Added the following service and use case:</p> <ul style="list-style-type: none"> <li>○ NG-RA</li> </ul> <p>Incorporated changes to:</p> <ul style="list-style-type: none"> <li>○ PVD-VDC use case</li> <li>○ HLN-EPVA use case</li> <li>○ NG-SR use case</li> <li>○ IVS-TS use case</li> <li>○ HLN-WCW use case</li> <li>○ HLN-TSR use case</li> </ul> <p>Updated Test and validation requirements of these use cases:</p> <ul style="list-style-type: none"> <li>○ IVS-TS</li> <li>○ IVS-FT</li> <li>○ HLN-RLX</li> <li>○ AVG-SAELG</li> <li>○ AVG-PSI</li> <li>○ NG-SR</li> <li>○ CP-MW</li> <li>○ CP-UI</li> <li>○ POIM-PA</li> </ul> <p>Replaced <b>all</b> references now using the global reference document WG2 REFERENCES 2.3.0 (3/2025). <b>Especially</b> note:</p> <ul style="list-style-type: none"> <li>○ Reference to Basic System Profile replaced by [C2C CC Vehicle C-ITS station profile]</li> <li>○ Reference to ETSI EN 302 637-2 V1.4.1 (2019-04) replaced by [ETSI TS 103 900]</li> </ul>	Final

## Acronyms

Acronym	Explanation
ABS	Anti-lock Braking System: operates by preventing the wheels from locking while braking, thereby maintaining tractive contact with the road surface.
ACC	Adaptive Cruise Control
AMQP	Advanced Message Queuing Protocol
AT	Authorisation Ticket
C2C	Car 2 Car
CAM	Cooperative Awareness Message
CC	causeCode
C-ITS	Cooperative Intelligent Transport Systems
C-ITS station	A set of hardware and software components required to collect, store, process, receive and transmit secured and trusted messages in order to enable the provision of a C-ITS service. This includes personal, central, vehicle and roadside ITS stations as defined in EN 302 665 v 1.1.1
C-ITS-S	Central C-ITS Station, is realised by a set of hardware and/or software components installed in the back office of the C-ITS service provider e.g. a Traffic Management Centre or a Fleet Management Centre
DENM	Decentralised Environmental Notification Message
CPM	Collective Perception Message
CP-MW	Collective Perception - Motorways
CP-UI	Collective Perception - Urban Intersections
DF	Data Frame
ESC	Electronic Stability Control: a computerised technology that improves a vehicle's stability by detecting and reducing loss of traction
ETSI	European Telecommunications Standards Institute
ETSI ITS G5	See ITS-G5
EU	European Union
EV	Emergency Vehicle
GDPR	General Data Protection Regulation
HGV	Heavy Goods Vehicle
HLN	Hazardous Location Notification
HLN-APR	Hazardous Location Notification – Animal or Person on the Road
HLN-AWWD	Hazardous Location Notification – Alert Wrong Way Driving
HLN-AZ	Hazardous Location Notification – Accident Zone
HLN-EPVA	Hazardous Location Notification – Emergency or Prioritised Vehicle Approaching

Acronym	Explanation
HLN-ERVI	Hazardous Location Notification – Emergency or Rescue/Recovery Vehicle in Intervention
HLN-OR	Hazardous Location Notification – Obstacle on the Road
HLN-PTVC	Hazardous Location Notification – Public Transport Vehicle Crossing
HLN-PTVS	Hazardous Location Notification – Public Transport Vehicle at a Stop
HLN-RLX	Hazardous Location Notification – Railway Level Crossing
HLN-SV	Hazardous Location Notification – Stationary Vehicle
HLN-TJA	Hazardous Location Notification – Traffic Jam Ahead
HLN-TSR	Hazardous Location Notification – Temporarily Slippery Road
HLN-UBR	Hazardous Location Notification – Unsecured Blockage of a Road
HLN-WCW	Hazardous Location Notification – Weather Condition Warning
HMI	Human Machine Interface
Hz	Hertz
I2V	Infrastructure to Vehicle Communication; Information exchange between infrastructure and vehicles.
ID	Identifier
ISO	International Organisation for Standardization
ITS	Intelligent Transport Systems
ITS-G5	ITS-G5 is a European standard for ad-hoc short-range communication of vehicles among each other (V2V) and with Road ITS Stations (V2I). The ITS-G5 Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band is given in ETSI EN 302 663. ITS-G5 is a profile of the amendment IEEE 802.11p, which has been incorporated into the main IEEE 802.11 standard, and an IEEE 802.2 LLC. It uses the 5.9 GHz frequency band to support safety- and non-safety ITS applications.
IVI	In-Vehicle Information
IVIM	Infrastructure to Vehicle Information Message
IVS	In-Vehicle Signage
IVS-TS	In-Vehicle Signage – Traffic Signs
IVS-FT	In-Vehicle Signage – Free Text
km	Kilometre
MAP	Topology information for the intersection
MAPEM	MAP Extended Message
ms	Millisecond
NG	Navigation Guidance
NG-RA	Navigation Guidance – Route Advice
NG-SR	Navigation Guidance – Smart Routing

Acronym	Explanation
NG-TSA	Navigation Guidance – Toll Station Approaching
OBU	On Board Unit
OEM	Original Equipment Manufacturer
OHLN	Other Hazardous Location Notifications
PA-FLS	Parking Availability Facility Layer Service
PCAP	Packet Capture
PVD	Probe Vehicle Data
POI	Points of Interest
POI-PA	Points of Interest – Parking Availability
PVD-EDC	Probe Vehicle Data – Event Data Collection
PVD-VDC	Probe Vehicle Data – Vehicle Data Collection
PT	Public Transport
PTW	Power Two Wheelers
RHS	Road Hazard Signalling
R-ITS-S	Roadside ITS Station (the so-called RSU)
RO	Road Operator
RSU	Roadside Unit (See R-ITS-S)
RWW	Road Works Warning
RWW-LC	Road Works Warning – Lane Closure (and other restrictions)
RWW-RC	Road Works Warning – Road Closure
RWW-RM	Road Works Warning – Road Works Mobile
RWW-WM	Road Works Warning – Winter Maintenance
SAE	Society of Automobile Engineers ( <a href="http://www.sae.org">www.sae.org</a> )
sCC	subCauseCode
SI	Signalised Intersections
SI-EVP	Signalised Intersections – Emergency Vehicle Priority
SI-GLOSA	Signalised Intersections – Green Light Optimal Speed Advisory
SI-ISVW	Signalised Intersections – Imminent Signal Violation Warning
SI-SPTI	Signalised Intersections – Signal Phase and Timing Information
SI-TLP	Signalised Intersections – Traffic Light Prioritisation
SI-TSC	Signalised Intersections – Toll Station Crossing
SPAT	Signal Phase And Timing
SPATEM	Signal Phase And Timing Extended Message

Acronym	Explanation
SREM	Signal Request Extended Message
SSEM	Signal request Status Extended Message
SSP	Service Specific Parameters
TCC	Traffic Control Centre
TF2	Task Force 2
TF3	Task Force 3
TMS	Traffic Management System
TCC	Traffic Control Centre
UK	United Kingdom
V-ITS-S	Vehicle ITS Station
V2I	Vehicle to Infrastructure communication; Information exchange between vehicles and infrastructure.
V2V	Vehicle to Vehicle Communication; information exchange between vehicles.
V2X	Vehicle to any communication; X is either infrastructure or car; Including communication between vehicles as well as between vehicles and infrastructure.
V <sub>ev</sub> 2V	Emergency Vehicle to Vehicle communication; information exchange between emergency vehicles and other vehicles
VDS	Variable Direction Signs
VMS	Variable Message Signs
V <sub>PT</sub> 2V	Public Transport Vehicle to Vehicle communication; information exchange between public transport vehicles and other vehicles
V <sub>ro</sub> 2V	Road operator vehicle to vehicle; information exchange between road operator vehicles and other vehicles
VRU	Vulnerable Road User
VTP	Variable Text Panels
WG2	Workgroup 2
WW	Wrong-Way (see HLN-AWWD)
WWD	Wrong-Way Driving (see HLN-AWWD)
<i>e.g.</i>	<i>In Latin “exempli gratia” which stands for: “For Example”</i>
<i>i.e.</i>	<i>In Latin “id est” which stands for “In other words”</i>

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# 1. Introduction

## 1.1 C-Roads platform for harmonisation of C-ITS deployment

The C-Roads Platform is a joint initiative of European Member States and road operators for testing and implementing C-ITS services in light of cross-border harmonisation and interoperability. Through the C-Roads Platform, authorities and road operators join together to harmonise the deployment activities of cooperative intelligent transport systems (C-ITS) across Europe. The goal is to achieve the deployment of interoperable cross-border C-ITS services for road users.

C-ITS enables vehicles to interact directly with each other and the surrounding road infrastructure. In road transport, C-ITS typically involves vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. In order to enable an efficient and undisturbed exchange of information within these services as well as a cross-border implementation, harmonised C-ITS specifications are indispensable. The approach starts from a functional perspective, then requirements applicable to all implementations and then towards technology specifications of currently validated implementations (ITS-G5 for short range communication, IP based for long range cellular). In order to meet these challenges, the C-ROADS platform is divided into five Working Groups. The first Working Group is concerned with organisational tasks, the second with Technical Aspects and the third with Evaluation and Assessment. The fourth Working Group is about Urban C-ITS Harmonisation and Working Group 5 is about Digital Transport Infrastructure (DTI).

The C-Roads Platform is steered by the C-Roads Steering Committee which is composed by Member State representatives. With the support of the Supporting Secretariat, decisions for achieving the goal of the implementation of interoperable end-user services are taken. In this respect specifications, plans and reports, which are proposed and recommended by specific Working Groups, are approved. Within WG2 these specifications are harmonized in 5 Task Forces and derived from pilot activities and the basis for further pilot and implementation activities. This especially goes with technical decisions, which influence deployment and procurement decisions at pilot sites.

The Working Groups are installed as decision support for the Steering Committee to ensure proper decisions towards interoperable deployments. Individual experts participating in the single pilots work together in these Working Groups to prepare proposals and recommendations. Also, members of the single pilot activities as well as of the C-Roads-Working Groups actively contribute to the work of the EU-C-ITS-Platform.

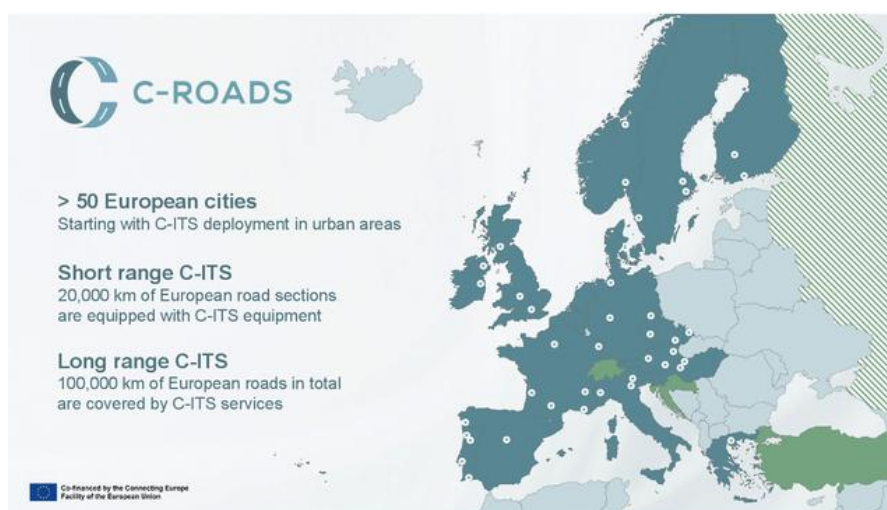


Figure 1:1 Overview of C-Roads coverage

## 1.2 Story board C-Roads C-ITS deployment documentation

This document is part of the C-Roads C-ITS Deployment Documentation and Requirements. The complete set of documents is much related to a common project life cycle of a system implementation. As a guide to the C-Roads Documentation, a story board based on such a project life cycle is provided in this section, with emphasis on the role of this document C-ITS Service and Use Case Definitions. The story board should be read from left to right and shows the different stages of the project life cycle and how each C-Roads Documentation is related to it, thereby it can be supportive to road authorities and other stakeholders. A complete description of the story board of a C-ITS implementation project, the different stages and the related C-Roads documents is given in [Introduction to the C-Roads WG2 Deployment Documentation and Requirements].

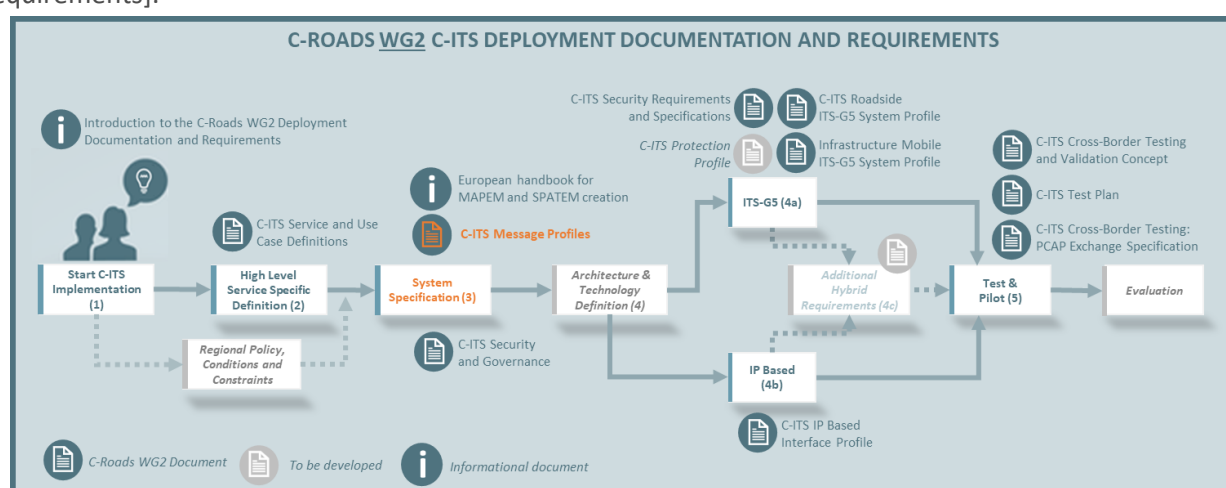


Figure 1:2: highlight of WG2 document in complete story board

The documents cover a wide range of aspects related to several stages as described in section 1.4 of [Introduction to the C-Roads WG2 Deployment Documentation and Requirements]. Starting with stage 3, generic requirements and the required governance are specified - those are applicable for all services, use cases and scenarios in a similar way. On stage 4a and 4b, the more detailed specifications are relevant -

including service specific security requirements. Both levels, generic and specific requirements, have impact on the test cases derived on stage 5.

## 1.3 Scope of this document

This document covers stage 2, where services and use cases are described in a functional way. It also provides for each use case the generic reference to the required specific documentation of the C-Roads WG 2 and the harmonised specific use case settings in order to achieve interoperability. These functional descriptions are the result of the harmonisation efforts that have taken place within TF2 (Service Harmonisation) and the alignment with the work of the other C-Roads WG2 task forces where the harmonisation of the interoperability requirements for the specific services and use cases takes place.

In the C-ITS service context the following terminology is used:

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

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

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

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

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

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

The following format is used to describe the services:

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

The following format is used to describe the use cases:

Type of road network	One or more of: All Motorways (physically separated by design) Dual carriageways (physically separated) Rural roads (physically separated / not physically separated) Urban roads (physically separated / not physically separated) Intersections
Type of vehicle (receiver) (sender for PVD)	Targeted vehicles by the information in the message; In case of PVD the sending vehicle type
Use case introduction	
Summary	A summary of the use cases (one or two lines)
Background	A description of the motivation/rationale of the use case
Objective	The intended outcome of the use case
Desired behaviour	A description of the expected behaviour of the system and the intended behaviour of users
Expected benefits	A description of the expected added value and actor benefits
Use case description	
Situation	A description of one or more situations relevant to the use case A specification of the triggering conditions for starting and terminating the use case.
Logic of transmission	The transmission logic to be used (I2V, V2V). For V2V, different vehicle roles may be distinguished. Also V2I can be used when it concerns data received from vehicles by the infrastructure side.

Actors and relations	A list of all relevant actors and their relations/interactions with the system and their role in the use case (incl. sender and receiver). The actors are: drivers (including PTW riders), road operator, service provider, end-user, vulnerable road user and other.
Use case scenario	A description of the story of the use case based on a sequence of situations (e.g., initial and after), events and actions, with illustrations. Sender and receiver should be addressed, in stakeholder neutral manner.
Intended Presentation/Alert principle	What is presented to the user and when.
Functional constraints/dependencies	A description of functional constraints and dependencies that are requirements (if any) related to e.g., business, security, telecommunications, privacy, legal, human behaviour, etc.
Link to other use cases	A list of other uses cases to which the use case is linked and a description of the link
<b>Interoperability requirements</b>	
Message profile requirements	Generic reference to the TF3 document “C-ITS Message Profiles” and use case specific settings are described.
Security and data protection requirements	Generic reference to the TF1 documents “C-ITS Security Requirements and Specifications” and “C-ITS Security & Governance” and also use case specific settings are described.
Communication technology requirements: ITS-G5	Generic reference to the TF3 documents “C-ITS Roadside ITS-G5 System Profile” and “C-ITS Mobile Roadside ITS-G5 System Profile” and use case specific settings are described.
Communication technology requirements: IP based	Generic reference to the TF4 document “C-ITS IP-Based Interface Profile” and use case specific settings are described.
Test and validation requirements	Generic reference to the TF5 documents “C-ITS Cross-Border Testing and Validation Concept” and “C-ITS Test Plan“. This field will detail the exhaustive list of test-cases for on-road cross border testing. All these tests are important for technical interoperability if the use-case is implemented in the MS. These tests were directly derived from the specifications and interoperability requirements.

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

Service	Use Case	Release
In-Vehicle Signage	Traffic Signs (IVS-TS)	2.0.0
	Free Text (IVS-FT)	2.0.0

Hazardous Location Notification	Accident Zone (HLN-AZ)	1.0
	Traffic Jam Ahead (HLN-TJA)	1.1
	Stationary vehicle (HLN-SV)	1.1
	Weather Condition Warning (HLN-WCW)	1.1
	Temporarily slippery road (HLN-TSR)	1.1
	Animal or person on the road (HLN-APR)	1.1
	Obstacle on the road (HLN-OR)	1.1
	Emergency or Rescue/Recovery Vehicle in Intervention (HLN-ERVI)	2.0.3
	Emergency or Prioritised Vehicle Approaching (HLN-EPVA)	2.0.4
	Railway Level Crossing (HLN-RLX)	1.5
	Unsecured Blockage of a Road (HLN-UBR)	1.6
	Alert Wrong Way Driving (HLN-AWWD)	1.6
	Public Transport Vehicle Crossing (HLN-PTVC)	1.6
	Public Transport Vehicle at a Stop (HLN-PTVS)	1.6
Road Works Warning	Lane Closure (RWW-LC)	1.0
	Road Closure (RWW-RC)	1.1
	Road Works – Mobile (RWW-RM)	1.1
	Winter Maintenance (RWW-WM)	1.5
Signalised Intersections	Signal Phase and Timing Information (SI-SPTI)	2.0.3
	Green Light Optimal Speed Advisory (SI-GLOSA)	2.0.3
	Imminent Signal Violation Warning (SI-ISVW)	2.0.3
	Traffic Light Prioritisation (SI-TLP)	2.0.3
	Emergency Vehicle Priority (SI-EVP)	2.0.3
	Toll Station Crossing (SI-TSC)	2.1.0
Automated Vehicle Guidance	SAE Level Guidance (AVG-SAELG)	2.0
	Platoon Support Information (AVG-PSI)	2.0
Probe Vehicle Data	Vehicle Data Collection (PVD-VDC)	1.5
	Event Data Collection (PVD-EDC)	1.5
Navigation Guidance <sup>3</sup>	Toll Station Approaching (NG-TSA)	2.0.9
	Smart Routing (NG-SR)	2.1.0

<sup>3</sup> Former service name was Topology Information

	Route Advice (NG-RA)	2.3.0
Points of Interest	Parking Availability (POI-PA)	2.2.0
Collective Perception	Collective Perception on Motorways (CP-MW)	2.1.1
	Collective Perception on Urban/Interurban Intersections	2.1.1

## 2. In-Vehicle Signage (IVS)

### 2.1 IVS: Service introduction

Service introduction	
Summary	In-Vehicle Signage (IVS) is an information service to inform drivers on actual static or dynamic traffic signs (or additional information mimicking virtual traffic signs) via in-vehicle systems. The traffic signs can be regulatory (mandatory) or informational (advisory).
Background	<p>The IVS service is meant to inform drivers via in-vehicle information systems about static and dynamic traffic signs mirroring physical traffic signs along the road. Additionally, further information (virtual traffic signs or additional free text) can be provided. IVS may target information to specific vehicle types. The IVS information is sent out by means of Infrastructure-to-Vehicle (I2V) communication. Today, in addition to static traffic signs, VMS systems are used by road operators to provide operational, tactical, or strategic information to drivers. Different types of variable or dynamic traffic sign systems are used, with both static pictograms and text and variable pictograms and text on:</p> <ul style="list-style-type: none"> <li>○ Variable Message Signs (VMS), including variable speed signs</li> <li>○ Variable Text Panels (VTP)</li> <li>○ Variable Direction Signs (VDS)</li> </ul>
Objective	<ul style="list-style-type: none"> <li>○ More attentive driving.</li> <li>○ Increased awareness on the content of traffic signs by providing sign information directly in the vehicle where it can potentially be presented throughout the period of its entire validity. This will severely reduce observation problems attributed to physical traffic signs, such as limited line of sight, obstructions obscuring sight of a sign or limited attention by drivers passing signs.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ IVS allows earlier and more comprehensive information to drivers by providing continuous signage information directly in the vehicle. This should result in better adaptation to current regulations and traffic conditions, reducing the risk and severity of accidents and congestion. Overall, this should improve traffic safety.</li> <li>○ Another benefit is the possibility to present information in the language chosen by the drivers or information only valid for the respective vehicle type (e.g., trucks), which increases the relevance of the information provided and can lead to less distraction.</li> </ul>
Use cases	<ul style="list-style-type: none"> <li>○ Traffic Signs (IVS-TS)</li> <li>○ Free Text (IVS-FT)</li> </ul>



## 2.2 IVS: Use Cases

### 2.2.1 IVS – Traffic Signs (IVS-TS)

Use case introduction	
Type of road network	All
Type of vehicle (receiver)	All
Summary	The Vienna Convention on Road Signs makes a distinction between danger warning signs, regulatory signs and informative signs. The purpose of this use case is to inform drivers via in-vehicle information systems about all static and dynamic signs that are part of the Vienna Convention on Road Signs <sup>4</sup> and are represented in the ISO 14823 graphic data dictionary <sup>5</sup> for road traffic signs. And which can be indicated either on physical traffic signs along the road or in terms of virtual VMS i.e. where a physical VMS is not present.
Background	<p>This use case enables the road operator to optimise the management of warnings, information and regulations knowing the real-time traffic characteristics.</p> <p>Currently, dynamic signs need to be clearly indicated on the road by signalisation, for instance via lane control signs located on (mobile) gantries. This use case makes it possible to easier apply/implement the use of dynamic regulations on the road network. The current use case description describes the situation where physical signs are present and represented in a digital way.</p>
Objective	<ul style="list-style-type: none"> <li>○ The aim is to inform drivers about current valid and applicable (dynamic) traffic signs, 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 on the road.</li> </ul>
Desired behaviour	<p>Drivers can:</p> <ul style="list-style-type: none"> <li>○ adapt their driving behaviour to be compliant with the applicable traffic regulations.</li> <li>○ adapt their driving behaviour/position on the road according to the information given.</li> <li>○ drive more attentive based on the warnings given.</li> </ul> <p>In the future, the information may be used by Advanced Driver Assistance Systems for assisted or automated driving.</p>

<sup>4</sup> <https://unece.org/road-traffic-and-road-signs-and-signals-agreements-and-conventions>

<sup>5</sup> <https://www.iso.org/standard/61546.html>

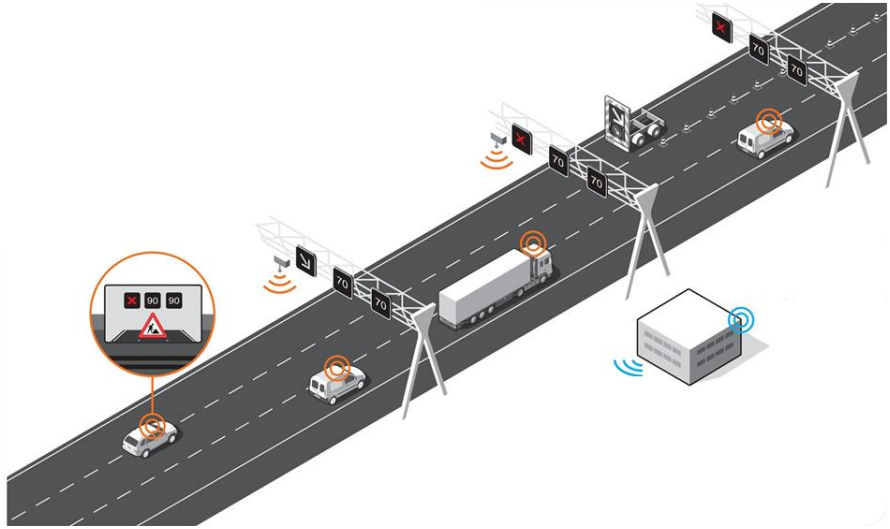
Expected benefits	<ul style="list-style-type: none"> <li>○ More convenience for drivers, resulting in better compliance to regulatory signs (e.g., speed limits), improved safety and potential environmental benefits.</li> <li>○ The virtual VMS allows to present a message exactly in the area where it is applicable, enhancing for example the compliance with regulations.</li> </ul>
<b>Use case description</b>	
Situation	<p>The aim of IVS is to relay the information presented on (electronic) traffic signs into the vehicle. To that end, VMS systems have been deployed on sensitive parts of the motorway network all over Europe. They are being used in conjunction with monitoring systems to enforce traffic regulations (such as speed control and lane management).</p>  <p><i>Figure 2:1 Example of status information on dynamic speed limit signs on a variable message system also sent as in-vehicle signage service</i></p>



Figure 2:2 Example of dynamic regulatory signs



Figure 2:3 Example of dynamic regulatory signs

Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ Road operator: The source of a majority of the traffic signs 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.</li> <li>○ Drivers: The traffic sign information is continuously received by all C-ITS equipped vehicles and presented to the drivers. The exact details of the presentation (how and when) is based on the individual application designer's decision. The drivers can use the information to better comply with the current traffic regulations or drive more attentively.</li> <li>○ Service provider: Disseminates the traffic sign information to the drivers.</li> </ul>

# Use case scenario

- The TCC sends a message with the applicable traffic signs. The traffic sign information can target all vehicles or a specific vehicle type (e.g. heavy goods vehicles) and it can be applicable to all lanes, but also to specific lanes (see examples).
- The message is received in the vehicle and presented to the driver, if relevant.
- The drivers can act accordingly.

## Special Scenario – Hard Shoulder Running (HSR)

- Hard Shoulder Running (HSR) enables the dynamic temporary use of hard shoulders at road sections, including junctions, with the aim to increase road capacity under certain conditions. Because HSR is based on traffic signs, it can be represented by the IVS-TS use case, with some specific requirements listed below.
- Any HSR scenario shall be based on the following signage and zones:
  - “Hard shoulder in operation” as sign indicating the start of the HSR section with a relevance zone up until “hard shoulder clearing sign”.
  - “Hard shoulder clearing” as sign noticing that the HS will be cleared, with a relevance zone until the “hard shoulder not in operation” sign.
  - “Hard shoulder not in operation” is not encoded as a separate sign as it is represented as the end of the relevance zone of the “hard shoulder clearing” sign.
- In case dynamic lane management systems are used along the HSR section, the messages representing signage for dynamic lane management should be linked to the HSR messages.

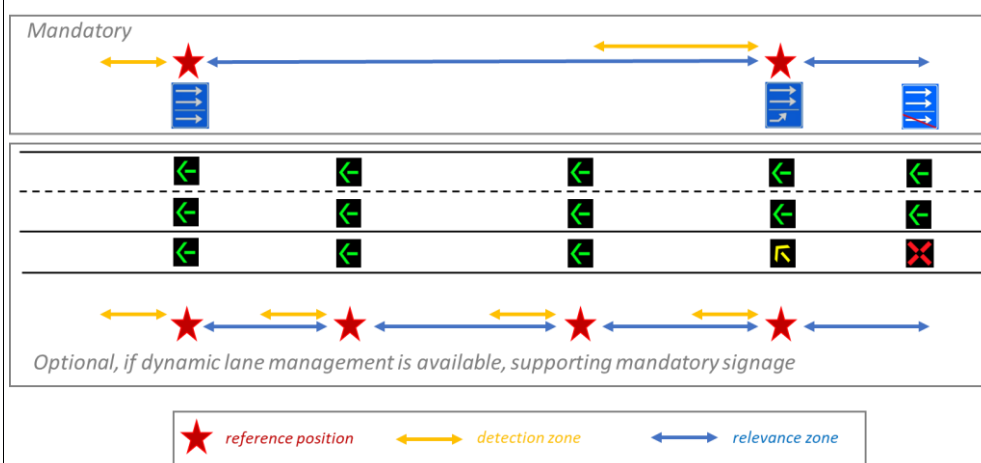








Figure 2:4 Example of active hard shoulder running

- For the mandatory HSR indication, the following signs shall be used:
  - “hard shoulder open”: 
    - ISO 14823 option “hard shoulder running in operation”

- serviceCategoryCode: informative
- pictogramCategoryCode:
  - nature: 6
  - serialNumber: 45
- “hard shoulder clearing”: 
  - ISO 14823 option „hard shoulder running being closed“
  - serviceCategoryCode: informative
  - pictogramCategoryCode:
    - nature: 6
    - serialNumber: 48
- “hard shoulder not in operation”  (only if a corresponding dynamic lane management is continuing after the closing, otherwise the end of the relevance zone of “hard shoulder clearing” represents the end of HSR)
  - ISO 14823 option „hard shoulder not in operation“
  - serviceCategoryCode: informative
  - pictogramCategoryCode:
    - nature: 6
    - serialNumber: 46
- If dynamic lane management systems are available along the HSR section, the following signs shall be used for the hard shoulder:
  - “hard shoulder open”: 
    - ISO 14823 option “lane free”
    - serviceCategoryCode: informative
    - pictogramCategoryCode:
      - nature: 6
      - serialNumber: 60
  - “hard shoulder clearing” (based on right-hand-traffic): 
    - ISO 14823 option „Clear lane to left or lane is merging to the left“
    - serviceCategoryCode: informative
    - pictogramCategoryCode:
      - nature: 6
      - serialNumber: 61
  - “hard shoulder not in operation”: 
    - ISO 14823 option „lane closed“
    - serviceCategoryCode: informative

Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>▪ pictogramCategoryCode: <ul style="list-style-type: none"> <li>• nature: 6</li> <li>• serialNumber: 59</li> </ul> </li> <li>○ IVS information shall be presented to the drivers and shall be consistent with the current valid (dynamic) traffic signs.</li> <li>○ The information shall be presented to the driver early enough and in the appropriate location on the road.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ This use case only covers the digital representation of traffic signs. If there is textual information available that is not directly applicable to a sign, the "Free Text" use case shall be used.</li> <li>○ How the information is presented to the drivers is not part of the service description. It is left to the provider of the In-Vehicle Information system with HMI how information is presented. Information may be translated to the preferred language of the driver.</li> <li>○ The information presented by means of I2V is not legally binding: Information should be handled as 'convenience information' and presented accordingly to the driver, as currently done within navigation systems.</li> </ul>
Link to other use cases	All HLN and RWW use cases: since traffic signs are part of many different use cases, the IVIM can be accompanying other messages.
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The IVI message for IVS-TS is profiled in chapter 4.2.2.2 of [C-Roads MP].</li> <li>○ IVI messages for IVS-TS shall use message management based on update and cancellation of messages.</li> <li>○ iviStatus shall be set to "new" for new information in the IVIM, to "update" when the IVIM changes and to "cancellation" when the information in the IVIM is no longer valid.</li> <li>○ A cancellation IVIM shall be repeated at least for 5min after its first transmission <i>NOTE: The exact effort to ensure that all vehicles receive the cancellation will be resolved in future releases.</i></li> <li>○ validTo may be used to encode an end time for the overall IVI message, at least 1 hour ahead of the time indicated by the DE timestamp. Providing this end time can serve the purpose of avoiding an issue of perpetually valid IVIM in case cancellation is missed repeatedly.</li> <li>○ The definition of all geographical zones should be included in as few GlcParts as possible.</li> <li>○ IVIM can contain more than one Geographical Location Container (GLC). An additional GLC should only be included in an IVIM if required zones cannot be defined within the value range constraints of DF DeltaPositions towards the referencePosition.</li> </ul>

- IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM.
- One GicPart in the GeneralIviContainer shall be used to encode one traffic sign (main sign) and up to three additional signs (subsigns) that may be associated to the main sign using DF RSCode.
- extraText shall be used to present additional text associated to a traffic sign (subpanel text) only if there is no subpanel code available in ISO 14823. extraText is ordered, so the first line of extraText corresponds to the first RSCode and so on. If a traffic sign does not have extra text, a string with a single NULL character (ASCII 0x00) shall be added. extraText may be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data.
- Temporal restrictions of individual signs (when a sign is either valid or invalid only for a certain time period) shall be encoded with suitable ISO14823Attributes (DTM, EDT) in the DF roadSignCodes and not by using either validFrom or validTo of the overall IVIM.
- The IVIM shall always correspond to the legal statement as displayed by the static or electronic sign it represents.
- Signs which indicate the end of a specific or all regulations / restrictions should not be transmitted explicitly as individual signs in an IVIM.
- Road operators should try to reduce the number of individual IVI messages transmitted in parallel as far as possible, by combining consecutive signage information into one message using the mechanisms provided in the IVIM to reuse zones. If separate IVIMs are used for any reason, they should aim to combine either 1) information applying to the same lane, or 2.) information applying to the same direction of travel or 3.) information applying to the same local area in a single message (in descending order of priority from 1) to 3)).
- Within one or multiple IVIMs issued by the same road operator, the same traffic sign should not be assigned more than once to the same relevance zone.
- If the aim is to inform vehicles on all stretches of road diverging from or converging into a relevance zone, suitable zones for these stretches shall be present in the GLC and referenced in the GIC as necessary.
- Information corresponding to physical signs (either static or electronic) shall as far as possible be encoded using machine-readable message components, via adhering as much as possible to the following rules:
  - Shifting of relevance zone(s) according to subpanel information
  - Extension of relevance zone(s) in case of sign repetition
  - Restriction of signs to certain vehicle types and/or dimensions
  - Encoding of ISO14823Attributes where applicable
    - Validity in time (DMT, EDT)
    - Lane Flow (DFL)
    - Vehicle dimensions (VED)
    - Speed (SPE)
    - Rate of Incline (ROI)

	<ul style="list-style-type: none"><li>▪ Distance between vehicles (DBT)</li><li>▪ Destination (DDD)<ul style="list-style-type: none"><li>○ Encoding of subpanels using roadSignCodes available in ISO 14823 for subpanels instead of extraText</li><li>○ The RoadConfigurationContainer (RCC) shall be provided, except if the road operator does not have the information, then both RCC and applicable lanes in the GeneralIviContainer (GIC) should be omitted and only signs valid for all legally drivable lanes on the entire carriageway shall be transmitted</li></ul></li></ul>																														
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the “General IVI Container” including lane status and all types of ISO/TS 14823 signs, as well as the “Road configuration container”. The IVIM permissions (SSP) shall be encoded as defined in [ETSI TS 103 301]. These SSPs are encoded in Octets 4-5 within the respective field of the certificate to be used (AT), in addition to the serviceProviderId encoded in Octets 1-3.</p> <table><tr><th></th><th colspan="2">SSP position</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th></tr><tr><td>General IVI Container / ISO 14823 / Danger Warning</td><td>4</td><td>1</td></tr><tr><td>General IVI Container / ISO 14823 / Regulatory</td><td>4</td><td>2</td></tr><tr><td>General IVI Container / ISO 14823 / Informative</td><td>4</td><td>3</td></tr><tr><td>General IVI Container / ISO 14823 / Public Facilities</td><td>4</td><td>4</td></tr><tr><td>General IVI Container / ISO 14823 / Ambient Condition</td><td>4</td><td>5</td></tr><tr><td>General IVI Container / ISO 14823 / Road Condition</td><td>4</td><td>6</td></tr><tr><td>General IVI Container / Lane Status</td><td>5</td><td>0</td></tr><tr><td>Road Configuration Container</td><td>5</td><td>1</td></tr></table> <p>The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	General IVI Container / ISO 14823 / Danger Warning	4	1	General IVI Container / ISO 14823 / Regulatory	4	2	General IVI Container / ISO 14823 / Informative	4	3	General IVI Container / ISO 14823 / Public Facilities	4	4	General IVI Container / ISO 14823 / Ambient Condition	4	5	General IVI Container / ISO 14823 / Road Condition	4	6	General IVI Container / Lane Status	5	0	Road Configuration Container	5	1
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General IVI Container / ISO 14823 / Road Condition	4	6																													
General IVI Container / Lane Status	5	0																													
Road Configuration Container	5	1																													



Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on IVIM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = IVS-TS</li> <li>○ messageType = IVIM</li> </ul> <p>Geographic area (Quadtree) for IVIM:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GLC_referencePosition_01_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GLC_GlcParts_2_1_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_TIMING_03_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_Update_Cancel_04_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_Status-Update_4_1_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_serviceProviderId_45_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_ivIdentificationNumber_45_1_R2.0.3</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_iviType_75_2_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_detectionZoneIds_110_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_roadSignCodes_111_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GLC_GlcParts_segment_setOfLanes_112_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_extraText_114_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_GlcParts_116_R2.3.0</li> </ul> </li> <li>○ IP based only:</li> </ul>

- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_reference position\_01\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_ZONES\_02\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_GlcPart\_2\_1\_R2.0.3
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_TIMING\_03\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Update\_Cancel\_04\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Status-Update\_04\_1\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_serviceProviderId\_45\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_iviIdentificationNumber\_45\_1\_R2.0.3

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_IVS\_GENERIC\_ITSG5\_IVIM\_GIC\_driverAwarenessZoneIds\_117\_R2.3.0
- Hybrid (IP based only):
  - TC\_CROADS\_IVS-TS\_HYBRID\_IVIM\_GeneralIviContainer\_74\_R2.0.3
  - TC\_CROADS\_IVS-TS\_HYBRID\_IVIM\_extraText\_74\_1\_R2.0.1
  - TC\_CROADS\_IVS-TS\_HYBRID\_IVIM\_iviType\_75\_R2.0.3
  - TC\_CROADS\_IVS-TS\_HYBRID\_IVIM\_roadSignCodes\_76\_R2.0.3

## 2.2.2 IVS – Free Text (IVS-FT)

Type of road network	All
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	The aim of this use case is to present in-vehicle information of type “Free Text” to the drivers. The information will either reproduce what is presented on a physical VMS (e.g., variable text panel) or present a completely new message that does not mirror a physical VMS (a virtual VMS).
Background	<p>This use case is not about providing completely new information, but about providing already existing information and improving its visibility to the drivers by enabling a continuous presentation in the vehicle. This means that the drivers do not need to perceive and comprehend rather complex information in the few seconds that the VMS panel is visible during transit. Note, presenting more information should not lead to more distraction of the drivers.</p> <p>Compared to traffic signs, it is possible to present additional content (text, images) to the drivers. Compared to physical VMS, there is a greater possibility to send more contextualised information than can be presented on a physical VMS.</p>
Objective	<ul style="list-style-type: none"> <li>○ Transmission of information to drivers in “Free Text” that is not provided by the other IVS use case "Traffic Signs".</li> <li>○ Adding details (in preferred language) to existing messages to give drivers more precise and comprehensible information to achieve the desired behaviour.</li> </ul>
Desired behaviour	The drivers adapt their driving behaviour to the applicable driving regulations, warnings, information, advice or guidance provided.
Expected benefits	<ul style="list-style-type: none"> <li>○ The use case allows for better traffic management (e.g., regulation, smart routing, etc.), because information can potentially be transmitted on the scale of the complete network, beyond the limited coverage of physical VMS.</li> <li>○ The use case allows continuous presentation of information in the vehicle compared to the short-term awareness provided by the physical VMS, thus limiting stress for the drivers to comprehend the content of the information and react accordingly.</li> <li>○ In case of regulatory information, the virtual VMS allows a message to be presented exactly in the application areas, enhancing the compliance with regulations.</li> <li>○ Another added benefit is the ability to present the information in the driver’s preferred language, if available.</li> </ul>

## Use case description

Situation	<p>In managing and operating the road ways, there are several occasions and situations in which case a road operator wants to provide additional (textual) information to the drivers to get their extra attention and influence traffic flow and traffic safety in a positive way, e.g.:</p> <ul style="list-style-type: none"> <li>○ Traffic management plan</li> <li>○ Pollution</li> <li>○ Amber alert</li> <li>○ Special events (sports, demonstration, ...)</li> <li>○ Travel time</li> <li>○ Available parking spaces on highway rest areas</li> <li>○ Information on services available on highway parking areas</li> </ul> <div>  </div> <p><i>Figure 2:5 Example of a warning sign and free text</i></p> <div>  </div> <p><i>Figure 2:6 Example of a regulatory sign and free text</i></p>
Logic of transmission	12V

Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road operator:</b> The source of this information is the road operator via the TCC. The road operator is expected to have validated the content of the message before sending this message into the system.</li> <li>○ <b>Drivers:</b> The "Free Text" information is continuously received by all C-ITS equipped vehicles and presented to the driver. The exact details of the visualisation (how and when) is based on the individual application designer's decision. The drivers will benefit from the information contained in the "Free Text" information and could act accordingly.</li> <li>○ <b>Service provider:</b> Disseminates the "Free Text" information to the drivers.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The road operator wants to send information to drivers via virtual VMS, physical VMS, radio, the internet, etc.</li> <li>○ The road operator sends information via all or selected information channels</li> </ul>
Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ "Free Text" information shall be presented to the drivers and shall be consistent with the actual dynamic signs.</li> <li>○ The information needs to be presented to the driver early enough and at the appropriate location.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ "Free Text" is used whenever a VMS is displaying textual information that cannot be encoded via traffic signs. Please note that "Free Text" information may still include additional traffic signs (as shown in the figures in the situation paragraph)..</li> <li>○ How the information is presented to the drivers is not part of the service description. It is left to the provider of the in-vehicle information system with HMI how information is presented. Information may be translated to the preferred language of the driver.</li> <li>○ 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 to be presented in the vehicle.</li> <li>○ The information presented by means of I2V is not legally binding: Information should be handled as 'convenience information' and presented accordingly to the drivers, as currently done within navigation systems.</li> </ul>
Link to other use cases	<ul style="list-style-type: none"> <li>○ All RWW use cases: VMS can be used to present additional information to drivers</li> </ul>
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The IVI message for IVS-FT is profiled in chapter 4.2.2.3 of [C-Roads MP].</li> <li>○ IVI messages for IVS-FT shall use message management based on update and cancellation of messages.</li> </ul>

- iviStatus shall be set to “new” for new information in the IVIM, to “update” when the IVIM changes and to “cancellation” when the information in the IVIM is no longer valid.
- A cancellation IVIM shall be repeated at least for 5min after its first transmission  
*NOTE: The exact effort to ensure that all vehicles receive the cancellation will be resolved in future releases.*
- validTo may be used to encode an end time for the overall IVI message, at least 1 hour ahead of the time indicated by the DE timestamp. Providing this end time can serve the purpose of avoiding an issue of perpetually valid IVIM in case cancellation is missed repeatedly.
- The definition of all geographical zones should be included in as few GicParts as possible.
- IVIM can contain more than one Geographical Location Container (GLC). An additional GLC should only be included in an IVIM if required zones cannot be defined within the value range constraints of DF DeltaPositions towards the referencePosition.
- IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM.
- "Free Text" Information without a sign shall be encoded in the TextContainer only. Free text information may be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data.
- If the "Free Text" Information includes at least one traffic sign, all signs shall be encoded in the optional GeneralIviContainer.
- Temporal restrictions of individual signs (when a sign is either valid or invalid only for a certain time period) shall be encoded with suitable ISO14823Attributes (DTM, EDT) in the DF roadSignCodes and not by using either validFrom or validTo of the overall IVIM.
- If traffic signs are present:
  - one GicPart in the GeneralIviContainer shall be used to encode one traffic sign (main sign) and up to three additional signs (subsigns) that may be associated to the main sign using DF RSCode.
  - extraText shall be used to present additional text associated to a sign (subpanel text). only if there is no subpanel code available in ISO 14823. extraText is ordered, so the first line of extraText corresponds to the first RSCode and so on. If a traffic sign does not have extra text, a string with a single NULL character (ASCII 0x00) shall be added. extraText may be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data.
  - The IVIM shall always correspond to the legal statement as displayed by the static or electronic sign it represents.
  - Signs which indicate the end of a specific or all regulations / restrictions should not be transmitted explicitly as individual signs in an IVIM.
  - Within one or multiple IVIMs issued by the same road operator, the same traffic sign should not be assigned more than once to the same relevance zone. Information corresponding to physical signs (either static or

	<p>electronic) shall as far as possible be encoded using machine-readable message components, via adhering as much as possible to the following rules:</p> <ul style="list-style-type: none"><li>▪ Shifting of relevance zone(s) according to subpanel information</li><li>▪ Extension of relevance zone(s) in case of sign repetition</li><li>▪ Restriction of signs to certain vehicle types and/or dimensions</li><li>▪ Encoding of ISO14823Attributes where applicable<ul style="list-style-type: none"><li>• Validity in time (DMT, EDT)</li><li>• Lane Flow (DFL)</li><li>• Vehicle dimensions (VED)</li><li>• Speed (SPE)</li><li>• Rate of Incline (ROI)</li><li>• Distance between vehicles (DBT)</li><li>• Destination (DDD)</li></ul></li><li>▪ Encoding of subpanels using roadSignCodes available in ISO 14823 for subpanels instead of extraText</li></ul> <ul style="list-style-type: none"><li>○ If the aim is to inform vehicles on all stretches of road diverging from or converging into a relevance zone, suitable zones for these stretches shall be present in the GLC and referenced in the TC as necessary.</li><li>○ The RoadConfigurationContainer (RCC) shall be provided, except if the road operator does not have the information, then both RCC and (if signs are present) applicable lanes in the GeneralIviContainer (GIC) should be omitted and only signs valid for all legally drivable lanes on the entire carriageway shall be transmitted.</li></ul>																		
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the “General IVI Container” including lane status and all types of ISO/TS 14823 signs, the “Road configuration container” as well as the “Text container”. The IVIM permissions (SSP) shall be encoded as defined in [ETSI TS 103 301]. These SSPs are encoded in Octets 4-5 within the respective field of the certificate to be used (AT), in addition to the serviceProviderId encoded in Octets 1-3.</p> <table><tr><th></th><th colspan="2">SSP position</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th></tr><tr><td>General IVI Container / ISO 14823 / Danger Warning</td><td>4</td><td>1</td></tr><tr><td>General IVI Container / ISO 14823 / Regulatory</td><td>4</td><td>2</td></tr><tr><td>General IVI Container / ISO 14823 / Informative</td><td>4</td><td>3</td></tr><tr><td>General IVI Container / ISO 14823 / Public Facilities</td><td>4</td><td>4</td></tr></table>		SSP position		CauseCodeType / Container	Octet position	Bit position	General IVI Container / ISO 14823 / Danger Warning	4	1	General IVI Container / ISO 14823 / Regulatory	4	2	General IVI Container / ISO 14823 / Informative	4	3	General IVI Container / ISO 14823 / Public Facilities	4	4
	SSP position																		
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General IVI Container / ISO 14823 / Public Facilities	4	4																	

	<table><tr><td>General IVI Container / ISO 14823 / Ambient Condition</td><td>4</td><td>5</td></tr><tr><td>General IVI Container / ISO 14823 / Road Condition</td><td>4</td><td>6</td></tr><tr><td>General IVI Container / Lane Status</td><td>5</td><td>0</td></tr><tr><td>Road Configuration Container</td><td>5</td><td>1</td></tr><tr><td>Text Container</td><td>5</td><td>2</td></tr></table> <p>The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>	General IVI Container / ISO 14823 / Ambient Condition	4	5	General IVI Container / ISO 14823 / Road Condition	4	6	General IVI Container / Lane Status	5	0	Road Configuration Container	5	1	Text Container	5	2
General IVI Container / ISO 14823 / Ambient Condition	4	5														
General IVI Container / ISO 14823 / Road Condition	4	6														
General IVI Container / Lane Status	5	0														
Road Configuration Container	5	1														
Text Container	5	2														
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>															
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on IVIM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = IVS-FT</li><li>○ messageType = IVIM</li></ul> <p>Geographic area (Quadtree) for IVIM:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>															
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"><li>○ ITS-G5 only:<ul style="list-style-type: none"><li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GLC_referencePosition_01_R2.3.0</li><li>○ TC_CROADS_GENERIC_ITSG5_IVIM_ZONES_02_R2.0.1</li></ul></li></ul>															



- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GLC\_GlcParts\_2\_1\_R2.3.0
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_TIMING\_03\_R2.0.1
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_Update\_Cancel\_04\_R2.0.1
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_Status-Update\_4\_1\_R2.0.1
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_serviceProviderId\_45\_R2.0.1
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_ivIdentificationNumber\_45\_1\_R2.0.3
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_iviType\_75\_2\_R2.3.0
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_detectionZonelds\_110\_R2.3.0
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_roadSignCodes\_111\_R2.3.0
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GLC\_GlcParts\_segment\_setOfLanes\_112\_R2.3.0
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_extraText\_114\_R2.3.0
- TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_GicParts\_116\_R2.3.0
- IP based only:
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_reference position\_01\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_ZONES\_02\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_GlcPart\_2\_1\_R2.0.3
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_TIMING\_03\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Update\_Cancel\_04\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Status-Update\_04\_1\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_serviceProviderId\_45\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_ivIdentificationNumber\_45\_1\_R2.0.3

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_IVS-FT\_ITSG5\_IVIM\_TextContainer\_iviType\_85\_R2.3.0
  - TC\_CROADS\_IVS-FT\_ITSG5\_IVIM\_GicPart\_86\_R2.0.1
  - TC\_CROADS\_IVS-FT\_ITSG5\_IVIM\_text\_86\_R2.0.3
  - TC\_CROADS\_IVS-FT\_ITSG5\_IVIM\_TextContainer\_84\_R2.0.3
  - TC\_CROADS\_IVS-FT\_ITSG5\_IVIM\_TextContainer\_driverAwarenessZonelds\_89\_1\_R2.3.0
  - TC\_CROADS\_IVS-FT\_ITSG5\_IVIM\_TextContainer\_detectionZonelds\_89\_2\_R2.3.0
- Hybrid (IP based only):
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_GeneralIviContainer\_74\_1\_R2.0.3
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_GeneralIviContainer-iviType\_75\_1\_R2.0.3
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_roadSignCodes\_76\_1\_R2.0.3
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_TextContainer\_84\_R2.0.3
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_GeneralIviContainer\_85\_R2.0.1
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_TextContainer-iviType\_85\_R2.0.3
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_text\_86\_R2.0.3
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_GicPart\_86\_R2.0.1
  - TC\_CROADS\_IVS-FT\_HYBRID\_IVIM\_extraText\_87\_R2.0.1

## 3. Hazardous Locations Notification (HLN)

### 3.1 HLN: Service introduction

Service introduction	
Summary	Hazardous Locations Notification (HLN) is a warning message related to one or a series of potentially hazardous events on the road. The approaching drivers get information and therefore warnings 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 to drivers potentially causing (more) accidents resulting in injuries/fatalities. This C-ITS service directly informs involved and relevant drivers so they can adapt their driving behaviour accordingly.
Objective	The aim of this service is to warn drivers of hazardous locations on their route in order to increase overall road safety by providing in-vehicle information about hazards, including the location and type of hazard, possibly also the remaining distance to the hazardous location, the duration of the events causing the hazard, as well as lane and speed advice.
Expected benefits	<ul style="list-style-type: none"> <li>More attentive driving while approaching and passing a hazardous location in order to minimise the risk of collisions/accidents resulting in fewer incidents/injuries/fatalities among drivers.</li> </ul>
Use cases	<ul style="list-style-type: none"> <li>Accident Zone (HLN – AZ)</li> <li>Traffic Jam Ahead (HLN – TJA)</li> <li>Stationary Vehicle (HLN – SV)</li> <li>Weather Condition Warning (HLN – WCW)</li> <li>Temporarily Slippery Road (I2V) (HLN – TSR)</li> <li>Animal or Person on the Road (HLN – APR)</li> <li>Obstacle on the Road (HLN – OR)</li> <li>Emergency or Rescue/Recovery Vehicle in Intervention (HLN – ERVI)</li> <li>Emergency or Prioritised Vehicle Approaching (HLN – EPVA)</li> <li>Railway Level Crossing (HLN – RLX)</li> <li>Unsecured Blockage of a Road (HLN – UBR)</li> <li>Alert Wrong Way Driving (HLN – AWWDD)</li> <li>Public Transport Vehicle Crossing (HLN – PTVC)</li> <li>Public Transport Vehicle at a Stop (HLN – PTVS)</li> </ul> <p>Other HLN use case descriptions are under review and may be added in future releases.</p>

## 3.2 HLN: Use Cases

### 3.2.1 HLN – Accident Zone (HLN-AZ)

Use case introduction	
Type of road network	All
Type of vehicle (receiver)	All
Summary	The road operator detects that an accident has happened on the road network and sends the information to drivers who can benefit from this information.
Background	<p>This use case is about exchanging information about accident zones between infrastructure and vehicles and describes the following scenario:</p> <ul style="list-style-type: none"> <li>○ Sending event information from the TCC to the vehicles.</li> </ul> <p>This scenario (TCC to vehicles) deals with the available infrastructure content (mainly the kind of events which are available in the TCC) and how this content/these events can be mapped into coded accident information.</p>
Objective	Warn drivers of accident zones ahead and around their position in order to increase overall road safety.
Desired behaviour	Precisely and correctly inform drivers to adapt their driving behaviour (e.g., reduce the approaching speed, drive more cautiously, etc.) before and whilst passing the accident zone.
Expected benefits	<ul style="list-style-type: none"> <li>○ Increased road safety and lower numbers of persons killed or injured in traffic accidents.</li> <li>○ Lower numbers of incidents and secondary damages following a dangerous situation on the road for road operators and drivers.</li> <li>○ Higher quality of traffic information services for service providers.</li> <li>○ More relaxed/comfortable driving for drivers.</li> </ul>
Use case description	
Situation	The drivers get informed about an accident zone in their vicinity, according to their driving direction.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road operator:</b> The road operator provides information about the accident zone detected on the road network mentioned in the use cases specifications and distributes respective warnings as C-ITS messages.</li> <li>○ <b>Drivers:</b> The drivers are informed about the accident zone ahead on their route by their chosen channel of information.</li> </ul>

Use case scenario	<ul style="list-style-type: none"> <li>○ <b>Service provider:</b> The service provider distributes C-ITS messages actively and dynamically to the subscribers (end-users).</li> <li>○ An accident is detected and confirmed in the TCC, the warning message is coded according to the specified definition and sent via defined channels to an ITS station, which sends the information.</li> <li>○ The road operator generates the event information within the TCC and distributes it via various channels with one message ID to vehicles.</li> <li>○ The service provider collects and distributes the HLN-AZ C-ITS message from/to his active users in the area.</li> <li>○ The drivers are informed ahead of the accident zone.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The road operators back-office systems in the TCC send event information to a C-ITS system which then creates, and sends C-ITS messages based on that content. When drivers approach an accident area, the vehicle receives the C-ITS messages.</li> <li>○ The information can then be presented via the In-Vehicle HMI early enough and should be only moderately intrusive (manufacturer's decision), allowing the driver to adjust his driving behaviour (e.g., speed and position) on the road.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ The information quality of the “Accident Zone” use case mostly depends on the accurate detection of the event and the confirmation level/maturity of the information in the back-office systems/TCC of road operators.</li> <li>○ 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.</li> <li>○ Various sensor measurements and procedures for traffic detection are needed in the back-office systems of the road operators in order to generate accurate information for the “Accident Zone” use case. Therefore, the availability of the service could be limited according to the limitations of the sensors used for event detection.</li> <li>○ How the information is presented to the drivers 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 be translated to the preferred language of the driver.</li> </ul>
Link to other use cases	<ul style="list-style-type: none"> <li>○ IVI-TS: The IVI use case can be used to also send an appropriate warning sign to the vehicles</li> <li>○ HLN-ERVI: If an emergency or rescue or recovery vehicle is at the accident location, possibly two DENMs are sent if the <math>V_{erv}</math> is C-ITS equipped</li> </ul>

#### Interoperability requirements

<p>Message profile requirements</p>	<ul style="list-style-type: none"> <li>○ The DENM message for HLN – AZ is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>○ For this use case, causeCode shall be set to accident2 and subCauseCode shall be set to one of the following (the road operator selects the best fitting value): <ul style="list-style-type: none"> <li>○ 0 (unavailable): used, if no further information is available</li> <li>○ 1 (multiple vehicles accident): for accidents with at least two vehicles involved</li> <li>○ 2 (heavy accident): serious injury or fatal accident</li> <li>○ 3 (accident involving lorry): used if an HGV/lorry is involved</li> <li>○ 4 (accident involving bus): used if a bus is involved</li> <li>○ 5 (accident involving hazardous materials): used for accidents involving hazardous materials according to ADR (Accord relatif au transport international des marchandises Dangereuses par Route; REF)</li> <li>○ 6 (accident in opposite lane) shall not be used. If the accident is on the opposite lane, this situation should be described by HLN-TJA</li> <li>○ 7 (unsecured accident): used if the accident zone is unprotected</li> </ul> </li> <li>○ stationType:15 (also in case of a central C-ITS station)</li> <li>○ eventSpeed shall not be used.</li> <li>○ detectionZonesToEventPosition represented by pathHistory elements shall be provided as specified in [C-Roads MP].</li> <li>○ a point based or single linear relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location or the upstream start of the accident zone.</li> </ul> </li> <li>○ awarenessDistance shall not be provided. <ul style="list-style-type: none"> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ For point based events: eventZone shall not be provided.</li> <li>○ For linear events: eventZone shall be provided and shall reflect the geographical extent of the accident zone.</li> </ul> </li> <li>○ informationQuality shall be set according to the definition specified in [C-Roads MP].</li> <li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li> <li>○ <i>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</i></li> </ul>
<p>Security and data protection requirements</p>	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p>

	<p>This use case is based on the causeCode accident2 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>accident2</td><td>1</td><td>1</td></tr></table> <p>The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	accident2	1	1
	SSP position									
CauseCodeType / Container	Octet position	Bit position								
accident2	1	1								
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>									
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN – AZ</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>									
Test and validation requirements	<p>[C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"><li>○ ITS-G5 only:<ul style="list-style-type: none"><li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li><li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li></ul></li></ul>									

- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8
- IP based only:
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
  - TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_HLN-AZ\_ITSG5\_DENM\_awarenessArea\_05\_3\_R2.0.8
  - TC\_CROADS\_HLN-AZ\_ITSG5\_DENM\_CC-sCC\_05\_R2.0.8
  - TC\_CROADS\_HLN-AZ\_ITSG5\_DENM\_eventSpeed\_05\_2\_R2.0.8
- Hybrid (IP based only):
  - TC\_CROADS\_HLN-AZ\_Hybrid\_DENM\_awarenessArea\_05\_3\_R2.0.8
  - TC\_CROADS\_HLN-AZ\_Hybrid\_DENM\_CC-sCC\_05\_R2.0.8
  - TC\_CROADS\_HLN-AZ\_Hybrid\_DENM\_eventSpeed\_05\_2\_R2.0.8

### 3.2.2 HLN – Traffic Jam Ahead (HLN-TJA)

Type of road network	Motorways, Dual carriageways, Rural roads
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	A road operator detects a traffic jam and sends the information to the drivers (mentioning the position and length of the traffic jam, as well as the affected section/lanes, if the information is available).
Background	With C-ITS, the availability and the accuracy of traffic jam ahead warnings is better than conventional means, and therefore drivers are warned with a higher quality of information, including the accuracy of the road segments, potentially affected lanes and vehicle speeds.
Objective	<p>The objective of this use case is to warn about a queue, but more importantly to warn about a potentially dangerous end of queue. The drivers can modify their driving behaviour (speed, lanes) towards the end of the queue.</p> <p>The accuracy of the position of the end of the queue is usually very low. This use case could help to improve it, since it can be signalled by vehicles encountering it when they adjust their speed and/or vehicle trajectory near the end of the traffic jam.</p>
Desired behaviour	<ul style="list-style-type: none"> <li>Well informed drivers adapting their driving behaviour (e.g., reducing their approaching speed, before arriving at the end of the traffic jam and while passing it).</li> <li>Precise and correctly informed drivers also drive more cautiously and concentrated near the end of the traffic jam.</li> <li>The constant speed adaptation of single vehicles when approaching the end of queue area has also an impact on the overall traffic flow.</li> </ul>
Expected benefits	<p>More homogenous traffic flow with less accident-related congestion, leading to:</p> <ul style="list-style-type: none"> <li>Economic benefits: saving resources, money, and time for all stakeholders,</li> <li>Social benefits: traffic safety, reduced number of incidents,</li> <li>Personal benefits: more comfortable driving,</li> <li>Environment benefits: reduced CO2 emissions and environmental pollution.</li> </ul>
<b>Use case description</b>	
Situation	<p>A traffic jam could either occur on one specific lane (e.g., at an exit of a motorway), or on all lanes of a section of the road.</p> <p>The TJA warning message for the respective lane or road section is sent out to end-users approaching the traffic jam area on various channels of information, but with one message ID.</p> <p>Sources of information could be:</p>



Logic of transmission	<ul style="list-style-type: none"> <li>○ Cameras (incident detection ones as well),</li> <li>○ Traffic loops,</li> <li>○ Operating agents/road operator equipped patrol vehicles,</li> <li>○ Other vehicles which have detected the danger.</li> </ul>
Actors and relations	<p>12V</p> <ul style="list-style-type: none"> <li>○ <b>Road operator:</b> The road operator detects and confirms TJA situations and forwards them to the C-ITS System. The operator in the TCC or (one or several) equipped vehicles braking is/are the sender of the TJA warning.</li> <li>○ <b>Service provider:</b> Disseminates TJA related information, to/from vehicles/drivers.</li> <li>○ <b>Drivers:</b> End-receiver is the mobile C-ITS station in the vehicle (and in the future possibly ACC system) or the driver.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The operator in the TCC gets informed about a traffic jam on the road network.</li> <li>○ The operator feeds the information into his TCC, confirms it with the length and/or lane, and then disseminates the message to the drivers.</li> <li>○ The vehicles near the traffic jam area receive the information and present it to their drivers.</li> <li>○ The drivers adapt their driving behaviour accordingly.</li> <li>○ In future, the in-vehicle ACC system could follow the warning message related advice directly.</li> <li>○ The road operator can have a system that automatically updates the length and/or lane of the traffic jam and communicate the end of the traffic jam area when a regular travelling speed is confirmed.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The in-vehicle information should be adapted to the relative position between the vehicle and the TJA warning positions.</li> <li>○ The presented information may vary depending on the position of the receiving vehicles or may not be presented at all if the vehicle is too close to the end of the queue.</li> <li>○ The in-vehicle information could inform the driver that ACC is active and working according to the driver's set of preferences.</li> <li>○ Related information is presented to the user via the dashboard. Layout and sequence of presentation is left to specific implementation.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ The accuracy of the end of queue information provided by the road operator can be low, depending on the systems used to update it and the available information sources used by the road operator. For example, for single sensor networks like loop detectors, the highest accuracy is the distance between two installed loop detectors, which would mean a low quality of locating the end of the queue.</li> </ul>

Link to other use cases	<ul style="list-style-type: none"> <li>○ The vehicles equipped with C-ITS could improve the quality of localisation and increase awareness of drivers approaching the traffic jam area. For high accuracy of this use case, it needs a high percentage of equipped vehicles included in message generation at the end of the traffic jam area.</li> <li>○ How the information is presented to the drivers 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 be translated to the preferred language of the driver.</li> </ul> <p>HLN-AZ: this use case is also triggered by HLN-AZ, if the accident is on the other driving direction</p>
<b>Interoperability requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The DENM message for HLN – TJA is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>○ In case the extent of the traffic jam is not known, <ul style="list-style-type: none"> <li>○ causeCode dangerousEndOfQueue27 and subCauseCode 0 (unavailable) shall be used.</li> <li>○ a point-based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>▪ The eventPosition shall be set to the upstream end of queue and the positionConfidenceEllipse shall be based on available data or shall be set to "unavailable" if no data is available.</li> <li>▪ awarenessDistance shall not be provided.</li> <li>▪ trafficDirection shall be provided as specified in [C-Roads MP].</li> </ul> </li> <li>○ eventZone shall not be provided.</li> </ul> </li> <li>○ In case the extent of the traffic jam is known, <ul style="list-style-type: none"> <li>○ causeCode trafficCondition1 and subCauseCode 5 (trafficJam) shall be used.</li> </ul> <p><i>NOTE: Current vehicle implementations require causeCode trafficCondition1 and subCauseCode 0 (unavailable) in this situation. An update to the C-ROADS specified usage of trafficCondition1/5 is already planned for these legacy vehicles.</i></p> <ul style="list-style-type: none"> <li>○ a single linear relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>▪ The eventPosition shall be set at the upstream end of the queue or even further ahead of the upstream end of queue.</li> <li>▪ awarenessDistance shall not be provided.</li> <li>▪ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>▪ eventZone shall be provided as specified in [C-Roads MP], starting at the eventPosition, continuing downstream describing the extent of the traffic jam to</li> </ul> </li> </ul> </li> </ul>

	<p>the point, where vehicles can progress freely at the allowed speed.</p> <ul style="list-style-type: none"><li>○ stationType: 15 (also in case of a central C-ITS station)</li><li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li><li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li><li>○ If no cancellation is used, validityDuration should be set to a maximum of 12 minutes, because an end of queue can appear and reappear frequently.</li><li>○ Message management shall be done by either providing short validity durations (maximum 12 minutes) or by actively terminating messages.</li></ul> <p><i>NOTE: For both scenarios (27/0 and 1/5): If the end of queue position changes, the eventPosition needs to be updated and the positionConfidence needs to reflect the accuracy of the event position. The positionConfidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</i></p>												
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the causeCode dangerousEnd-OfQueue27 or trafficCondition1 and therefore requires an appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th></tr><tr><td>dangerousEndOfQueue27</td><td>2</td><td>6</td></tr><tr><td>trafficCondition1</td><td>1</td><td>0</td></tr></table> <p>The here listed SSP for cC1 shall be granted only for C-ITS stations used by road operators or any contractor on their behalf. The SSP for causeCode dangerousEndOfQueue27 shall be granted for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	dangerousEndOfQueue27	2	6	trafficCondition1	1	0
	SSP position												
CauseCodeType / Container	Octet position	Bit position											
dangerousEndOfQueue27	2	6											
trafficCondition1	1	0											

Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = HLN – TJA</li> <li>○ messageType = DENM</li> </ul> <p>Geographic area (Quadtree) for DENM:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_StationType_66_R2.0.8</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.8</li> </ul> </li> </ul>

- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_HLN-TJA\_ITSG5\_DENM\_awarenessArea\_06\_5\_R2.0.8
  - TC\_CROADS\_HLN-TJA\_ITSG5\_DENM\_CC-sCC\_06\_R2.1.0
  - TC\_CROADS\_HLN-TJA\_ITSG5\_DENM\_eventZone\_06\_4\_R2.0.8
  - TC\_CROADS\_HLN-TJA\_ITSG5\_DENM\_validityDuration\_06\_3\_R2.0.8
- IP based only:
  - TC\_CROADS\_HLN-TJA\_Hybrid\_DENM\_awarenessArea\_06\_5\_R2.0.8
  - TC\_CROADS\_HLN-TJA\_Hybrid\_DENM\_CC-sCC\_06\_R2.1.0
  - TC\_CROADS\_HLN-TJA\_Hybrid\_DENM\_eventZone\_06\_4\_R2.0.8
  - TC\_CROADS\_HLN-TJA\_Hybrid\_DENM\_validityDuration\_06\_3\_R2.0.8

### 3.2.3 HLN – Stationary vehicle (HLN-SV)

Type of road network	Motorways, Dual carriageways, Rural roads
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	<p>The Stationary Vehicle(s) service warns approaching drivers of stationary/broken-down vehicles ahead that present a hazard to other vehicles on the road. It is a preventive safety service, as drivers are informed in advance and have more time to prepare for danger.</p> <p>The road operator could have event management systems to trigger conventional (non-C-ITS) and C-ITS I2V messages to warn other vehicle drivers of stationary/broken-down vehicles. In line with the ETSI ITS standard, this service could rely on V2V ITS-G5 communication, in particular on the messages sent by the stationary/broken-down vehicle and processed/filtered by nearby receiving vehicles.</p> <p>An interesting variation of this use case that contributes to the quality of the information is that the stationary/broken-down vehicle information is also processed by a nearby roadside unit and then, in order to further distribute the same warning via the roadside infrastructure, other RSU's connected through the road operator distribute the SV warning by resending it.</p>
Background	<p>While the C-ITS platform presents a single entry for this use case, [ETSI TR 102 638] includes two distinct use cases:</p> <ul style="list-style-type: none"> <li>○ Slow vehicle warning as a use case of cooperative awareness application,</li> <li>○ Stationary vehicle as a use case of road hazard warning application.</li> </ul> <p>The Stationary Vehicle warning is achieved through a DENM (event notification) by the sender vehicle application, which sends a notification with a specific Stationary Vehicle cause code based on the state of the vehicle (broken, stopped with emergency lights on, etc.).</p> <p>The variant of I2V information via a stationary vehicle was tested with regard to the I2V part, i.e., the infrastructure informs vehicles about a stationary vehicle.</p> <p>So far, no thorough and operative scenario demonstration has been done, where stationary vehicles, 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.</p>
Objective	Avoiding collisions (mostly rear-end) with stationary vehicles on the road and increasing road safety.

Desired behaviour	<ul style="list-style-type: none"> <li>○ The vehicle drivers adapt their driving behaviour by slowing down and/or changing lanes.</li> <li>○ As the I2V warning is targeted and accurate by the road operator's event management system, reliability is high and driver attention is increased near these traffic situations or areas.</li> <li>○ In the future, the SV information may be used by Advanced Driver Assistance Systems for supported and automated driving. In addition, the driver awareness is raised to the possible presence of vulnerable road user(s) (VRU) on the road.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ As reported in the study [Introduction to the C-Roads WG2 Deployment Documentation and Requirements], the main benefit is expected in road safety, whereas minimal impact is expected in traffic efficiency and fuel consumption.</li> <li>○ Concerning safety, this service helps to prevent dangerous manoeuvres as drivers are informed in advance and have more time to prepare for the hazard and take appropriate countermeasures, also with regard to possible vulnerable road users nearby.</li> </ul>
<b>Use case description</b>	
Situation	<p>The road operators' event management systems forward the necessary information to the C-ITS communication system.</p> <p>Sources of information can be:</p> <ul style="list-style-type: none"> <li>○ Cameras (incident detection ones as well),</li> <li>○ Operating agents/road operator equipped patrol vehicles,</li> <li>○ Other C-ITS-equipped vehicles which have detected the danger.</li> </ul> <p>A Stationary Vehicle itself is expected to inform drivers in their vicinity about broken down vehicles as specified in [C2C CC Vehicle C-ITS station profile], see esp. "Triggering Conditions and Data Quality Stationary Vehicle Warning".</p>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road operators:</b> Detect slow moving or broken-down vehicles with their event management systems, verify and forward C-ITS messages via different communication channels with one warning message ID.</li> <li>○ <b>Drivers:</b> The drivers may act as information source and end-user of SV warning messages.</li> <li>○ <b>Service providers:</b> Distribute positions of stationary/broken-down vehicles via different communication networks to their users approaching the event position of the warning.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The road operator detects a slow moving or broken-down vehicle (conventional (non-C-ITS) vehicle or C-ITS equipped vehicle).</li> </ul>

	<ul style="list-style-type: none"> <li>○ The road operator generates an appropriate warning message that is sent I2V to the C-ITS Systems in the relevant area.</li> <li>○ Approaching vehicles receive the warning and drivers adapt their driving behaviour.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The driver is provided with related information, presented on the dashboard. Layout and sequence of presentation is left to OEM-specific implementation.</li> <li>○ The warning to the driver must be presented early enough to allow drivers to adjust the speed of their vehicles, but not so early that the warning is forgotten. The warning can be repeated when approaching the position of the event.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ How the information is presented to the drivers is not part of the service description.</li> <li>○ It is left to the provider of the in-vehicle information system with HMI how information is presented. Information might be translated to the preferred language of the driver.</li> </ul>
Link to other use cases	HLN-ERVI: If an emergency or rescue or recovery vehicle arrives at the stationary vehicle, the HLN-ERVI use case will be triggered by the emergency or recovery vehicle.

#### Interoperability requirements

Message profile requirements	<ul style="list-style-type: none"> <li>• The DENM message for HLN – SV is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>• For this use case, causeCode stationaryVehicle94 and subCauseCode 0 (unavailable) or 2 (vehicle breakdown) shall be used.</li> <li>• eventSpeed shall not be used.</li> <li>• stationType: 15 (also in case of a central C-ITS station)</li> <li>• informationQuality shall be set according to the definition specified in [C-Roads MP].</li> <li>• detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li> <li>• a point based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location of the stationary/broken-down vehicle.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall not be provided.</li> </ul> </li> <li>• lanePositions shall be provided if the information is available and reliable.</li> <li>• The stationaryVehicle DE shall not be provided.</li> </ul>
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	<ul style="list-style-type: none"><li>• Message management shall be done by either providing short validity durations or by actively terminating messages.</li><li>• <i>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</i></li></ul>									
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the causeCode stationaryVehicle94 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>stationaryVehicle94</td><td>3</td><td>2</td></tr></table> <p>The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	stationaryVehicle94	3	2
	SSP position									
CauseCodeType / Container	Octet position	Bit position								
stationaryVehicle94	3	2								
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>									
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN – SV</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and</p>									

	<p>C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_StationType_66_R2.0.8</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_stationType_66_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.8</li> </ul> </li> </ul> <p>List of applicable Specific Test Cases:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-SV_ITSG5_DENM_awarenessArea_16-4_R2.0.8</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-SV_ITSG5_DENM_awarenessTrafficDirection_8_R2.0.8</li> <li>○ TC_CROADS_HLN-SV_ITSG5_DENM_eventSpeed_16-2_R2.0.8</li> <li>○ TC_CROADS_HLN-SV_ITSG5_DENM_lanePosition_16-8_R2.0.8</li> </ul> <p>○ IP based only:</p> <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-SV_HYBRID_DENM_awarenessArea_16-4_R2.0.8</li> <li>○ TC_CROADS_HLN-SV_HYBRID_DENM_awarenessTrafficDirection_8_R2.0.8</li> <li>○ TC_CROADS_HLN-SV_HYBRID_DENM_CC-sCC_13_R2.0.8</li> <li>○ TC_CROADS_HLN-SV_HYBRID_DENM_eventSpeed_16-2_R2.0.8</li> <li>○ TC_CROADS_HLN-SV_HYBRID_DENM_lanePosition_16-8_R2.0.8</li> <li>○ TC_CROADS_HLN-SV_HYBRID_DENM_stationaryVehicle_16-5_R2.0.8</li> </ul>
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### 3.2.4 HLN – Weather Condition Warning (HLN-WCW)

Type of road network	All
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	<p>In the Weather Condition Warning (WCW) use case, drivers are informed about static and dynamic road weather conditions. As reported in the [Study on 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.</p> <p>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." [C-ITS Platform Final report]</p>
Background	<p>With reference to 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 European Roads (Article 3, category (h)). Article 2 defines exceptional weather conditions as "unusual, severe or unseasonal weather conditions which might affect safe driving".</p> <p>The Weather Conditions Warning (WCW) use case is intended to inform drivers via in-vehicle information systems of weather conditions (current or expected) and road status along the road. WCW information is provided by means of I2V communication, referring to a sub use case of Hazardous Location Notifications, as specified in [ETSI TR 102 638] and coherently in the [C-ITS Platform Final report].</p>
Objective	Improve traffic safety via additional means of C-ITS messages by informing drivers in a more accurate way about adverse weather conditions and road status information.
Desired behaviour	<ul style="list-style-type: none"> <li>○ The vehicle drivers adapt their driving behaviour compliant to the applicable driving regulations and any advice or guidance provided.</li> <li>○ In the future the information may be used by Advanced Driver Assistance Systems for supported and automated driving.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ The primary expected impact is more attentive driving by providing actual and continuous (expected) information on road weather conditions (e.g., poor road traction conditions, visibility, wind, rainfall</li> </ul>

	<p>etc.), which improves traffic safety as it reduces (the numbers and the severity of) accidents.</p> <ul style="list-style-type: none"> <li>○ A topic of future day 2 C-ITS services can be to evaluate the applicability of this concept to Autonomous Driving functions.</li> </ul>
<b>Use case description</b>	
Situation	WCW is expected to inform drivers of current and/or expected information related to precipitation or extreme weather conditions or low visibility ranges due to, for example, fog.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Validates the warning and issues triggering information via different communication channels with one message ID.</li> <li>○ <b>Service provider:</b> Collects and ensures that the triggering information is correct, triggers an I2V warning, and/or aggregates information in cloud services.</li> <li>○ <b>Weather information provider:</b> Shares real-time information with the road operator, or TCC.</li> <li>○ <b>End-User:</b> Receives the warning via the on-board unit and/or receives notification that the automatic vehicle control is taking adverse weather conditions into account.</li> <li>○ <b>Drivers:</b> Are informed about dangerous weather conditions ahead in time to adapt the driving behaviour.</li> <li>○ <b>Vulnerable road users:</b> Vulnerable Road users or special vehicle categories (e.g., PTW) could receive adapted WCW messages.</li> </ul> <p>Additional Information sources for the use case could be as follows:</p> <ul style="list-style-type: none"> <li>○ Roadside sensors/weather forecasts provide weather data.</li> <li>○ C-ITS vehicles.</li> </ul>
Use case scenario	<p>The operators in the TCC get informed about extreme weather conditions (and the consequences e.g., low visibility) on the road network.</p> <p>They put the information together, confirm it in their TCC and then distribute the WCW message via different communication channels and send it to the drivers. The vehicles receive the information and present it to the drivers, so that they can adapt their driving behaviour.</p> <p>Additional scenarios can be implemented as follows:</p> <p><u>Scenario 1:</u> Data is sent directly after the TCC has confirmed the data and the triggering conditions.</p>



Figure 3:1 Scenario 1 HLN-WCW

Scenario 2: The vehicle receives the WCW message and asks the Service Provider (linked to TCC) for a confirmation of the data already on-board and displays the message in time to react.

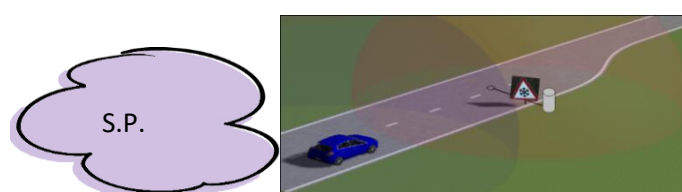


Figure 3:2 Scenario 2 HLN-WCW

The event is cleared by the respective actors involved in each scenario by the end of lifetime with a next update.

The sources of information for this use case are the following:

- [Study on the Deployment of C-ITS in Europe: Final Report] pp 158-160, includes references to the EU projects mentioned.
- [ETSI TR 102 638], for Hazardous location notifications [ETSI TS 103 301].

Intended  
Presentation/Alert  
principle

- The user is provided with related information, presented on the dashboard. The layout is left to OEM-specific implementation.
- The WCW message is presented early enough for the drivers to adjust their driving behaviour, and at the same time not too far away from the affected road segment.
- The distribution of this warning message to end-users may extend beyond the single road segment or area affected.
- The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.

Functional constraints/  
dependencies

The document [ETSI TS 101 539 1] defines adverse weather condition specific functional requirements, as part of Road Hazard Signalling (RHS) in clause 6.3.6. It includes:

- DENM transmission conditions.
- Event triggering condition.
- Relevance area.
- Event termination condition.
- Use case specific data element values to be provided.
- How the information is presented to the drivers is not part of the service description.

	<ul style="list-style-type: none"> <li>○ It is left to the provider of the in-vehicle information system with HMI how information is presented.</li> <li>○ Information might be translated to the preferred language of the driver.</li> </ul>
Link to other use cases	None
<b>Interoperability requirements</b>	
Message profile requirements	<p>The DENM message for HLN – WCW is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</p> <ul style="list-style-type: none"> <li>○ For this use case, <i>causeCode</i> <i>adverseWeatherCondition-ExtremeWeatherCondition17</i>, <i>adverseWeatherCondition-Visibility18</i>, or <i>adverseWeatherCondition-Precipitation19</i> shall be used. All respective <i>subCauseCodes</i> are applicable.</li> <li>○ <i>stationType</i>: 15 (also in case of a central C-ITS station)</li> <li>○ <i>informationQuality</i> shall be set according to the definition in [C-Roads MP].</li> <li>○ <i>detectionZonesToEventPosition</i> shall be provided as specified in [C-Roads MP].</li> <li>○ a single circular awareness area shall be provided. It shall be represented as: <ul style="list-style-type: none"> <li>○ <i>eventPosition</i> shall be set to the centre of the area subject to the event.</li> <li>○ <i>awarenessDistance</i> shall be provided using values 0 to 6.</li> <li>○ <i>trafficDirection</i> shall be set to <i>allTrafficDirections</i> (0).</li> <li>○ <i>eventZone</i> shall not be provided.</li> </ul> </li> <li>○ <i>Legacy note: For highway scenarios, single linear awareness areas are allowed.</i> It shall be represented as: <ul style="list-style-type: none"> <li>○ <i>eventPosition</i> shall be set to the most upstream location of the event.</li> <li>○ <i>awarenessDistance</i> shall not be provided.</li> <li>○ <i>trafficDirection</i> shall be provided as specified in [C-Roads MP].</li> <li>○ <i>eventZone</i> shall be provided.</li> </ul> </li> <li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the <i>causeCode</i> <i>adverseWeatherCondition-ExtremeWeatherCondition17</i>, <i>adverseWeatherCondition-Visibility18</i> or <i>adverseWeatherCondition-Precipitation19</i> and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p>

	<p>The here shall be for C-ITS used by operators contractor behalf.</p> <table><tr><th></th><th colspan="2">SSP position</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th></tr><tr><td>adverseWeatherCondition-ExtremeWeatherCondition17</td><td>2</td><td>2</td></tr><tr><td>adverseWeatherCondition-Visibility18</td><td>2</td><td>3</td></tr><tr><td>adverseWeatherCondition-Precipitation19</td><td>2</td><td>4</td></tr></table> <p>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</p>		SSP position		CauseCodeType / Container	Octet position	Bit position	adverseWeatherCondition-ExtremeWeatherCondition17	2	2	adverseWeatherCondition-Visibility18	2	3	adverseWeatherCondition-Precipitation19	2	4	listed SSP granted stations road or any on their
	SSP position																
CauseCodeType / Container	Octet position	Bit position															
adverseWeatherCondition-ExtremeWeatherCondition17	2	2															
adverseWeatherCondition-Visibility18	2	3															
adverseWeatherCondition-Precipitation19	2	4															
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>																
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN – WCW</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM message: The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>																
Test and validation requirements	<p>[C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"><li>○ ITS-G5 only:</li></ul>																



- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_CANCEL\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8

○ IP based only:

- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of applicable specific test cases:

○ ITS-G5 only:

- TC\_CROADS\_HLN-WCW\_ITSG5\_DENM\_awarenessArea\_18-3\_R2.0.8
- TC\_CROADS\_HLN-WCW\_ITSG5\_DENM\_awarenessTrafficDirection\_18-2\_R2.0.8
- TC\_CROADS\_HLN-WCW\_ITSG5\_DENM\_CC-sCC\_18\_R2.0.8

○ IP based only:

- TC\_CROADS\_HLN-WCW\_HYBRID\_DENM\_awarenessArea\_18-3\_R2.0.8
- TC\_CROADS\_HLN-WCW\_HYBRID\_DENM\_awarenessTrafficDirection\_18-2\_R2.0.8
- TC\_CROADS\_HLN-WCW\_HYBRID\_DENM\_CC-sCC\_18\_R2.0.8
- TC\_CROADS\_HLN-WCW\_HYBRID\_DENM\_eventZone\_18-3\_R2.0.8

### 3.2.5 HLN – Temporarily slippery road (HLN-TSR)

Type of road network	All
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	A road operator knows that a section of a road (or a single lane or point) is temporarily slippery and sends this information to the drivers, and/or a vehicle detects that it is slipping and sends an alert message to other vehicles. The combination of these two information sources within a C-ITS system allows for much better information quality and accuracy compared to the two individual sources used so far.
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 and the coverage and information quality can be greatly improved using I2V and V2V C-ITS systems that complement each other. This use case could reduce the risks of accidents by disseminating this information more widely and reaching the end-users 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 so that they can adapt their speed and trajectory to the situation.
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased attention of the driver.</li> <li>○ Adaptation of the driving speed.</li> <li>○ Change of lanes (if needed).</li> <li>○ Rerouting (e.g., for HGV or specific vehicle categories).</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accidents.</li> <li>○ Improved traffic management.</li> </ul>
<b>Use case description</b>	
Situation	<ul style="list-style-type: none"> <li>○ Depending on the cause of the slippery section, this use case can concern both directions of roads, even for dual carriageways.</li> <li>○ Dealing with this information can be different for HGV and passenger vehicles since HGV might even adapt their itinerary completely.</li> <li>○ Natural causes and/or spillage of various materials on the road are possible reasons for this risky situation and the generation of a warning message: <ul style="list-style-type: none"> <li>○ Oil, chemical fluids etc.</li> <li>○ Rolling elements (e.g. bottles, golf balls, fruits,)</li> <li>○ Black ice or water</li> </ul> </li> </ul>

	<p>Sources of this information can be:</p> <ul style="list-style-type: none"> <li>○ Cameras</li> <li>○ Phone calls of a witness</li> <li>○ Operating agents</li> <li>○ C-ITS equipped vehicles with sensors which have detected the danger</li> </ul>
Logic of transmission	I2V, V2V
Actors and relations	<p><u>I2V:</u></p> <ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Generates the warning in the TCC and sends it to the C-ITS systems via various communication channels with one message ID.</li> <li>○ <b>Service provider:</b> Forwards the warning messages to their users and contribute to the detection of slippery road segments.</li> <li>○ <b>Drivers:</b> End-users are the drivers. For slippery segments detected by the vehicle sensors, drivers also act as data/information provider.</li> </ul> <p><u>V2V:</u></p> <ul style="list-style-type: none"> <li>○ Sender is the vehicle detecting the slippery road.</li> <li>○ End-users are all vehicles around or ahead of the slippery road segment.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The operators in the TCC get informed about a section that is slippery on the road network.</li> <li>○ The TCC operators put the information into the TCC system, and the message is then disseminated to the drivers via the C-ITS systems and by various communication channels with one message ID.</li> <li>○ The vehicles receive the information and present it to the drivers.</li> <li>○ The drivers adapt their driving behaviour.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The drivers are provided with related information, presented on the dashboard. The layout is left to OEM-specific implementation.</li> <li>○ The alert needs to be early enough for the drivers to adjust their driving speed without stress, but not too early so that the drivers do not forget about the alert.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ 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 sources of information could inform about a similar event, but not with exactly the same warning message, therefore the vehicle shall consider the priority between both messages.</li> <li>○ For service providers the transmission speed and targeting accuracy for the drivers is a major dependency to implement this use case successfully, and to deliver high quality warning messages to the TCC.</li> </ul>

	<ul style="list-style-type: none"> <li>○ Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators to generate the information about all the slippery road segment locations for this use case. Therefore, restrictions of the service-availability could apply.</li> <li>○ The Information quality of this use case depends mainly on the detection of the event “temporarily slippery road” and the confirmation/maturity of the information.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	IVS-TS: Sending the respective warning sign to the vehicles
<b>Interoperability requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The DENM message for HLN-TSR is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>○ For this use case, causeCode adverseWeatherCondition-Adhesion6 and subCauseCode between 0 and 10 or causeCode hazardousLocation-SurfaceCondition9 with subCauseCode 0,1,4,5 or 7 shall be used.</li> <li>○ eventSpeed shall not be provided.</li> <li>○ In case of a linear event, a single linear awareness area shall be provided. It shall be represented as: <ul style="list-style-type: none"> <li>○ eventPosition shall be set to the most upstream location of the event.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall be provided.</li> </ul> </li> <li>○ In all other cases, a single circular awareness area shall be sent encoded as: <ul style="list-style-type: none"> <li>○ eventPosition shall be set to the centre of the area subject to the event.</li> <li>○ awarenessDistance shall be provided using values 0 to 6.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall not be provided.</li> </ul> </li> <li>○ The alacarte container shall not be provided.</li> <li>○ stationType: 10,15 (15 also in case of a central C-ITS station)</li> <li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li> <li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li> <li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li> </ul>

Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the causeCode adverseWeatherCondition-Adhesion6 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>adverseWeatherCondition-Adhesion6</td><td>1</td><td>3</td></tr><tr><td>hazardousLocation-SurfaceCondition9</td><td>1</td><td>4</td></tr></table> <p>The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	adverseWeatherCondition-Adhesion6	1	3	hazardousLocation-SurfaceCondition9	1	4
	SSP position												
CauseCodeType / Container	Octet position	Bit position											
adverseWeatherCondition-Adhesion6	1	3											
hazardousLocation-SurfaceCondition9	1	4											
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>												
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN-TSR</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM message:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that</p>												

	the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_StationType_66_R2.0.8</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_stationType_66_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.8</li> </ul> </li> </ul> <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-TSR_ITSG5-DENM_awarenessArea_17_2_R2.0.8</li> <li>○ TC_CROADS_HLN-TSR_ITSG5-DENM_CC-sCC_17_R2.0.8</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-TSR_HYBRID-DENM_alacarteContainer_17_3_R2.0.8</li> <li>○ TC_CROADS_HLN-TSR_HYBRID-DENM_CC-sCC_17_1_R2.0.8</li> </ul> </li> </ul>

- TC\_CROADS\_HLN-TSR\_HYBRID-DENM\_eventSpeed\_17\_4\_R2.0.8

### 3.2.6 HLN – Animal or person on the road (HLN-APR)

Type of road network	Motorways, Dual carriageways
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	A road operator knows that one or several animal(s) is(are) present on the road network and sends the information to drivers. Or a driver detects one or several animals on the road and signals that information via his HMI, sending a message to other drivers. Both situations and warnings could also be combined.
Background	Today, this information is typically provided only by 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 drivers.
Objective	The objective of this use case is to alert drivers of a potential danger. Since there is usually no automatic detection and the animal can be moving quite fast, the accuracy of the localization is not very high. Note, drivers need to increase their attention while driving.
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased driver attention.</li> <li>○ Adaptation of driving speed.</li> <li>○ Change of itinerary (e.g., because of a flock of animals in mountains).</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accidents.</li> <li>○ Improved traffic management.</li> </ul>
<b>Use case description</b>	
Situation	<p>The starting point of this use case can be several situations like a vehicle breakdown, an accident or a person taking a call reporting that persons or also animals are on a part of the road network and their movements are a dangerous situation for all involved drivers in the area.</p> <p>The dangerous situations could be:</p> <ul style="list-style-type: none"> <li>○ persons present or</li> <li>○ a flock, or group of animals need to be detected, and the warnings created and distributed to all possible road users involved.</li> </ul> <p>According to the type of the road (and the speed limit consequently), the danger can be more or less important. A flock of animals in the mountains can be quite frequent for example.</p> <p>Sources of information can be:</p> <ul style="list-style-type: none"> <li>○ Cameras</li> <li>○ Phone call of a witness</li> <li>○ Operating agents</li> </ul>



	<ul style="list-style-type: none"> <li>Other C-ITS equipped vehicles which have detected the danger with various – C-ITS messages as follows</li> </ul>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li><b>Road operator:</b> Sender is a road operator in the TCC.</li> <li><b>Drivers:</b> End-receivers are the drivers.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>The operators in the TCC get informed about the presence of one or several persons or animal(s) on the road network.</li> <li>The TCC operator puts the information in the TCC systems, and the message is then sent by the C-ITS systems on various communication channels with one message ID to the drivers.</li> <li>The vehicles receive the information and present it to the drivers.</li> <li>The drivers adapt their driving behaviour.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>The alert to the drivers needs to be early enough for them to adapt their speed or itinerary (in case of a flock for example). However, since the drivers should not forget about the alert, it could be repeated closer to the location.</li> <li>The information could be presented differently according to the type of the road.</li> <li>The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>For service providers, transmission speed and targeting accuracy for the drivers is a major dependency to implement this use case successfully.</li> <li>Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators to generate the information about persons/animals detected on road segments for this use case. Therefore, restrictions of the service-availability could apply.</li> <li>The Information quality of this use case depends mainly on the detection of the event “animals or persons on the road” and the confirmation/maturity of the information.</li> <li>The localisation can be very imprecise. And the information cannot always be verified by the road operator.</li> <li>How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	Note that HLN-APR use case is about the actual presence of animals on the road. And not the generic indication of an area prone to animals crossing the road.

	IVS-TS: Sending the respective warning sign to the vehicles.							
Interoperability requirements								
Message profile requirements	<ul style="list-style-type: none"><li>○ The DENM message for HLN-APR is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li><li>○ In case of a linear event, a single linear awareness area shall be provided. It shall be represented as:<ul style="list-style-type: none"><li>○ eventPosition shall be set to the beginning of the road segment where the animal or person was detected.</li><li>○ awarenessDistance shall not be provided.</li><li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li><li>○ eventZone shall be provided.</li></ul></li><li>○ In all other cases, a single circular awareness area shall be provided. It shall be represented as:<ul style="list-style-type: none"><li>○ eventPosition shall be set to the location where the animal or person was detected.</li><li>○ awarenessDistance shall be provided using values 0 to 6.</li><li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li><li>○ eventZone shall not be provided.</li></ul></li><li>○ For this use case, causeCode hazardousLocation-AnimalOnTheRoad11 or humanPresenceOnTheRoad12 shall be used. All respective subCauseCodes are applicable.</li><li>○ stationType: 15 (also in case of a central C-ITS station)</li><li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li><li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li><li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li><li>○ NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</li></ul>							
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications]</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the causeCode hazardousLocation-AnimalOnTheRoad11 or humanPresenceOnTheRoad12 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr></table>			SSP position		CauseCodeType / Container	Octet position	Bit position
	SSP position							
CauseCodeType / Container	Octet position	Bit position						

	<table><tr><td>hazardousLocation-AnimalOnTheRoad11</td><td>1</td><td>6</td></tr><tr><td>humanPresenceOnTheRoad12</td><td>1</td><td>7</td></tr></table>	hazardousLocation-AnimalOnTheRoad11	1	6	humanPresenceOnTheRoad12	1	7
hazardousLocation-AnimalOnTheRoad11	1	6					
humanPresenceOnTheRoad12	1	7					
	<p>The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>						
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>						
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN-APR</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM message:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>						
Test and validation requirements	<p>[C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"><li>○ ITS-G5 only:<ul style="list-style-type: none"><li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li><li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li><li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li></ul></li></ul>						

- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8

- IP based only:

- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of use case specific test cases:

- ITS-G5 only:

- TC\_CROADS\_HLN-APR\_ITSG5-DENM\_awarenessArea\_19-2\_R2.0.8
- TC\_CROADS\_HLN-APR\_ITSG5-DENM\_awarenessTrafficDirection\_19-3\_R2.0.8
- TC\_CROADS\_HLN-APR\_ITSG5-DENM\_CC-sCC\_19\_R2.0.8

- IP based only:

- TC\_CROADS\_HLN-APR\_Hybrid-DENM\_awarenessArea\_19-1\_R2.0.8
- TC\_CROADS\_HLN-APR\_Hybrid-DENM\_awarenessTrafficDirection\_19-1\_R2.0.8
- TC\_CROADS\_HLN-APR\_Hybrid-DENM\_CC-sCC\_19\_R2.0.8

### 3.2.7 HLN – Obstacle on the road (HLN-OR)

Type of road network	Motorways, Dual carriageways, Rural roads
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	A road operator knows that there is one or several obstacles on one or several lanes of the road network and sends this information to drivers. However, traffic can still pass the obstacles (not a blockage).
Background	Today, this information is typically provided only by VMS or radio. With C-ITS, the availability is better.
Objective	The objective of this use case is to alert drivers of a potential danger. Since there is no automatic detection, the accuracy of the localisation is not very high. Note, drivers need to increase their attention while driving.
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased attention.</li> <li>○ Adaptation of the speed.</li> <li>○ Change of lanes (if needed).</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accidents.</li> <li>○ Improved traffic management for road operators.</li> </ul>
<b>Use case description</b>	
Situation	<p>The obstacles can be small and not harmful, but still dangerous, since they can surprise drivers, who might brake or show unpredictable behaviour if not alerted. There can also be big obstacles, such as lost furniture for example from a HGV, etc., that could result in the blockage of a lane.</p> <p>Sources of information can be:</p> <ul style="list-style-type: none"> <li>○ Cameras</li> <li>○ Phone call of a witness</li> <li>○ Operating agents</li> <li>○ Other vehicles which have detected the danger and sent out vehicle C-ITS messages as possible source of information</li> </ul>
Logic of transmission	I2V, V2V
Actors and relations	<p>I2V:</p> <ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Sender is the road operator in the TCC.</li> <li>○ <b>Drivers:</b> End-receivers are the drivers.</li> </ul> <p>V2V:</p> <ul style="list-style-type: none"> <li>○ <b>Road operator agent:</b> Source of the information and sender of the information from the road operator vehicle.</li> </ul>

	<ul style="list-style-type: none"> <li>○ <b>Drivers:</b> End-Receivers are all other vehicles around.</li> </ul>
Use case scenario	<p>I2V scenario:</p> <ul style="list-style-type: none"> <li>○ The operators in the TCC get informed about the presence of one or several obstacle(s) on the road network.</li> <li>○ The TCC operator puts the information in the TCC system, and the message is then sent by the C-ITS systems on various communication channels with one message ID to the drivers.</li> <li>○ The vehicles receive the information and present it to the driver.</li> <li>○ The drivers adapt their driving behaviour.</li> </ul> <p><u>V2V scenario:</u></p> <ul style="list-style-type: none"> <li>○ A road operator agent detects the presence of one or several obstacle(s) on the road.</li> <li>○ The road operator agent signals it via the specific HMI: the message is then sent to the road users.</li> <li>○ The other vehicles around receive the information and display it to their drivers.</li> <li>○ The other drivers adapt their behaviour.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The warning presented to the drivers needs to be early enough for the drivers to adapt their speed or even their itinerary. However, since the driver should not forget about the alert, it could be repeated closer to the location.</li> <li>○ The information could be presented differently according to the type of the road.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ For service providers, transmission speed and targeting accuracy for drivers is a major dependency to implement this use case successfully.</li> <li>○ Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators to generate the information about persons/animals detected on road segment locations for this use case. Therefore, restrictions of the service-availability could apply.</li> <li>○ The Information quality of this use case depends mainly on the detection of the event “animals or persons on the road” and the confirmation/maturity of the information.</li> <li>○ Due to the dynamic event the localisation can be very imprecise. And the information cannot always be verified by the road operator. Moreover, for the V2V scenario, the precise localization of the obstacle from the road operator vehicle deserves the necessary attention How the information is presented to the drivers 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.</li> </ul>

Link to other use cases	HLN-ERVI: If an emergency or rescue or recovery vehicle arrives at the location of the obstacle on the road, the HLN-ERVI use case shall be triggered additionally.
<b>Interoperability requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The DENM message for HLN-OR is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>○ In case of a point location, a point-based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location of the obstacle.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall not be provided.</li> </ul> </li> <li>○ In the case of multiple obstacles spread on the road, a single linear relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location of the most upstream obstacle.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall be provided as specified in the [C-Roads MP].</li> <li>○ NOTE: Currently V2V implementations only use point locations</li> </ul> </li> <li>○ For this use case, causeCode hazardousLocation-ObstacleOnTheRoad10 and subCauseCode between 0 and 5 shall be used. subCauseCodes 6 and 7 shall not be used.</li> <li>○ stationType: <ul style="list-style-type: none"> <li>○ I2V scenario: 15 (also in case of a central C-ITS station)</li> <li>○ V2V scenario: stationType shall be set according to [C-Roads MP]</li> </ul> </li> <li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li> <li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li> <li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li> <li>○ For V2V scenario: <ul style="list-style-type: none"> <li>○ trafficDirection: allTrafficDirections</li> <li>○ NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</li> </ul> </li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p>

	<p>This use case is based on the causeCode hazardousLocation-ObstacleOnTheRoad10 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>hazardousLocation-ObstacleOnTheRoad10</td><td>1</td><td>5</td></tr></table> <p>The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	hazardousLocation-ObstacleOnTheRoad10	1	5
	SSP position									
CauseCodeType / Container	Octet position	Bit position								
hazardousLocation-ObstacleOnTheRoad10	1	5								
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>									
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN-OR</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM message:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>									
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"><li>○ ITS-G5 only:<ul style="list-style-type: none"><li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li><li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li></ul></li></ul>									



- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8
- IP based only:
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
  - TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of use case specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_HLN-OR\_ITSG5-DENM\_awarenessArea\_20-1\_R2.0.8
  - TC\_CROADS\_HLN-OR\_ITSG5-DENM\_awarenessTrafficDirection\_20-3\_R2.0.8
  - TC\_CROADS\_HLN-OR\_ITSG5-DENM\_CC-sCC\_20\_R2.0.8
- IP based only:
  - TC\_CROADS\_HLN-OR\_Hybrid-DENM\_awarenessArea\_20-1\_R2.0.8
  - TC\_CROADS\_HLN-OR\_Hybrid-DENM\_awarenessTrafficDirection\_20-3\_R2.0.8
  - TC\_CROADS\_HLN-OR\_Hybrid-DENM\_CC-sCC\_19\_R2.0.8

### 3.2.8 HLN – Emergency or Rescue/Recovery Vehicle in Intervention (HLN-ERVI)

Type of road network	Motorways, Dual carriageways
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	The intent of the emergency or rescue/recovery vehicle in intervention (ERVI) use case is to warn drivers about the location of the involved vehicle in intervention (e.g., a traffic accident, incident or rescue and recovery work) so the other drivers will be able to adjust their driving behaviour accordingly and in time. The equipped emergency or rescue/recovery vehicle is sending a warning message when the vehicle is stationary with an activated light bar and being stationary for more than the defined time period.
Background	The location of an accident, incident or another type of intervention and the involved vehicles could be unclear and could surprise or confuse drivers arriving to this section, which could complicate passing the intervention location. This could lead to another accident and pose a serious danger for the involved vehicles/persons at the intervention site. An alert sufficiently in advance would prevent this type of situation by adapting the behaviour of the approaching drivers.
Objective	<p>Ensure that drivers are informed in a timely manner through C-ITS messages about the place of intervention ahead, so it is possible for them to adjust their driving speed and distance to lower the risk of other complications or incidents/accidents.</p> <p>Ensure more attentive driving while approaching and passing the area of an accident by providing in-vehicle information and warnings about the type of rescue and recovery work.</p>
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased driver attention.</li> <li>○ Adaptation of the driving speed.</li> <li>○ Adaptation of the driving trajectory (e.g., lane changes if needed) by leaving space to the emergency vehicle.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accidents with stationary emergency and rescue/recovery vehicles and thus increased safety for the involved crews.</li> <li>○ Avoid follow-up accidents and possible additional confusion for drivers.</li> <li>○ Increased driving comfort.</li> <li>○ Increasing safety of operation for all participants.</li> </ul>
<b>Use case description</b>	
Situation	A stationary emergency/prioritised vehicle or a rescue/recovery vehicle in intervention safeguards the location of the accident or another type of stationary hazard area where the emergency responders and/or rescuers are

working. This can also include a stop during a patrol tour to take a picture/fix equipment or intervening to protect drivers that might have stopped, either on the road or on the hard shoulder. When other drivers are approaching the place of intervention and are in the relevant zone, they are notified through an application installed in-vehicle or on a mobile device about the position and distance to the intervention. Drivers can adjust their driving speed and position on the road to pass by easily.

Differentiation with HLN-SV use case:

There is a difference to the regular stationary vehicle use case (HLN-SV). Basically, standing emergency or rescue/recovery vehicles could always send stationary vehicle warnings. However, this intervention use case means that an actual intervention is going on e.g., small backward and forward movements (towing truck), or reposition at the incident location might occur, and personnel might be on the road next to the vehicle in intervention. Vehicle extensions might be used that require more space (e.g., crane of a recovery service or ladder of a fire engine). Thus, “in intervention” could imply that there is work going on, which requires more space and more attention of other drivers than in the case of a “regular” stationary vehicle.

#### Triggering conditions:

This use case can be triggered manually or automatically as described below

Type of triggering	Triggering Condition
Automatic status detection	Light bar in use, vehicle stationary for 30s
	Light bar in use, engine relay (run lock) activated or ignition off
Human supervision and activation	Manual trigger

For this use case, a vehicle is considered stationary when the speed dropped below 1,5 m/s for a predefined duration of 30s, or if the engine is turned off, the run lock is activated, or the hand brake is activated (see also HLN-EPVA).

The use case shall be terminated, if the vehicle moves faster than 1.5 m/s and more than 40m from the position where the vehicle became stationary (i.e. where the timer has expired).

Logic of transmission	V <sub>erv</sub> 2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Drivers:</b> Receive information on their in-vehicle display about an emergency and/or rescue/recovery vehicle activity on the road, its distance and the exact position.</li> <li>○ <b>Emergency or rescue/recovery vehicle drivers:</b> Use the ERVI use case to warn other drivers about the place and position of the accident or another type of intervention on the road ahead when approaching this location. They also send information about the distance, direction and lane position of the emergency or rescue/recovery vehicle(s).</li> </ul>

	<ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Provides information about the emergency or rescue/recovery vehicle in intervention detected on its network mentioned in the use case specifications and distributes respective warnings as C-ITS messages to all vehicles approaching the respective road segments involved.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The equipped emergency/prioritised or rescue/recovery vehicle arrives at the incident.</li> <li>○ The unit starts to automatically transmit the message when the light bars of the vehicle are activated, and the vehicle is stationary at least for a predefined time or the warning is activated manually via an HMI device.</li> <li>○ Vehicles in the relevance zone receive the message and drivers adapt their driving behaviour.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ Vehicles approaching the intervention site receive the message, process it and present the information to the drivers.</li> <li>○ When the drivers arrive near the intervention site, they receive an alert with possible instructions.</li> <li>○ The warnings may include the type of dangers, distance to the emergency vehicle and lane position.</li> <li>○ The alert needs to be presented on the HMI early enough and should be moderately intrusive (at the manufacturer's discretion).</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ The location information needs to be accurate on road and lane level and related to the physical location of the actual rescue or recovery work.</li> <li>○ For road operators, the detection quality of the incident and the linked traffic conditions are of high importance to be able to warn precisely and generate a correct message for this use case.</li> <li>○ For service providers, transmission speed and targeting accuracy for the drivers is a major dependency to implement this use case successfully.</li> <li>○ The link of this use case with other C-ITS messages needs to be carefully taken into account when implementing the warning priorities for mobile units. E.g., on its way towards the location, the equipped emergency vehicle could use the HLN-EPVA use case.</li> <li>○ Another message could be sent by the TCC providing information on the actual event protected by the operating vehicle (e.g., HLN-AZ). Two</li> </ul>

	<p>messages could then be sent. It should be advised to see if it is possible to link the events dynamically.</p> <ul style="list-style-type: none"><li>○ In case of a big accident/incident with a lot of intervention vehicles, a problem could be that a lot of messages would be sent.</li></ul>								
Link to other use cases	This use case can be triggered by or in addition to multiple others. The switch from HLN-EPVA to ERVI is of special interest since the emergency/rescue/recovery vehicle is first approaching before they reach their destination for the intervention.								
Interoperability requirements									
Message profile requirements	<p><i>NOTE: This specification covers the <math>V_{erv}2V</math> – message only. An I2V implementation is not covered.</i></p> <p>The DENM message for ERVI is profiled in chapter 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</p> <ul style="list-style-type: none"><li>○ a point-based relevance zone shall be sent. It shall be represented as:<ul style="list-style-type: none"><li>○ The eventPosition shall always contain the current position of the emergency vehicle at the time the message is sent.</li><li>○ awarenessDistance: less than 5km (5)</li><li>○ trafficDirection: In case of separated carriageways: sameAsReferenceDirection-upstreamOfReferencePosition, in case of non-separated carriageways or unknown: allTrafficDirections.</li></ul><p><i>NOTE: the GN destination area shall be set accordingly to 1000m.</i></p><ul style="list-style-type: none"><li>○ eventZone shall not be provided.</li></ul></li><li>○ Transmission Logic: <math>V_{erv}2V</math> – message sent from the vehicle in intervention:<ul style="list-style-type: none"><li>○ stationType shall be set according to [ETSI TS 102 894-2] <i>NOTE: the stationType of V-ITS-S should reflect the type of the vehicle, not the role of the vehicle. The special role of an emergency vehicle is reflected in the vehicleRole, while the stationType could be motorcycle, lightTruck, trailer etc as defined in TS 102 894-2. “specialVehicles(10)” should be used for special purpose vehicles, which refers to special construction according to UNECE regulation.</i></li><li>○ An instance of detectionZonesToEventPosition shall be provided based on the path history of the vehicle as specified in [C-Roads MSP] and [C-Roads MP].</li><li>○ At least one of the following triggering conditions shall be met, and informationQuality shall be set as follows:</li></ul></li></ul> <table><tr><th>Type of triggering</th><th>Triggering Condition</th><th>informationQuality</th></tr><tr><td rowspan="2">Automatic status detection</td><td>Light bar in use, vehicle stationary for 30s</td><td>2</td></tr><tr><td>Light bar in use, engine relay (run lock) activated or ignition off</td><td>4</td></tr></table>	Type of triggering	Triggering Condition	informationQuality	Automatic status detection	Light bar in use, vehicle stationary for 30s	2	Light bar in use, engine relay (run lock) activated or ignition off	4
Type of triggering	Triggering Condition	informationQuality							
Automatic status detection	Light bar in use, vehicle stationary for 30s	2							
	Light bar in use, engine relay (run lock) activated or ignition off	4							

Human supervision and activation	Manual trigger	6
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- For this use case, a vehicle is considered stationary when the speed dropped below 1,5 m/s for a predefined duration of at least 30s, or if the engine is turned off, the run lock is activated, or the hand brake is activated (see also HLN-EPVA).
- eventPositionHeading and eventSpeed shall be provided.
- Message management shall be done as follows:

Message management	Setting
DENM update	every second
Repetition	not used
validityDuration	30 s
Termination	Cancellation

- The use case shall be terminated when the triggering conditions are no longer given, or when the triggering conditions of HLN-EPVA are met.

*NOTE: Recovery vehicles without priority such as towing trucks will not use HLN-EPVA. They could be considered for slow vehicle warnings when they depart from an incident location.*

#### Case 1: Emergency vehicle in intervention

- For this case, causeCode rescueAndRecoveryWorkInProgress15 and subCauseCode 1 (emergencyVehicles) shall be used.
- CAM vehicleRole: "emergency (6)"
- CAM SpecialVehicleContainer: EmergencyContainer
- IncidentIndication in the EmergencyContainer shall be set to the causeCode/subCauseCode of this case.

#### Case 2: Prioritised vehicle in intervention

*NOTE: Prioritised approaching vehicles (Case 2 in HLN-EPVA) change into this case when becoming stationary, while keeping the vehicleRole and container.*

- For this scenario, causeCode rescueAndRecoveryWorkInProgress15 and subCauseCode 0 shall be used.
- CAM vehicleRole: "safetyCar(7)"
- CAM SpecialVehicleContainer: SafetyCarContainer
- IncidentIndication in the SafetyCarContainer shall be set to the causeCode/subCauseCode of this case.

#### Case 3: Recovery vehicle in intervention

- For this use case, causeCode rescueAndRecoveryWorkInProgress15 and subCauseCode 0 shall be used.
- CAM vehicleRole: "rescue(5)"
- CAM SpecialVehicleContainer: RescueContainer

Security and data protection requirements	<ul style="list-style-type: none"><li>NOTE: there is no IncidentIndication in the RescueContainer</li></ul>								
	Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].								
	An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.								
	This use case is based on the causeCode rescueAndRecoveryWorkInProgress15 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT): <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>rescueAndRecoveryWorkInProgress15</td><td>2</td><td>1</td></tr></table>		SSP position		CauseCodeType / Container	Octet position	Bit position	rescueAndRecoveryWorkInProgress15	2
	SSP position								
CauseCodeType / Container	Octet position	Bit position							
rescueAndRecoveryWorkInProgress15	2	1							
Communication technology requirements: ITS-G5	The here listed SSPs shall be granted only for C-ITS stations used by organisations which by national and/or regional regulations have absolute right of way or some other sort of priority (e.g. road operators or emergency services).								
	NOTE: An alignment of the definition for emergency services with C2C-CC is outstanding.								
Communication technology requirements: ITS-G5	NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.								
	For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.								
Communication technology requirements: IP based	For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.								
	For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.								
Communication technology requirements: IP based	For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply: <ul style="list-style-type: none"><li>serviceType = HLN-ERVI</li><li>messageType = DENM</li></ul>								
	Geographic area (Quadtree) for DENM message, see appendix A of [C-ITS IP Based Interface Profile]: The event is characterised by its referencePosition, detectionZone(s),								

<p>Test and validation requirements</p>	<p>relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p> <p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_StationType_66_R2.0.8</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_stationType_66_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.8</li> </ul> </li> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-ERVI_ITSG5_DENM_eventZone_63_1_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_ITSG5-DENM_CC-sCC_63_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_ITSG5_DENM_eventPositionHeading_63_6_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_ITSG5-DENM_eventSpeed_63_4_R2.0.8</li> </ul> </li> </ul>
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	<ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-ERVI_ITSG5-DENM_Geonet_destinationArea_63_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_ITSG5-DENM_UPDATE_63_R2.0.8</li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-ERVI_HYBRID_DENM_awarenessArea_63_1_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_Hybrid-DENM_CC-sCC_63_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_Hybrid_DENM_eventPositionHeading_63_6_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_Hybrid_DENM_eventPositionHeading_63_6_R2.0.8</li> <li>○ TC_CROADS_HLN-ERVI_Hybrid_DENM_Geonet_destinationArea_63_2_R2.0.8</li> </ul> </li> </ul>
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### 3.2.9 HLN – Emergency or Prioritised Vehicle Approaching (HLN-EPVA)

Type of road network	All
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	<p>The intention of this use case is to warn drivers about an approaching emergency or prioritised vehicle in order to facilitate free passage of such emergency or prioritised vehicle, when they are on a mission.</p> <p>There is a wide range of vehicles with a special role that participate in traffic and that need other drivers to give way or to facilitate their passage, when they are on a mission. In this use case, two categories of right-of-way are considered:</p> <ul style="list-style-type: none"> <li>○ Certain vehicles have the absolute right of way in many countries (e.g. ambulance, police, fire brigade), if they activate their emergency signals – usually a light bar, often used together with a siren.</li> <li>○ In some countries, certain vehicles (e.g., road operator vehicles) can have a kind of priority that does not give them the absolute right of way, but other drivers must facilitate their passage or give way to the extent necessary that they can fulfil their mission.</li> </ul> <p>The expected behaviour of drivers being in the vicinity of a vehicle with a special role might differ per special vehicle category but also per country. Therefore, in this use case there is a distinction by whether these vehicles have the right of way (absolute or in a “weaker” form) as described above.</p> <p><i>NOTE: Vehicles without any right of way or priority in their national traffic rules are not subject of this use case. They might fall into other use cases, e.g., RWW-RM, RWW-WM.</i></p>
Background	<p>Emergency vehicles and other prioritised special vehicles signal the urgency or importance of their journey to other drivers so that the drivers can potentially form an emergency corridor. However, when this information is noticed too late, these vehicles on their mission might be blocked by other vehicles. Additionally, a high driving speed difference between these vehicles and other drivers, without the latter being aware of the upcoming presence of these vehicles, increases the risk of accidents.</p>
Objective	<p>The objective is to warn drivers in time about an approaching emergency or prioritised vehicle, to ensure a free passage for the specific vehicle, and to reduce dangerous situations in connection with these vehicles.</p> <p>Also, increasing the safety of the emergency vehicle personnel and drivers. In addition, reducing the travel time for the emergency and prioritised vehicles by avoiding blockages and/or when necessary, by fostering the formation of an</p>

Desired behaviour	<p>emergency corridor in advance.</p> <p>In this use case two specific types of behaviour are distinguished.</p> <ul style="list-style-type: none"> <li>○ Give way to an emergency vehicle (e.g., pull over to the side of the road or clear an intersection).</li> <li>○ Facilitate the passage of the special vehicle or facilitate its mission (e.g., ensure the passage of a road operator vehicle) if it has some kind of priority.</li> </ul> <p>In all cases, it is desired that the drivers drive more attentively and where necessary adapt their driving behaviour accordingly.</p>
Expected benefits	<ul style="list-style-type: none"> <li>○ More attentive driving while an emergency or prioritised vehicle is approaching.</li> <li>○ Minimise risks of collisions and accidents.</li> <li>○ Faster formation of the emergency corridor and therefore reduced travel time for the emergency vehicles.</li> <li>○ Avoidance of congestion.</li> <li>○ Faster arrival to the incident/accident site to improve road safety of such zones.</li> <li>○ Reduction of risks taken by road operating agents to reach those accident sites.</li> <li>○ Improvement of traffic management</li> </ul>
<b>Use case description</b>	
Situation	<ul style="list-style-type: none"> <li>○ The emergency or prioritised vehicle assumes a task/mission, which is indicated by an active light bar, a siren, or a combination of both based on the national regulations for priority.</li> <li>○ The sending of appropriate messages to the drivers nearby can be started automatically (automatically activated when the light bar/siren is activated) or manually, based on the desire of the implementer.</li> <li>○ However, the activation of the light bar, siren or both is a precondition to trigger (manually or automatically) this use case.</li> <li>○ As soon as the siren and/or light bar is off, the sending of HLN-EPVA messages shall stop.</li> <li>○ If the vehicle is stationary, then the sending of HLN-EPVA messages shall stop. Instead, the use case for stationary special vehicles applies, see HLN-ERVI, as long as the light bar is still active.</li> <li>○ The drivers receive the information about the approaching vehicle.</li> <li>○ The drivers adapt their driving behaviour accordingly by either ensuring a free passage of the approaching vehicle and/or driving more attentive knowing an emergency or prioritised vehicle in mission is in the vicinity.</li> </ul> <p><b>Triggering conditions:</b></p> <ul style="list-style-type: none"> <li>○ This use case can be triggered manually or automatically as described below</li> <li>○ For this use case, a vehicle is considered stationary when the speed dropped below 1,5 m/s for a predefined duration in the range of [15 –</li> </ul>

	<p>60]s, or if the engine is turned off, the run lock is activated, or the hand brake is activated.</p> <ul style="list-style-type: none"> <li>○</li> </ul> <table border="1"> <thead> <tr> <th>Type of triggering</th><th>Triggering Condition</th></tr> </thead> <tbody> <tr> <td rowspan="2">Automatic status detection</td><td>Light bar in use, vehicle motion status unknown*</td></tr> <tr> <td>Light bar in use, vehicle not stationary</td></tr> <tr> <td>Human supervision and activation</td><td>Manual trigger</td></tr> <tr> <td colspan="2">(*) This holds only if triggering conditions of HLN-ERVI are not satisfied.</td></tr> </tbody> </table>	Type of triggering	Triggering Condition	Automatic status detection	Light bar in use, vehicle motion status unknown*	Light bar in use, vehicle not stationary	Human supervision and activation	Manual trigger	(*) This holds only if triggering conditions of HLN-ERVI are not satisfied.	
Type of triggering	Triggering Condition									
Automatic status detection	Light bar in use, vehicle motion status unknown*									
	Light bar in use, vehicle not stationary									
Human supervision and activation	Manual trigger									
(*) This holds only if triggering conditions of HLN-ERVI are not satisfied.										
Logic of transmission	I2V, V <sub>EPV2V</sub>									
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Emergency or prioritised vehicle:</b> Sends appropriate HLN-EPVA messages to the vehicles in the vicinity of the emergency/prioritised vehicle or HLN-EPVA information to the Emergency Control Centre.</li> <li>○ <b>Emergency Control Centre:</b> Collects the necessary information (e.g., mission status, status of light bar/usage of siren) of the approaching emergency or prioritised vehicle and sends this information to the TCC.</li> <li>○ <b>Traffic Control Centre:</b> Creates the HLN-EPVA message based on the information received from the ECC and sends out the HLN-EPVA message</li> <li>○ <b>Drivers:</b> Receive the HLN-EPVA message sent by the emergency or prioritised vehicle or by the TCC. The drivers are informed about the situation and can act accordingly.</li> </ul>									
Use case scenario	<p>The below mentioned cases could have 2 types of implementations, either V<sub>EPV2V</sub> or I2V.</p> <p><u>Case 1:</u> Emergency Vehicle with absolute right of way The vehicle is an emergency vehicle and assumes a task/mission giving them the absolute right of way according to applicable traffic rules. The vehicle is not stationary, and the light bar and possibly siren is active.</p> <p><i>NOTE: In most cases the light bar of an emergency vehicle is blue (fire brigade, ambulance, police), sometimes combined with other colours. Thus, the scenario does not depend on light colour, but on an active light bar that signals that the vehicle is on a mission and has right of way according to the applicable regulations of that country.</i></p> <p><u>Case 1a:</u> V<sub>EPV2V</sub></p> <ul style="list-style-type: none"> <li>○ The emergency vehicle sends appropriate HLN-EPVA messages which can directly be used for communication to the vehicles in the vicinity of the emergency vehicle. The drivers receive this HLN-EPVA message and can act according to the given circumstances.</li> </ul>									

	<p><u>Case 1b: I2V</u></p> <ul style="list-style-type: none"> <li>○ The emergency vehicle sends frequently the necessary information about its status to the ECC. With respect to information on the position, position updates shall be retrieved at least every second. The ECC relays this information to the TCC. The TCC creates the appropriate HLN-EPVA messages and sends them to the vehicles in the vicinity of the emergency vehicle.</li> </ul> <p>For both cases, the exact interoperability requirements can be found in the interoperability requirements section of this use case.</p> <p><u>Case 2: Prioritised vehicle with some kind of priority</u></p> <p>In this scenario the vehicle assumes a task/mission where other drivers must facilitate its passage according to applicable traffic rules. The vehicle is not stationary, and the light bar and possibly siren is active.</p> <p><u>Case 2a: V<sub>EPV</sub>2V</u></p> <ul style="list-style-type: none"> <li>○ The prioritised vehicle sends appropriate HLN-EPVA messages which can directly be used for communication to the vehicles in the vicinity of the prioritised vehicle. The drivers receive this HLN-EPVA message and can act according to the given circumstances.</li> </ul> <p><u>Case 2b: I2V</u></p> <ul style="list-style-type: none"> <li>○ The prioritised vehicle sends frequently the necessary information about its status to ECC. The ECC relays this information to the TCC. The TCC creates the appropriate HLN-EPVA messages and sends them to the vehicles in the vicinity of the prioritised vehicle.</li> </ul> <p>For both cases, the exact interoperability requirements can be found in the interoperability requirements.</p> <p><i>NOTE: Traffic rules regarding right of way for emergency and prioritised vehicles differ internationally and are not always sharply distinguished. For Day-1 applications it is the corresponding implementing authority's responsibility to evaluate under which conditions to apply the scenarios according to the national traffic rules. Activation of a use case scenario with a resulting warning to the driver to give way, when the driver must not give way shall be avoided as it could cause dangerous traffic situations.</i></p>
Intended Presentation/Alert principle	<p>The drivers are provided with related information, to be presented on the dashboard. Layout and sequence of presentation is left to specific implementation.</p> <p>The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>

Functional constraints/dependencies	<p>This use case has been described and harmonised with just limited input from the stakeholder group of e.g., emergency responders. Their representation in C-Roads is only very limited. A broader consultation on an EU level with these stakeholders could lead to improvements to this use case.</p> <p>How the information is presented to the drivers 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.</p> <p>There are specific interoperability requirements with respect to the I2V implementation of this use case.</p> <p>In I2V implementations, the location, speed and light bar status of the emergency or prioritised vehicle shall be monitored and reported to the TCC while the vehicle is driving. The TCC then triggers the event and sends the HLN-EPVA message.</p> <p>The trigger for this use case is a confirmed mission status and the vehicle must be moving.</p> <p>I2V implementations are only recommended, if no V2V implementation exists and the vehicle is connected to a backend system via a non-ITS interface to avoid misalignment of information.</p>
Link to other use cases	<p>This use case is functionally linked to HLN-ERVI. When the vehicle arrives at the event location, this use case shall be terminated and HLN-ERVI activated.</p>
<b>Interoperability requirements</b>	
Message profile requirements	<p>The DENM message for HLN-EPVA is profiled in chapters 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</p> <p><u>All cases:</u></p> <ul style="list-style-type: none"> <li>○ An instance of detectionZonesToEventPosition shall be provided based on the path history of the vehicle as specified in [C-Roads MSP] and [C-Roads MP].</li> <li>○ trafficDirection shall be set to allTrafficDirections.</li> <li>○ awarenessDistance should be used. If so, the awarenessDistance shall be set to lessThan1000.</li> </ul> <p><i>NOTE: the GN destination area shall be set accordingly to 1000m</i></p> <ul style="list-style-type: none"> <li>○ eventPositionHeading and eventSpeed shall be provided.</li> <li>○ For this use case, a vehicle is considered stationary when the speed dropped below 1,5 m/s for a predefined duration in the range of [15 – 60]s, or if the engine is turned off, the run lock is activated, or the hand brake is activated.</li> </ul>

Case 1a (V<sub>EPV2V</sub>): Emergency Vehicle with absolute right of way

- The causeCode shall be set to emergencyVehicleApproaching95 and the subCauseCode to emergencyVehicleApproaching (1).
- The vehicle shall send CAMs with associated vehicleRole and SpecialVehicleContainer (containing lightBarSirenInUse) as specified below
  - CAM vehicleRole shall be set to emergency(6) .
  - CAM SpecialVehicleContainer shall be set to EmergencyContainer.
  - IncidentIndication in the SafetyContainer shall be set to the causeCode/subCauseCode of this case.

Case 1b (I2V): Emergency Vehicle with absolute right of way

- The causeCode is emergencyVehicleApproaching95 and the subCauseCode is “emergencyVehicleApproaching (1)”

Case 2a (V<sub>EPV2V</sub>): Prioritised vehicle with some kind of priority

- The causeCode shall be set to emergencyVehicleApproaching95 and the subCauseCode to prioritisedVehicleApproaching (2).
- The vehicle shall send CAMs with associated vehicleRole and SpecialVehicleContainer (containing lightBarSirenInUse) as specified below
  - CAM vehicleRole shall be set to safetyCar(7).
  - CAM SpecialVehicleContainer shall be set to SafetyCarContainer.
  - IncidentIndication in the EmergencyContainer shall be set to the causeCode/subCauseCode of this case.

Case 2b (I2V): Prioritised vehicle with some kind of priority

- The causeCode shall be set to emergencyVehicleApproaching95 and the subCauseCode to prioritisedVehicleApproaching (2).

Case 1a and 2a (V<sub>EPV2V</sub>)

- a point-based relevance zone shall be sent. It shall be represented as:
  - The eventPosition shall always contain the current position of the emergency vehicle at the time the message is sent.
  - awarenessDistance as defined above.
  - trafficDirection as defined above.
  - eventZone shall not be provided.
- The stationType: shall be set according to [ETSI TS 102 894-2]  
*NOTE: the stationType of V-ITS-S should reflect the type of the vehicle, not the role of the vehicle. The special role of an emergency vehicle is reflected in the vehicleRole, while the stationType could be motorcycle, lightTruck, trailer, etc. as defined in TS 102 894-2. specialVehicles(10)*

should be used for special purpose vehicles, which refers to special construction according to UNECE regulation.

- At least one of the following triggering conditions shall be met, and informationQuality shall be set as follows:

Type of triggering	Triggering Condition	InformationQuality
Automatic status detection	Light bar in use, vehicle motion status unknown*	2
	Light bar in use, vehicle not stationary	4
Human supervision and activation	Manual trigger	6
(*) This holds only if triggering conditions of HLN-ERVI are not satisfied.		

- Message management shall be done providing short validity durations as follows:

Message management	Setting
DENM update	every 250 ms
Repetition duration	no repetition
Repetition interval	no repetition
validityDuration	2 s
Termination	Not used

- The use case shall be terminated when the triggering conditions are no longer given, or when the triggering conditions of HLN-ERVI are met.

#### Case 1b and 2b (I2V)

- a single linear relevance zone shall be sent. It shall be represented as:
  - The eventPosition shall be set to the most up to date position of the emergency vehicle at the time the message is sent.
  - awarenessDistance as above.
  - trafficDirection as above.
  - eventZone shall be provided for an estimation of the path, which the vehicle has covered since the last position update received from the vehicle until the current time, when the C-ITS message is generated.

*NOTE: Position updates shall be retrieved at least every second in order to match the DENM update requirements.*

The eventZone shall be matched to a road topology.

- stationType: roadsideUnit(15) (also in case of a central C-ITS station)
- At least one of the following triggering conditions shall be met, and informationQuality shall be set as follows:

Type of triggering	Triggering Condition	InformationQuality
status detection by TCC	"mission status confirmed" by the driver, vehicle not stationary	2



Security and data protection requirements	automatic status detection by tracking or fleet management device	Light bar in use (automatically detectable), vehicle not stationary	2 or 4, see Note 1 below.						
	Human supervisor and activation	Manual trigger	2 or 4, see Note 1 and Note 2 below.						
	<p>NOTE 1:</p> <ul style="list-style-type: none"><li>InformationQuality 2, if the timestamped information is obtained by a trustworthy third-party organisation that provides reliable and high-quality information e.g., location information from fleet management with emergency status validated by an operator in the PSAP (emergency service dispatch centre).</li><li>InformationQuality 4 applies if the event information and the generation of C-ITS messages is in the responsibility of the same organisation under the quality constraints of the informationQuality definition in the Message Profiles.</li></ul> <p>NOTE 2:</p> <ul style="list-style-type: none"><li>Since it is unlikely that the vehicle and its position are continuously monitored via CCTV and validated by a human operator, informationQuality 6 shall not be used.</li></ul>								
	<ul style="list-style-type: none"><li>Message management shall be done providing short validity durations as follows:</li></ul> <table><tr><th>Message management</th><th>Setting</th></tr><tr><td>validityDuration</td><td>2 s</td></tr><tr><td>Termination</td><td>Not used</td></tr></table> <ul style="list-style-type: none"><li>The use case shall be terminated when the emergency vehicle has arrived at its destination.</li><li>detectionTime shall refer to the time when the position of the vehicle has been recorded within the vehicle.</li><li>NOTE: detectionTime is not the time when the event is reported in the backend or processed in the R-ITS-S, but the time when acquiring the vehicle location within the vehicle (e.g. GPS timestamp). It is different from the referenceTime.</li></ul>				Message management	Setting	validityDuration	2 s	Termination
Message management	Setting								
validityDuration	2 s								
Termination	Not used								
Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].									
An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.									
This use case is based on the causeCode emergencyVehicleApproaching95 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):									

	<table><tr><td>emergencyVehicleApproaching95</td><td>3</td><td>3</td></tr><tr><td>emergencyContainer</td><td>1</td><td>6</td></tr><tr><td>safetyCarContainer</td><td>1</td><td>7</td></tr></table>	emergencyVehicleApproaching95	3	3	emergencyContainer	1	6	safetyCarContainer	1	7
emergencyVehicleApproaching95	3	3								
emergencyContainer	1	6								
safetyCarContainer	1	7								
	<p>The here listed SSPs shall be granted only for C-ITS stations used by organisations which by national and/or regional regulations have absolute right of way or some other sort of priority (e.g. road operators or emergency services).</p> <p><i>NOTE: An alignment of the definition for emergency services with C2C-CC is outstanding.</i></p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>									
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>									
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN-EPVA</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>									
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"><li>○ ITS-G5 only:</li></ul>									

- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_CANCEL\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8

○ IP based only:

- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of applicable specific test cases:

○ ITS-G5 only:

- TC\_CROADS\_HLN-EPVA\_ITSG5\_DENM\_awarenessArea\_60\_1\_R2.0.8
- TC\_CROADS\_HLN-EPVA\_ITSG5\_DENM\_awarenessDistance\_60\_7\_R2.0.8
- TC\_CROADS\_HLN-EPVA\_ITSG5\_DENM\_detectionTime\_60\_10\_R2.0.8
- TC\_CROADS\_HLN-EPVA\_ITSG5\_DENM\_CC-sCC\_60\_R2.0.8
- TC\_CROADS\_HLN-EPVA\_ITSG5\_DENM\_eventPositionHeading\_60\_6\_R2.0.8
- TC\_CROADS\_HLN-EPVA\_ITSG5\_DENM\_eventSpeed\_60\_4\_R2.0.8
- TC\_CROADS\_HLN-EPVA\_ITSG5-DENM\_UPDATE\_63\_R2.0.8
- TC\_CROADS\_HLN-EPVA\_ITSG5-DENM\_validityDuration\_63\_R2.0.8

- TC\_CROADS\_HLN-EPVA\_ITSG5-DENM\_Geonet\_destinationArea\_63\_R2.0.8
- Hybrid (IP based only):
  - TC\_CROADS\_HLN-EPVA\_HYBRID\_DENM\_awarenessArea\_60\_1\_R2.0.8
  - TC\_CROADS\_HLN-EPVA\_HYBRID\_DENM\_CC-sCC\_60\_R2.0.8
  - TC\_CROADS\_HLN-EPVA\_HYBRID\_DENM\_detectionTime\_60\_10\_R2.0.8
  - TC\_CROADS\_HLN-EPVA\_HYBRID\_DENM\_eventSpeed\_60\_4\_R2.0.8
  - TC\_CROADS\_HLN-EPVA\_HYBRID-DENM\_Geonet\_destinationArea\_63\_R2.0.8
  - TC\_CROADS\_HLN-EPVA\_HYBRID-DENM\_validityDuration\_63\_R2.0.8

### 3.2.10 HLN – Railway Level Crossing (HLN-RLX)

Type of road network	Dual carriageways, Rural roads, Urban roads
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	The railway infrastructure manager or a service provider informs the drivers about the presence of a railway level crossing and its type/parameters/status. This use case covers both protected level crossings along with unprotected ones. The messaging to the drivers and the information provided is addressed, too.
Background	<p>Very serious accidents, sometimes with a high number of fatalities, occur at railway level crossings. These accidents are often caused by drivers overlooking the warning lights of the signalling system and failing to stop in front of the crossing. Even at level crossings with barriers, serious accidents occur due to reluctance of drivers to stop before the barriers are down and, in addition, tendencies of drivers to bypass half barriers during active warning (waiting) phase at a crossing (so called S-manoevre). Accidents are also frequent on railway crossings without any signalling protection systems.</p> <p>It needs to be noted that railway level crossings principally differ from road Intersections in that the train has always priority and cannot be stopped suddenly and that light warning principles of signalling systems on crossings differ from those on road intersections. Also, different legal bodies are responsible for road and railway in Europe (with a few exceptions).</p> <p>With respect to the type of railway crossings, two distinctions are made:</p> <ul style="list-style-type: none"> <li>○ ‘active level crossing’ means a level crossing where the crossing users are protected from or warned of the approaching train by devices activated when it is unsafe for the user to traverse the crossing.</li> <li>○ ‘passive level crossing’ means a level crossing without any form of warning system or protection activated when it is unsafe for the user to traverse the crossing.</li> </ul>
Objective	<p>The drivers get warned about the presence of a railway level crossing to raise their attention when approaching it. A special warning is also shown to the drivers in case of an active level crossing.</p> <p>Other use cases and scenarios of light railway crossings involving traffic lights in urban environments with equipment at the crossing can be part of the intersection safety use cases.</p>
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased driver attention.</li> </ul>

	<ul style="list-style-type: none"> <li>○ Adaptation of the driving speed in the vicinity of railway crossing and when passing the crossing according to national speed limits.</li> <li>○ Stopping the vehicle in front of the crossing if the crossing is in a warning state.</li> <li>○ Waiting for the train to pass the level crossing.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accident between road and railway vehicles.</li> <li>○ Reducing the risk of road vehicle accidents in the vicinity of railway level crossings.</li> <li>○ Increased driving comfort.</li> </ul>
<b>Use case description</b>	
Situation	A vehicle is approaching a railway level crossing which is 'active' (e.g. be equipped with a signalling system with warning lights and/or barriers, without barriers, or 'passive' (e.g. with a warning cross only). In due time and location, drivers are informed about the presence of the railway crossing, and, if the warning is active, about the current status of the crossing. The message is sent to both sides of the level crossing, covering all roads leading to the level crossing and denoting the boundaries or stopping points of the crossing.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Railway infrastructure manager:</b> Is responsible that the signalling system generates warnings locally at the railway crossing and distributes respective warnings directly (with low latency) as C-ITS messages to all drivers approaching the crossing or via alternate communication channels. In addition, the railway infrastructure manager provides this information to the TCC in order to be published by the road operator to other users like navigation information providers, etc.</li> <li>○ <b>Service provider:</b> Receives the warning messages from the railway infrastructure manager and provides them to the end-users. He can also maintain (static) database of railway crossings and generate messages based on that (without the information about the state of the crossing).</li> <li>○ <b>Drivers:</b> End-users receive the warnings in the vicinity of the railway crossing and adapt their behaviour if necessary.</li> </ul>
Use case scenario	<p><u>Scenario 1: Presence of a railway crossing (Basic warning), active and passive</u></p> <ul style="list-style-type: none"> <li>○ Information about the location of the level crossing including the national ID, the type of the level crossing, the number of rail tracks, its length, width, height and other optional information like recommended/maximum passing speed for road vehicles, is available in the railway system.</li> <li>○ The information is periodically sent out by the C-ITS system at the crossing directly on various communication channels to the drivers using one message ID.</li> </ul>

- Inclusion of optional information is dependent on the rules of the respective railway infrastructure manager.
- The information is received in the vehicle and presented to the driver.
- The driver should drive cautiously and adhere to possible regulations with respect to crossing the railway crossing.

#### Scenario 2: Train approaching (active level crossing)

- If the approaching train is detected (by the signalling system), the C-ITS system will automatically and continuously distribute C-ITS messages with a special warning about the warning state active at the crossing, including optional information like estimated time to the end of the warning state, direction of the approaching train(s), etc. directly or on alternate communication channels with one message ID to the drivers.
- Inclusion of optional information is dependent on the rules of the respective railway infrastructure manager.
- The information is received in the vehicle and presented to the driver.
- The driver shall safely come to a stop before the railway crossing or before any preceding stopped vehicles.

#### Scenario 3: Railway crossing out of order (active level crossing)

- If the railway crossing signalling system is malfunctioning or out of order and such an event is detected by the signalling system itself or remotely by the railway infrastructure manager's means, or if fully closed for traffic, respective warning information is continuously sent out by the C-ITS system on various communication channels with one message ID to the drivers. In case of malfunctioning, which can be demonstrated to the driver in several different ways, it is recommended to send only "long-term warning state" information as the drivers may not precisely comprehend the meaning and react in a wrong way.
- The information is received in the vehicle and presented to the driver.
- The driver shall adjust its behaviour according to national regulations with respect to this specific situation (e.g. shall not cross, recommended not to cross, cross with caution a.o.). A specific behaviour cannot be specified due to different regulations in the EU countries with respect to this situation.

#### Scenario 4: Status of active level crossing unknown

- There might be no information available on the status of the active railway crossing systems (e.g. red lights, barriers, train detection) due to e.g. power outage or communication failure.
- The information that no specific information is available on the active railway crossing is received in the vehicle and presented to the driver.

<p>Intended Presentation/Alert principle</p> <p>Functional constraints/dependencies</p> <p>Link to other use cases</p>	<ul style="list-style-type: none"> <li>○ The driver shall drive very cautiously and shall determine the driving behaviour only on the physical status of the red lights and barriers.</li> </ul> <p><u>Scenario 5: Detection of approaching trains based on positioning systems from the train</u></p> <ul style="list-style-type: none"> <li>○ The backend of the service provider is equipped with a system to detect trains approaching the level crossing based on GNSS information and/or other positioning systems from the trains.</li> <li>○ The service provider distributes C-ITS messages with a special warning when a train approaching the level crossing is detected. The message may include optional information like estimated time to the end of the warning state, direction of the approaching train(s), etc.</li> <li>○ The vehicle receives the information and presents it to the driver.</li> <li>○ In case of an approaching train, the driver shall safely come to a stop before the railway crossing.</li> <li>○ The warning needs to be presented early enough to the driver and with adequate priority for the driver to adapt his driving behaviour. However, since the driver should not forget about the alert, it could be repeated closer to the location.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> <li>○ The user is provided with related information. Layout and sequence of presentation is left to OEM-specific implementation.</li> </ul> <p>Due to strict safety requirements on railway traffic and the risk that the C-ITS system, which is not fail-safe, might send information valid for another time instance, no 'positive' information should be sent to the driver and also should not be implemented in the OBU, i.e., informing that the railway crossing is open (no train approaching). Only neutral (railway crossing is ahead) and 'negative' (signalling system is broken down or railway crossing closed/train is approaching) information should be given.</p> <p>How the information is presented to the drivers 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.</p> <p>None</p>
<b>Interoperability requirements</b>	
<p>Message profile requirements</p>	<p>The most suitable type of C-ITS message for this use case is DENM for the status (opened, closed, breakdown, unguarded, ...) and IVIM for the restriction and other information (length, width, height, weight, irregular ground, etc.).</p> <p>In addition, a SPATEM/MAPEM can be added relatively to a traffic light, if relevant e.g., in urban area or at freight railway sidings. For the RLX status,</p>



currently only the scenario of a risk of collision can be handled by the DENM standard.

- The DENM message for HLN-RLX is profiled in the chapter 4.2.1.1 and 4.2.1.3 of [C-Roads MP].
- causeCode: railwayLevelCrossing100  
*NOTE: Before the cause code railwayLevelCrossing100 was standardised specifically for railway level crossing, the more general causeCode collisionRisk97 and subCauseCode 2 (crossing collision risk) has been used. Collision risk is still used for public transport crossing HLN-PTVC.*
- subCauseCode:
  - Scenario 1: Presence of a railway crossing (Basic warning), active and passive level crossing
    - If train *approaching* detection system is installed, sCC shall be set to 4 (nominal);
    - else sCC shall be set to 3 (unguarded)
  - Scenario 2: Train Approaching (active level crossing)
    - sCC shall be set to 2 (closed)
  - Scenario 3: Railway crossing out of order (active level crossing)
    - sCC shall be set to 1 (doNotCrossAbnormalSituation)
  - Scenario 4: status of active crossing unknown (active level crossing)
    - sCC shall be set to 0 (unknown)
  - Scenario 5: Detection of approaching trains based on positioning systems from the train (passive level crossing)
    - sCC shall be set to 5 (trainApproaching)
  - *NOTE 1: As defined, the sCC 0,1,2 and 4 all imply an active crossing, only sCC 3&5 would apply to a passive crossing*
  - *NOTE 2: Scenario 5 only applies to passive crossings as stated by the applicability of the sCC ('in case a train is approaching, and the railway is without barriers')*
- a single linear relevance zone shall be sent. It shall be represented as:
  - eventPosition shall be at the light/barrier of the level crossing for the direction concerned.
  - awarenessDistance shall not be provided.
  - trafficDirection shall be provided as specified in [C-Roads MP].
  - eventZone shall be provided.
  - eventZone shall end at the light/barrier of the opposite direction. So, at least two DENMs are needed to describe the event (one per direction).
- informationQuality shall be set to 4 or 6 for this use case, depending on the confidence the railway operator can have in his system (e.g., SIL4 systems could lead to a 6, while non-SIL4 systems could justify a 4).
- For each affected driving direction, a separate DENM shall be send.
- stationType: 15 (also in case of a central C-ITS station)

	<ul style="list-style-type: none"><li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li><li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.<ul style="list-style-type: none"><li>○ It shall be used on the following situations: Train is approaching, or the signalling system is broken down.</li></ul></li></ul>									
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>railwayLevelCrossing100</td><td>4</td><td>3</td></tr></table> <p>The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf and railway operators.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	railwayLevelCrossing100	4	3
	SSP position									
CauseCodeType / Container	Octet position	Bit position								
railwayLevelCrossing100	4	3								
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>									
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN-RLX</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM message:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that</p>									

	the exact details of specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_StationType_66_R2.0.8</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_stationType_66_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.8</li> </ul> </li> </ul> <p>List of applicable Specific Test Cases:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-RLX_ITSG5_DENM_CC-sCC_40_R2.3.0</li> <li>○ TC_CROADS_HLN-RLX_ITSG5_DENM_awarenessArea_40_3_R2.3.0</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_HLN-RLX_HYBRID_DENM_CC-sCC_40_R2.3.0</li> <li>○ TC_CROADS_HLN-RLX_HYBRID_DENM_awarenessArea_40_3_R2.3.0</li> </ul> </li> </ul>



### 3.2.11 HLN – Unsecured Blockage of a Road (HLN-UBR)

Type of road network	Motorways, Dual carriageways, Rural roads
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	An operator in the TCC gets the information that there is an unsecured blockage of a road. Till the time that operating agents arrive to the site to protect and manage it, the operator sends a warning message to the drivers. A blockage means that there is no traffic going through the road segment. The complete road is blocked (not an obstacle on one or more lanes).
Background	Today, this information is provided only by the VMS or the radio. With C-ITS, the availability of information is better. In mountainous regions for example, where there are a lot of kilometres to be driven before road operators reach a site, providing such warning information to drivers before the road operator arrives to the site can be essential.
Objective	<p>The objective of this use-case is two-fold:</p> <ul style="list-style-type: none"> <li>○ For vehicles that are very close to the blockage: to alert them about a danger ahead.</li> <li>○ For vehicles much more upstream, to allow them to reroute early enough.</li> </ul> <p>This use case concerns one whole road, or one direction of a dual carriage way.</p>
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased vigilance of the approaching drivers.</li> <li>○ Adaptation of the speed.</li> <li>○ Rerouting if blocked road is far away and rerouting possible for the targeted destination.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accidents.</li> <li>○ Improved traffic management.</li> <li>○ Reduce the number of drivers impacted by the road blockage.</li> </ul>
<b>Use case description</b>	
Situation	<p>A vehicle close to the blockage is warned of the dangerous situation ahead. Or a more upstream vehicle is informed to adapt the driving route.</p> <p>Causes of blockage:</p> <ul style="list-style-type: none"> <li>○ Rocks falling,</li> <li>○ Accidents of HGV,</li> <li>○ Water flood,</li> <li>○ etc.</li> </ul> <p>This use case does not include a single broken-down vehicle, or a vehicle blocking a single lane of a dual carriage way road.</p> <p>Sources of information can be:</p>

Logic of transmission	<ul style="list-style-type: none"> <li>○ Other vehicles which have detected the danger,</li> <li>○ Cameras,</li> <li>○ Phone call of a witness,</li> <li>○ etc.</li> </ul>
Actors and relations	I2V
Use case scenario	<ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Sender is an operator in the TCC.</li> <li>○ <b>Drivers:</b> End-receivers are the drivers in the vehicles.</li> <li>○ The operators in the TCC get informed about a section of road that is blocked.</li> <li>○ The operator puts the information in the TCC, and the message is then sent to the drivers.</li> <li>○ The vehicles receive the information and presents it to the driver.</li> <li>○ The drivers adapt their behaviour, depending on the distance and driving situation compared to the location of the blockage.</li> <li>○ When the operating agents arrive on site, the blockage becomes managed, and additional use cases activated.</li> <li>○ This C-ITS message will be terminated and enhanced with more accurate information and use cases.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The warning to the drivers must be sent in time and the presentation to the drivers must be early enough for them to adapt their speed or even their itinerary. However, since the drivers should not forget about the alert, it could be repeated closer to the location.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility. The message of this use case should be enhanced when road operator vehicles get on the blocked road segment and terminated the warning message.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ The information quality of this use case depends highly on the information source and the detection quality of the information, but as a first warning it is for sure useful to enhance aware driving.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	<p>HLN-EPVA: when an unsecured blockage is detected, usually an emergency or rescue/recovery vehicle is dispatched to secure the location. For the approach, the HLN-EPVA shall be triggered.</p> <p>HLN-ERVI: Once the vehicle reaches the location, the HLN-ERVI use case shall be triggered.</p>
<b>Interoperability requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The DENM message for HLN-UBR is profiled in chapter 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> </ul>

<p>Security and data protection requirements</p>	<ul style="list-style-type: none"> <li>○ For this use case, for now, causeCode impassability5 and subCauseCode 0 (unavailable) shall be used. <i>NOTE: Current vehicle implementations do not support causeCode impassability5. If the impassability has a clear reason, consider using other causeCodes already supported in vehicles describing this reason instead, e.g. human presence on the road (humanPresenceOnTheRoad12/x), stationary / broken down vehicle (stationaryVehicle94/2), rescue and recovery work in progress (rescueAndRecoveryWorkInProgress15/0) and add linkedCause impassability5/0.</i></li> <li>○ In case of a point location, a point-based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location of the blockage.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall not be used.</li> </ul> </li> <li>○ In multiple blockages on the road, a single linear relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location of the most upstream blockage</li> <li>○ awarenessDistance shall not be provided</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall be provided as specified in [C-Roads MP]</li> </ul> </li> <li>○ stationType: 15 (also in case of a central C-ITS station)</li> <li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li> <li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li> <li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li> <li>○ <i>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</i></li> </ul> <p><i>NOTE: A C-Roads follow up action with ETSI is planned to provide a more adequate solution on the CC and sCC.</i></p> <p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the causeCode impassability5 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table border="1"> <tr> <td></td><td>SSP position</td></tr> </table>		SSP position
	SSP position		

	<table><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th></tr><tr><td>impassability5</td><td>4</td><td>0</td></tr></table>	CauseCodeType / Container	Octet position	Bit position	impassability5	4	0
CauseCodeType / Container	Octet position	Bit position					
impassability5	4	0					
	<p>The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>						
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>						
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"><li>○ serviceType = HLN-UBR</li><li>○ messageType = DENM</li></ul> <p>Geographic area (Quadtree) for DENM message:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>						
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"><li>○ ITS-G5 only:<ul style="list-style-type: none"><li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li><li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li><li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li><li>○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.8</li></ul></li></ul>						



- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8

- IP based only:

- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of applicable specific test cases:

- ITS-G5 only

- TC\_CROADS\_HLN-UBR\_ITSG5\_DENM\_awarenessArea\_48-3\_R2.0.8
- TC\_CROADS\_HLN-UBR\_ITSG5\_DENM\_CC-sCC\_48\_R2.0.8

- Hybrid (IP based only):

- TC\_CROADS\_HLN-UBR\_HYBRID\_DENM\_awarenessArea\_48-3\_R2.0.8
- TC\_CROADS\_HLN-UBR\_HYBRID\_DENM\_CC-sCC\_48\_R2.0.8

### 3.2.12 HLN – Alert Wrong Way Driving (HLN-AWWD)

Type of road network	Motorways, Dual carriageways
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	<p>This use case is intended to warn a driver that he could encounter a vehicle that is driving in the wrong way. It is not the primary aim of this use case to alert the wrong way driver that he is on the wrong way. This V2V use case could be added in the future to the warning sequence if detection quality and confirmed status of information is improved.</p> <p><i>NOTE: The following description is valid only for right lane driving countries, in e.g. UK the lane situation would be mirrored, but the resulting danger for all vehicles involved is similarly high.</i></p>
Background	<p>Today, information about a wrong way driver exists but is only received via radio and/or VMS. The detection rate, time and accuracy of information is initially low, even if the wrong way driver alert is activated. Because of the high relative vehicle speeds involved between the approaching vehicles on the same lane, this generates always a highly risky situation on the road motorway network.</p> <p>For these reasons the application of a collaborative C-ITS service where vehicles and infrastructure cooperate to quickly detect, and immediately warn nearby vehicles and drivers reaching the “warning zone” could be of high positive impact for road safety.</p> <p>As the wrong way drivers occur at varying network positions, including motorway entrances and exits, the main limitation of current technologies is the low quality and slow detection of the vehicle involved, this can be improved by applying C-ITS and combining I2V and V2V applications.</p>
Objective	<p>The objective is to encourage the drivers to adapt their driving lane, speed and behaviour in case of a wrong way driver to minimise risks.</p> <p>The aim is <u>not to alert wrong way drivers</u> that they are driving in the wrong direction. This can be an optional V2V message and possibly even an in-vehicle detection application in the future.</p> <p>This would increase road safety by reducing driving speeds and thus accidents on motorways, as the wrong-way driver would be detected more quickly and located more accurately, triggering a detailed warning sequence for all nearby and approaching drivers.</p>
Desired behaviour	<p>Vehicle drivers receiving this information:</p> <ul style="list-style-type: none"> <li>Can adapt their speed and/or trajectory by driving at the most right.</li> </ul> <p><i>NOTE: This is valid only for right lane driving countries, in e.g. UK the lane situation would be mirrored.</i></p>

Expected benefits	<ul style="list-style-type: none"> <li>○ Can put themselves in a safe place (rest area, motorway interchange, etc).</li> <li>○ Pay more attention to their direct traffic surroundings.</li> </ul> <p>The added value of this use case is that potentially involved drivers are informed faster and more accurately. Moreover, the service aims to inform more drivers than currently (not all drivers listen to the radio).</p> <p>This leads to:</p> <ul style="list-style-type: none"> <li>○ Increased road safety by less accidents due to wrong way driving and less “horrible driving situations” for drivers involved in such a situation even without a direct accident.</li> <li>○ Reduction of the number of follow up accidents by detecting high risk situations linked to wrong way drivers fast and efficiently and distributing the correct and precise warning sequence of messages to all drivers approaching the risky area.</li> </ul>
<b>Use case description</b>	
Situation	<p>The wrong way driving alert could be triggered by several situations:</p> <ul style="list-style-type: none"> <li>○ On a motorway, a vehicle takes a slip road (entrance or exit segment) in the wrong way or turns back in the toll station/rest area and drives on the motorway in the wrong driving direction.</li> <li>○ On a ring road with separate carriageways, the situation can be the same, but with slip roads/exits more regular.</li> </ul> <p>Because the wrong way driver is entering the motorway* segment he mostly uses the most left lane**, which for the correct drivers is the lane with the highest travelling speed.</p> <p>For the wrong way driving alert, the following phases of the use case should be defined depending on the confirmed information status of the road operator. Possibly, the warning sequence in a single case can also consist of more than two linked use case phases as follows. Phase 1 and 3 always apply. The WWD alert could be extended with Phase 2 if more specific information becomes available.</p> <p><u>Phase 1</u>: Warning all drivers approaching the risky area or segment of the transport network that a wrong way driver present. The WWD alert informs drivers to drive carefully and slowly and only on the right lane** and not to overtake (and therefore use the most left lane of the motorway**) on both directions of the motorway.</p> <p><u>Phase 2</u>: If the wrong way driver position, heading and lane is confirmed, all drivers approaching this respective road segment are alerted to drive carefully and switch lanes to drive on the right lanes**. And at the same time alert drivers on the opposite driving direction of the motorway that the WWD alert has been clarified and regular traffic conditions have been resumed.</p> <p><u>Phase 3</u>: After clearance of the complete warning case, all involved drivers are informed that regular traffic conditions have been resumed.</p>

	<p><i>*In the urban environment, the use case is currently not regularly reported even if evidence shows that it could also be relevant but is rarely detected. (Urban use case could be added in the future).</i></p> <p><i>**This described traffic situation is valid only for right lane driving countries, in e.g. UK the lane situation would be mirrored, but the resulting danger for all vehicles involved similarly high.</i></p>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Drivers:</b> The end-users of this service are drivers in their vehicle, exposed to the wrong way driving vehicle in their direction and in the opposite direction of driving at the beginning of the WWD-alert. Following the confirmation of WWD position, heading and driving direction including the lane only the vehicle drivers on the carriageway approaching the RWW are informed, the other driving direction gets a de-escalation or warning cancellation.</li> <li>○ <b>Road operator:</b> the sender of the message is the operator in the TCC, using various detection sources of the wrong way driving vehicle e.g.: <ul style="list-style-type: none"> <li>○ Automated wrong-way detector</li> <li>○ Camera's</li> <li>○ Phone call (field operator, police, drivers, radio).</li> <li>○ Other C-ITS equipped vehicles</li> </ul> </li> <li>○ <b>Service providers:</b> Providing the message to the involved drivers and contributing the fast and precise detection of WWD cases by sending their WWD cases from vehicles to the involved road operators/public.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ An operator in the TCC is alerted of the presence of a wrong way driving vehicle on a motorway segment.</li> <li>○ Phase 1: The TCC sends the information for the relevant road segments for both directions. The subject of the message is "wrong way driver on your way". No detailed recommendations will be given initially. It informs drivers only to drive slowly and not to overtake.</li> <li>○ Vehicles receive the information.</li> <li>○ If the information is relevant for a vehicle (driver), the information is presented to the driver with a high priority.</li> <li>○ Phase 2: Wrong way driver details (driving position, speed, heading, driving lane) are confirmed by a second source of information to the road operator in the TCC.</li> <li>○ Vehicles involved receive the driving direction dependent updated information.</li> <li>○ Updated information (for same traffic event and message) is presented to the driver with a high priority.</li> <li>○ A message cancellation is transmitted after clearance of the WWD alert.</li> </ul>

<p>Intended Presentation/Alert principle</p>	<p><i>NOTE: If the detailed information does not become available, steps 5-7 will not be applicable.</i></p> <p>This use case could in the future also be extended in urban road networks, where drivers are driving against the allowed driving direction of a single direction road, which is also mainly a V2V use case.</p> <p>In a later stage of C-ITS deployment this could be enhanced by (an advanced vehicle detection application) warning the wrong way driver to stop immediately at the safe border of his current driving lane (and not try to turn, deviate or perform other driving actions).</p> <p>There are two main presentation possibilities:</p> <ul style="list-style-type: none"> <li>○ A moderately intrusive alert to encourage the drivers to adapt their driving behaviour (change lane to right as precaution) without risk of an overreaction (this can be related to phase 1).</li> <li>○ An intrusive alert to encourage the drivers to adapt their driving behaviour in case of urgency (this can be related to phase 2).</li> </ul> <p>In both cases, the alert should be given early enough to give the drivers the time to adapt their driving behaviour, possibly reduce vehicle speed and follow a lane advice. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
<p>Functional constraints/dependencies</p>	<ul style="list-style-type: none"> <li>○ For this particular use case, the validity duration, dissemination area, status and information quality will need to be determined and ascertained in the TCC for every phase of the use case.</li> <li>○ The information will not be precise enough to manage an imminent emergency.</li> </ul> <p>This use case would benefit from a future extension with V2V messages between vehicles and of an in-vehicle application for all C-ITS vehicles involved (also ego vehicle detection).</p> <p>This use case would benefit a lot if all C-ITS vehicles would have a robust WWD-Detection logic on board for the ego vehicle and for other vehicles in the surrounding traffic environment.</p> <p>Additionally, if the WWD use case is active, a specific V2V message forwarding in the opposite direction of the WWD would enhance the message distribution to the correct driver's group (approaching the risky situation with the WWD).</p> <p>How the information is presented to the drivers 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.</p>
<p>Link to other use cases</p>	<p>None</p>
<p><b>Interoperability requirements</b></p>	

<p>Message profile requirements</p>	<ul style="list-style-type: none"> <li>○ The DENM message for HLN use-cases is profiled in chapter 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>○ For this use-case, causeCode wrongWayDriving14 and subCauseCode 2 (wrongDirection) shall be used.</li> <li>○ stationType: 15 (also in case of a central C-ITS station)</li> <li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li> <li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li> <li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li> <li>○ A single linear awareness area shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ eventPosition shall be set to a position upstream of the position where the wrong way driver was last detected.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall be provided.</li> </ul> <p>The relevance zone of the event is a linear which starts upstream of the last known position of the WW driving vehicle and ends downstream this last know position. Upstream and downstream have to be understood as the correct driving direction for the infrastructure concerned (and not in reference to the driving direction of the WW driver). This linear of relevance is the eventZone of the DENM. This results in the WW driving vehicle being somewhere along the eventZone, between the eventPosition and the last point of the eventZone.</p> <p>In case the WW driver position is well known, the eventZone can be shortened by the road operator. To be on the safe side, the start of this linear event (i.e eventPosition) could be extended by the road operator to a position upstream of a suitable road junction or motorway exit, so that receiver-vehicles can choose to leave the carriageway to avoid any risk of accident with the WW driver.</p> </li> <li>○ <i>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</i></li> </ul>
<p>Security and data protection requirements</p>	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the causeCode wrongWayDriving14 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p>

	SSP position	
CauseCodeType / Container	Octet position	Bit position
wrongWayDriving14	2	0

The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf.

*NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.*

Communication  
technology  
requirements: ITS-G5

For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.

For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.

Communication  
technology  
requirements: IP based

For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.

For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:

- serviceType = HLN-AWWD
- messageType = DENM

Geographic area (Quadtree) for DENM message:

The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].

Test and validation  
requirements

[C-Roads\_TVC] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from [C-Roads\_TP]:

- ITS-G5 only:
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_CANCEL\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_TIMING\_03\_R2.0.8

- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8

○ IP based only:

- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
- TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
- TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
- TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8

List of applicable specific test cases:

○ ITS-G5 only



- TC\_CROADS\_HLN-AWWD\_ITSG5-DENM\_CC\_sCC\_49\_R2.0.8
- TC\_CROADS\_HLN-AWWD\_ITSG5-DENM\_awareness-area\_50\_R2.0.8

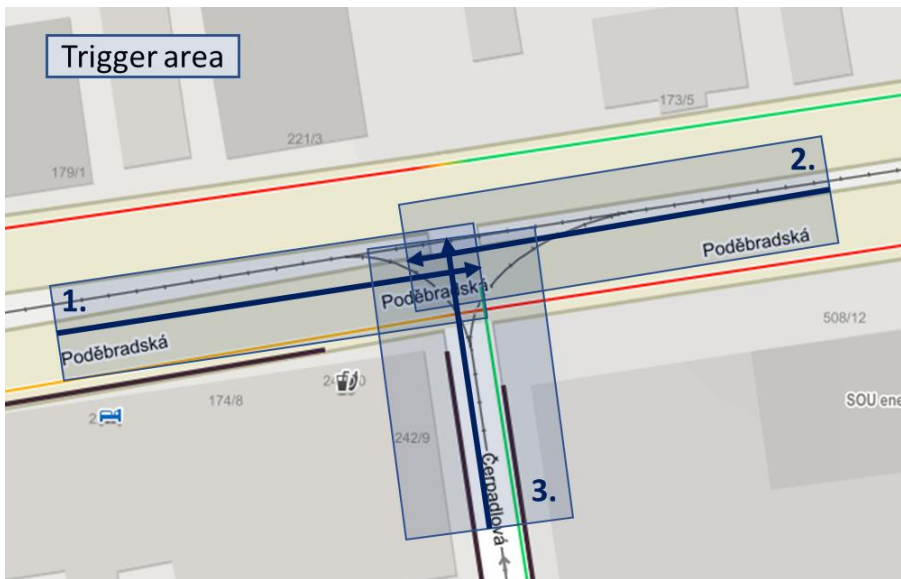
○ IP based only:

- TC\_CROADS\_HLN-AWWD\_Hybrid-DENM\_awareness-area\_50\_R2.0.8
- TC\_CROADS\_HLN-AWWD\_Hybrid-DENM\_CC\_sCC\_49\_R2.0.8



### 3.2.13 HLN – Public Transport Vehicle Crossing (HLN-PTVC)

Type of road network	Urban roads
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	The intent of this use case is to inform drivers that they are approaching a location with a high risk of collision with PT vehicles via in-vehicle information and warning.
Background	<p>The use case applies mainly in cities, as there are many places where tram tracks cross a road with other vehicles and these places are not equipped with traffic lights. Mainly during turning manoeuvres, drivers don't expect to cross tram tracks, which often can lead to accidents with trams.</p>  <p style="text-align: center;"><i>Figure 3:3 Example of HLN-PTVC</i></p> <p>Other dangerous situations include situations where buses merge from bus priority lanes into mixed traffic lanes. Most drivers are unaware that they have to give priority to buses, which can also lead to conflicts and accidents.</p>  <p style="text-align: center;"><i>Figure 3:4 Example of PTVC situation</i></p>
Objective	The drivers get warned about the presence of locations with a risk of collision with PT vehicles, i.e. where tram tracks cross a road (or in the connection with reserved lanes). The aim of this use case is to raise the driver's attention and to remind them to "Give priority!" when approaching the location.
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased driver attention.</li> <li>○ Adaptation of the driving speed.</li> </ul>

Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accident with PT vehicles.</li> <li>○ Increased driving comfort.</li> </ul>
<b>Use case description</b>	
Situation	<p>A vehicle is approaching a location with a high risk of collision with PT vehicles. All these dangerous locations are known, pre-selected and saved in the database. At the same time, the PT vehicle enters the trigger area in the appropriate direction and begins to generate and transmit specific warning message. The database of the dangerous locations and their trigger areas are saved in the PT vehicle's OBU; for IP-based, they may also be deployed in the backend.</p> <p>The dangerous locations (and its trigger areas) are usually chosen by road operators or public transport companies who know where the spots of frequent accidents with PT vehicles (trams and buses) are. The type of locations is quite varied and always depends on the specific topology of the specific intersection.</p>  <p>The map shows the intersection of Poděbradská and Černádková streets. Three trigger areas are highlighted with blue boxes and numbered 1, 2, and 3. Area 1 is on Poděbradská approaching the intersection from the left. Area 2 is on Poděbradská approaching the intersection from the right. Area 3 is on Černádková approaching the intersection from the bottom. A central box labeled 'Trigger area' with a crosshair indicates the intersection point. Various street numbers and landmarks like 'SOU energie' are visible on the map.</p> <p><i>Figure 3:5 Example 1 of trigger area HLN-PTVC</i></p>

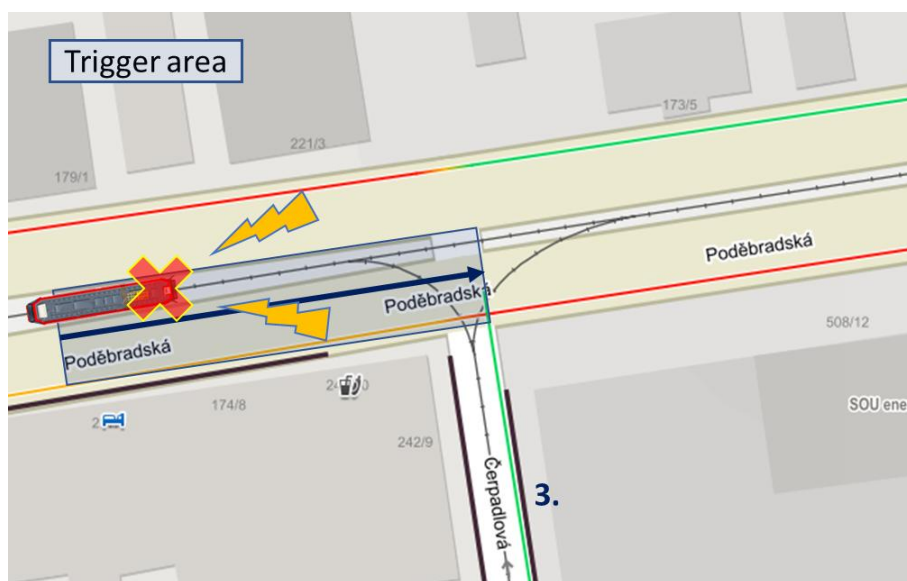


Figure 3:6 Example 2 of trigger area HLN-PTVC

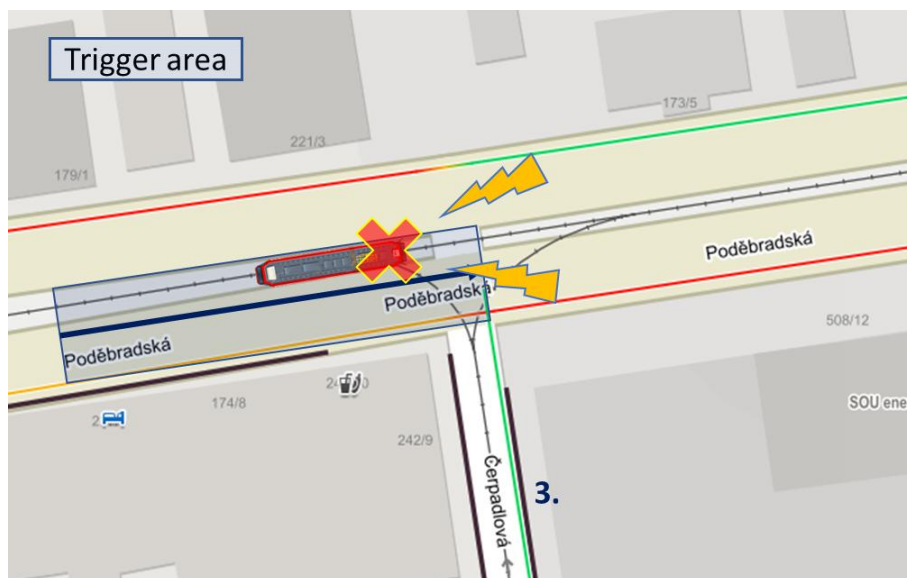


Figure 3:7 Example 3 of trigger area HLN-PTVC

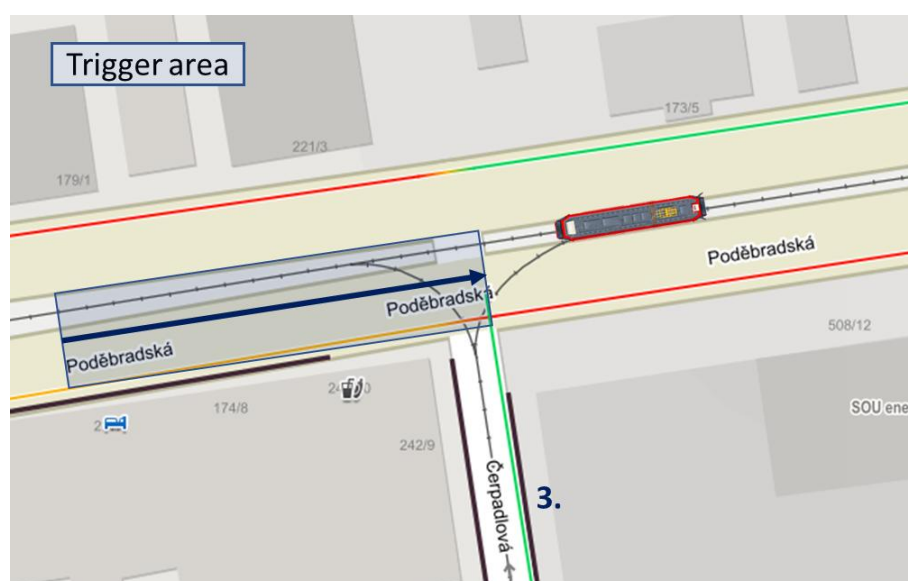


Figure 3:8 Example 4 of trigger area HLN-PTVC

Logic of transmission

V<sub>PT2V</sub>

Actors and relations

- **Public transport operator:** Is the origin of the information of the message. The direct source are OBUs in their vehicles.
- **Road user:** End-users in the vicinity of the PT vehicle crossing receive the warnings.

Use case scenario

- The PT vehicle enters a trigger area of a dangerous location in the appropriate direction.
- A warning message about a potential collision is generated and transmitted by an OBU in the PT vehicle containing its actual position (within eventPosition DE).
- The information is sent to vehicles equipped with an OBU.
- The vehicle receives the information and presents it to the driver.
- The drivers adapt their driving behaviour.

Intended  
Presentation/Alert  
principle

- The warning to the drivers needs to be presented early enough for them to adapt their driving behaviour. However, since they should not forget about the alert, it could be repeated closer to the location.
- The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.

Functional constraints/  
dependencies

- This use case should be implemented only in locations without traffic light control (or when it is disabled).
- For buses, it is expected to be used in locations where dedicated bus lanes cross regular traffic.
- The (location) information of the trigger area should be accurate, detailed and up to date.
- The trigger area shall be defined at least by 2 points which also defines the direction to avoid that the area activates a transmitting of DENM

	<p>even though the PT vehicle just left the dangerous location.</p> <ul style="list-style-type: none"> <li>○ The settings of the trigger areas shall consider the length of PT vehicle, GNSS antenna placement and an adequate amount of time between first transmission and reaching the PT vehicle.</li> <li>○ The approaching PT vehicle should transmit its position with a certain accuracy and in a timely manner.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	None
<b>Interoperability requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The DENM message for HLN-PTVC is profiled in chapter 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>○ For this use-case, causeCode collisionRisk97 and subCauseCode 2 (crossing collision risk) shall be used.</li> <li>○ A point-based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location of the PT vehicle.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall not be provided.</li> </ul> </li> <li>○ stationType shall be set to 6 (bus) or 11 (tram) → indicator of PT vehicles.</li> <li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li> <li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li> <li>○ Message management shall be done by either providing short validity durations or by actively terminating messages.</li> <li>○ <i>NOTE: The position confidence depends on the accuracy of the localisation method. If no precise value can be given, the value 4095 (unavailable) shall be used.</i></li> </ul> <p>In addition to the DENM, a CAM shall be sent.</p> <ul style="list-style-type: none"> <li>○ CAM vehicleRole shall be set to publicTransport (1).</li> <li>○ CAM SpecialVehicleContainer: publicTransportContainer</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p>

This use case is based on the collisionRisk97 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):

CauseCodeType / Container	SSP position	
	Octet position	Bit position
collisionRisk97	3	5

The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf and public transport operators.

*NOTE: C-Roads investigates the necessity to restrict this UC. If it is necessary, it is proposed to request a separate cC for PT use cases and restrict the usage of this new cC.*

*NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.*

Communication technology requirements: ITS-G5

For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.

Communication technology requirements: IP based

For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.

For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.

For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:

- serviceType = HLN-PTVC
- messageType = DENM

Geographic area (Quadtree) for DENM message:

The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].

Test and validation requirements

[C-Roads\_TV] contains the generic applicable framework and process for interoperability testing.



List of applicable generic test cases from [C-Roads\_TP]:

- ITS-G5 only:
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_CANCEL\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_TIMING\_03\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_Traces\_02\_R2.1.0
  - TC\_CROADS\_GENERIC\_ITSG5\_DENM\_UPDATE\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5-DENM\_EventPosition\_01\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5-DENM\_informationQuality\_65\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5-DENM\_referenceDenms\_36\_R2.0.8
  - TC\_CROADS\_GENERIC\_ITSG5-DENM\_StationType\_66\_R2.0.8
- IP based only:
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_awarenessTrafficDirection\_35\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_CANCEL\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_Hybrid\_DENM\_informationQuality\_65\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_positionConfidenceEllipse\_01\_1\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_referenceDenms\_36\_R2.0.8
  - TC\_CROADS\_GENERIC\_Hybrid\_DENM\_stationType\_66\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_TIMING\_03\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_Traces\_02\_R2.1.0
  - TC\_CROADS\_GENERIC\_HYBRID\_DENM\_UPDATE\_04\_R2.0.8
  - TC\_CROADS\_GENERIC\_HYBRID-DENM\_EventPosition\_01\_R2.0.8


List of applicable specific test cases:

- ITS-G5 only
  - TC\_CROADS\_HLN-PTVC\_ITSG5\_DENM\_awarenessArea\_52\_2\_R2.0.8
  - TC\_CROADS\_HLN-PTVC\_ITSG5\_DENM\_awarenessTrafficDirection\_52\_5\_R2.0.8
  - TC\_CROADS\_HLN-PTVC\_ITSG5-DENM\_CC-sCC\_51\_R2.0.8
  - TC\_CROADS\_HLN-PTVC\_ITSG5-CAM\_vehicleRole\_7\_1\_R2.0.8
- IP based only:
  - TC\_CROADS\_HLN-PTVC\_HYBRID\_DENM\_awarenessArea\_52\_2\_R2.0.8
  - TC\_CROADS\_HLN-PTVC\_HYBRID\_DENM\_awarenessTrafficDirection\_52\_4\_R2.0.8
  - TC\_CROADS\_HLN-PTVC\_HYBRID\_DENM\_CC-sCC\_51\_R2.0.8





### 3.2.14 HLN – Public Transport Vehicle at a Stop (HLN-PTVS)

Type of road network	Urban roads
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	The intention of this use case is to provide in-vehicle information and warnings about public transport vehicles at a stop.
Background	<p>Public transport vehicles stopping at some types of stops create an obstacle on the road. These situations happen mainly at stops on lanes or stops where passengers get off directly on the road. At these locations, approaching vehicles could collide with the stationary public transport vehicle or even the passengers. These locations can be very dangerous mainly in combination with bad weather conditions.</p> <div>  </div> <p><i>Figure 3:9 Example of HLN-PTVS</i></p>
Objective	<p>The drivers get warned about the presence of a public transport vehicle at the stop to raise their attention when approaching it by providing in-vehicle information and warnings about this situation.</p> <p>During getting on and off public transport, passengers often don't pay much attention. Due to the warning, the driver can be prepared for unexpected pedestrian behaviour.</p>
Desired behaviour	<ul style="list-style-type: none"> <li>○ Increased driver attention.</li> <li>○ Adaptation of the driving speed in the vicinity of the stop (stopping the vehicle behind the stationary PT vehicle).</li> <li>○ Readiness for unexpected pedestrian behaviour.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Reducing the risk of accident with PT vehicles.</li> <li>○ Reducing the risk of road vehicle accidents in the vicinity of PT stops.</li> <li>○ Increased driving comfort.</li> </ul>
<b>Use case description</b>	
Situation	<p>A vehicle is approaching a PT stop (e.g., stop on a lane), where a PT vehicle is standing, and passengers are getting on/off the vehicle in a hurry.</p> <p>The driver is informed about this situation.</p>

Logic of transmission	V <sub>PT</sub> 2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Public transport operator:</b> Is the origin of the information of the message. The direct source are OBUs in their vehicles.</li> <li>○ <b>Drivers:</b> End-users receive the warnings in the vicinity of the PT vehicle at a stop.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The PT vehicle stops at a stop.</li> <li>○ Warning messages begin to be generated by the PT vehicle's OBU.</li> <li>○ Information is sent to vehicles equipped with OBU.</li> <li>○ The vehicle receives the information and presents it to the driver.</li> <li>○ The drivers adapt their driving behaviour.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The warning to the drivers needs to be presented early enough for them to adapt their driving behaviour.</li> <li>○ The user is provided with related information. Layout and sequence of presentation are left to OEM-specific implementation.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ The sent position of the PT vehicle and the exact lane it is located should be sufficiently accurate.</li> <li>○ The sent info that the PT vehicle is coming to a stop should be communicated early enough to leave time for surrounding vehicles to be aware and react.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	None
<b>Interoperability requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The DENM message for HLN-PTVS is profiled in chapter 4.2.1.1 and 4.2.1.3 of [C-Roads MP].</li> <li>○ For this use-case, stationaryVehicle94 and subCauseCode 4 (publicTransportStop) shall be used.</li> <li>○ A point-based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> <li>○ The eventPosition shall be set to the location of the PT vehicle.</li> <li>○ awarenessDistance shall not be provided.</li> <li>○ trafficDirection shall be provided as specified in [C-Roads MP].</li> <li>○ eventZone shall not be provided.</li> </ul> </li> <li>○ stationType shall be set to 6 (bus) or 11 (tram) to clearly indicate public transport vehicles.</li> <li>○ detectionZonesToEventPosition shall be provided as specified in [C-Roads MP].</li> <li>○ informationQuality shall be set according to the definition in [C-Roads MP].</li> </ul>

	<ul style="list-style-type: none"><li>○ Message management shall be done by either providing short validity durations or by actively terminating messages. validityDuration should be short, corresponding to the mean time of a stop.</li><li>○ <i>NOTE: The position confidence depends on whether the PTV uses GPS. If no precise value can be given, the value 4095 (unavailable) shall be used.</i></li></ul> <p>In addition to the DENM, a CAM shall be sent.</p> <ul style="list-style-type: none"><li>○ CAM vehicleRole shall be set to publicTransport (1)</li><li>○ CAM SpecialVehicleContainer shall be set to publicTransportContainer</li></ul>									
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the stationaryVehicle94 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>stationaryVehicle94</td><td>3</td><td>2</td></tr></table> <p>The here listed SSP shall be granted for C-ITS stations used by road operators or any contractor on their behalf and public transport operators.</p> <p><i>NOTE: C-Roads investigates the necessity to restrict this UC. If it's necessary, it is proposed to request a separate cC for PT use cases and restrict the usage of this new cC.</i></p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	stationaryVehicle94	3	2
	SSP position									
CauseCodeType / Container	Octet position	Bit position								
stationaryVehicle94	3	2								
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>									
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p>									

Test and validation requirements	<p>For use cases based on DENM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = HLN-PTVS</li> <li>○ messageType = DENM</li> </ul> <p>Geographic area (Quadtree) for DENM message:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p> <p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_ITSG5-DENM_StationType_66_R2.0.8</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_awarenessTrafficDirection_35_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_informationQuality_65_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_positionConfidenceEllipse_01_1_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36_R2.0.8</li> <li>○ TC_CROADS_GENERIC_Hybrid_DENM_stationType_66_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_Traces_02_R2.1.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.8</li> <li>○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.8</li> </ul> </li> </ul>
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List of applicable specific test cases:

- ITS-G5 only
  - TC\_CROADS\_HLN-PTVS\_ITSG5\_DENM\_awarenessArea\_54-2\_R2.0.8
  - TC\_CROADS\_HLN-PTVS\_ITSG5\_DENM\_awarenessTrafficDirection\_54-5\_R2.0.8
  - TC\_CROADS\_HLN-PTVS\_ITSG5-DENM\_CC-sCC\_53\_R2.0.8
  - TC\_CROADS\_HLN-PTVS\_ITSG5-CAM\_vehicleRole\_8\_1\_R2.0.8
- IP based only:
  - TC\_CROADS\_HLN-PTVS\_HYBRID\_DENM\_awarenessArea\_54\_2\_R2.0.8
  - TC\_CROADS\_HLN-PTVS\_HYBRID\_DENM\_awarenessTrafficDirection\_54\_4\_R2.0.8
  - TC\_CROADS\_HLN-PTVS\_HYBRID\_DENM\_CC-sCC\_53\_R2.0.8

## 4. Road Works Warning (RWW)

### 4.1 RWW: Service introduction

Service introduction	
Summary	The Road Works Warning service warns drivers of road works, which can be mobile or static, short term or long term. Road works are all types of road operations by the road operator, including operations involving road operator vehicles.
Background	<p>Road works usually affect the road layout and often also the driving regulations. Despite dedicated signage prior to road work zones, such changed conditions often come as a surprise to drivers. This may lead to unsafe situations and sometimes even accidents involving both drivers and workers (i.e., changes in road layout and applicable driving regulations). Moreover, the driver's attention may decrease with regular or longer road works.</p> <p>Road operator vehicles are not always recognised and are not equipped in the same way as e.g., police vehicles or fire engines. Use cases involving road operator vehicles (e.g., salting, ploughing, securing accident zone, vehicle recovery by road operator) support the safety of the road operators and drivers involved.</p>
Objective	More attentive and adapted driving while approaching and passing a work zone or road operator vehicles in operation by providing in-vehicle information and warnings about road works, changes to the road layout and applicable driving regulations.
Expected benefits	<ul style="list-style-type: none"> <li>○ The primary expected impact is more attentive driving while approaching and passing a work zone or road operator vehicles in operation, helping to avoid sudden braking or steering/swerving manoeuvres, thereby increasing traffic safety by reducing (the severity of) accidents.</li> <li>○ RWW aims at reducing the number of collisions with road vehicle safety-objects and road operator vehicles near road works. RWW informs the drivers that they are approaching a work zone and simultaneously provides information on the changes of the road layout.</li> <li>○ Better traffic flow in the around road works.</li> <li>○ Less accidents.</li> </ul>
Use cases	<ul style="list-style-type: none"> <li>○ Lane closure (and other restrictions) (RWW – LC)</li> <li>○ Road Closure (RWW – PC)</li> <li>○ Road Works – Mobile (RWW – RM)</li> <li>○ Winter Maintenance (RWW – WM)</li> </ul> <p>Other RWW use cases are under review and may be added in future releases.</p>

## 5. Signalised Intersections (SI)

### 5.1 SI: Service introduction

Service introduction	
Summary	This service will provide information to drivers and vehicle data to traffic light controllers for a safe and efficient approach and crossing of signalised intersections. The implementation of the infrastructure-based intersection use cases will increase the safety and efficiency of traffic flow and minimise environmental pollution at signalised intersections.
Background	Intersections can be complex traffic environments where traffic flow can be affected negatively by various traffic aspects. Additionally, intersections are also areas with higher risks of accidents, because of conflicting traffic streams. Also, emissions are higher due to stops and acceleration. For these reasons C-ITS services that allow a smooth passing of one or more intersections with a constant speed for a large number of drivers decrease negative effects of urban traffic.
Objective	More attentive driving while approaching and passing an intersection by providing in-vehicle information, speed advice and priority to designated vehicles (e.g. public transport, emergency vehicles, heavy goods vehicles, etc.), resulting in better energy efficiency and increased road safety.
Expected benefits	Enhanced safety for emergency vehicles as conflicting traffic streams can be stopped and drivers can cross the road with less risk.
Use cases	<ul style="list-style-type: none"> <li>○ Signal Phase and Timing Information (SI – SPTI)</li> <li>○ Green Light Optimal Speed Advisory (SI – GLOSA)</li> <li>○ Imminent Signal Violation Warning (SI – ISVW)</li> <li>○ Traffic Light Prioritisation (SI – TLP)</li> <li>○ Emergency Vehicle Priority (SI – EVP)</li> </ul>

## 5.2 SI: Use Cases

### 5.2.1 SI – Signal Phase and Timing Information (SI-SPTI)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	In this use case, drivers approaching and passing signalised intersections are provided with information about the current signal phase as well as upcoming phase(s) and the moment these are expected to start and end.
Background	Intersections cause delays and stops, which have a negative effect on environmental pollution and traffic safety. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights can be provided to drivers to optimise their driving speed and to eliminate inefficiencies.
Objective	Enabling drivers to adapt their driving behaviour to the time they have left until the next traffic signal phase in order to minimise sudden stops, deceleration, and acceleration (delay), resulting in better safety, throughput and sustainability.
Desired behaviour	Drivers can adapt their speed while approaching a signalised intersection or they can turn off their engine when stopping before a red phase.
Expected benefits	The expected benefits are increased awareness of traffic lights and their phase changes, and more efficient and effective driving behaviour while approaching or waiting at signalised intersections with fewer stops, reducing emissions, anger and aggressiveness and increasing safety.
<b>Use case description</b>	
Situation	A V2X-equipped vehicle approaches an I2V-enabled signalised intersection, which transmits the current phase state and predicted timing of the traffic lights, as well as a road topology for the intersection ahead, periodically and in real-time.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road authority:</b> 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).</li> <li>○ <b>Road operator:</b> Ensures coordination of signalised intersections and provides access to signal phase and timing data.</li> <li>○ <b>Data provider:</b> Processes the signal phase and timing data.</li> <li>○ <b>Service provider:</b> Disseminates signal phase and timing information to drivers.</li> <li>○ <b>Drivers:</b> Receive signal phase and timing information and adapt their driving behaviour according to this information.</li> </ul>
Use case scenario	<u>Case 1: Vehicle approaches a green traffic light</u>



	<ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current green phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. The V2X-equipped vehicle approaching the intersection, aware of its own location, velocity, and speed limit receives the messages and extracts the relevant time to red information and uses that to determine its trajectory towards the intersection.</li> </ul> <p><u>Case 2: Vehicle approaches a red traffic light</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current red phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. The V2X-equipped vehicle approaching the intersection, aware of its own location, velocity, and speed limit receives the messages and extracts the relevant time to green information and uses that to determine its trajectory towards the intersection.</li> </ul> <p><u>Case 3: Vehicle is stopped at red traffic light</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current red phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. The V2X-equipped vehicle extracts the relevant time to green information.</li> </ul>
Intended Presentation/Alert principle	<p>The signal phase and timing information needs to be provided to the drivers on an HMI early enough and should be moderately intrusive. The notification could be, for example, a traffic light symbol, countdown timer, sand glass, alert to turn off the engine or an alert to prepare for green. The presentation of signal phase and timing through the HMI should be done in a way that discourages drivers from increasing their speed beyond the speed limit or to depart before the start of the green phase. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ Current signal phase state and timing of upcoming phase changes from the signalised intersection shall be sufficiently accurate and reliable to ensure high quality information.</li> <li>○ The signal phase state as indicated by the physical signal heads shall always outweigh the information provided in the vehicle.</li> <li>○ Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	<p>This use case is the basis for SI-GLOSA.</p>
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The SPATEM and MAPEM messages for SI – SPTI are profiled in chapter 4.2.3 of [C-Roads MP].</li> </ul>

<p>Security and data protection requirements</p>	<ul style="list-style-type: none"> <li>○ The data frame 'speeds' is not used in this use case.</li> </ul> <p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
<p>Communication technology requirements: ITS-G5</p>	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
<p>Communication technology requirements: IP based</p>	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = SI-SPTI</li> <li>○ messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
<p>Test and validation requirements</p>	<p>[C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_SI_GENERIC_ITS-G5_SPaTEM-MAPEM_Timing_01_R2.0.4</li> <li>○ TC_CROADS_SI-GENERIC_ITSG5_MAPEM_Location_03_R2.0.4</li> <li>○ TC_CROADS_SI-GENERIC_ITSG5_MAPEM_SPATEM_Generic-Relation_02_R2.0.4</li> </ul> </li> <li>○ Hybrid (IP based only):</li> </ul>

- TC\_CROADS\_SI\_GENERIC\_HYBRID\_SPaTEM-MAPEM\_Timing\_01\_R2.0.4.xlsx
- TC\_CROADS\_SI-GENERIC\_HYBRID\_MAPEM\_Location\_03\_R2.0.4.xlsx
- TC\_CROADS\_SI-GENERIC\_HYBRID\_MAPEM\_SPaTEM\_Generic-Relation\_02\_R2.0.4

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_SI-SPTI\_ITSG5\_SPaTEM\_SignalPhaseAndTimingInformation\_08\_R2.0.4
  - TC\_CROADS\_SI-SPTI\_ITSG5\_SPaTEM\_speeds\_08\_1\_R2.0.4
- Hybrid (IP based only):
  - TC\_CROADS\_SI-SPTI\_HYBRID\_SPaTEM\_SignalPhaseAndTimingInformation\_08\_R2.0.4
  - TC\_CROADS\_SI-SPTI\_HYBRID\_SPaTEM\_speeds\_08\_1\_R2.0.4

## 5.2.2 SI – Green Light Optimal Speed Advisory (SI-GLOSA)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	In this use case, drivers will be provided with speed advice information for a safe and efficient approach and crossing of signalised intersections.
Background	Intersections cause delays and stops, which have a negative effect on 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 provided to drivers to optimise their driving speed and to eliminate inefficiencies.
Objective	Calculating a speed advice for one or multiple intersections, enabling drivers to adapt their approaching speed and to pass one or more signalised intersections safely, sustainably, and in an energy efficient manner (e.g. by minimizing stops, acceleration and deceleration).
Desired behaviour	Drivers can adapt their speed according to the speed advice while approaching, stopping and/or passing a signalised intersection or driving through a sequence of signalised intersections.
Expected benefits	The expected benefit is a smoother driving behaviour while approaching and passing a sequence of signalised intersections, which reduces stops, reduces emissions and increases safety.
<b>Use case description</b>	
Situation	<p><u>Single intersection:</u></p> <ul style="list-style-type: none"> <li>○ A V2X-equipped vehicle approaches a single I2V-enabled signalised intersection, which transmits the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead periodically and in real-time.</li> </ul> <p><u>Sequence of intersections:</u></p> <ul style="list-style-type: none"> <li>● A V2X-equipped vehicle approaches a sequence of I2V-enabled signalised intersections, which transmit the current phase state and predicted timing of the traffic lights and road topology for the intersection(s) ahead periodically and in real-time.</li> </ul>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road authority:</b> 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).</li> <li>○ <b>Road operator:</b> Ensures coordination of signalised intersections and provides access to signal phase and timing data.</li> <li>○ <b>Data provider:</b> Processes the signal phase and timing data.</li> <li>○ <b>Service provider:</b> Calculates speed advice and disseminates this information to drivers.</li> </ul>

	<ul style="list-style-type: none"> <li>○ <b>Drivers:</b> Receive speed advisory information and adapt their driving behaviour according to this information.</li> </ul>
Use case scenario	<p><u>Scenario 1a: Vehicle calculates speed advice</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. 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.</li> </ul> <p><u>Scenario 1b: Infrastructure calculates speed advice</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection calculates and transmits advisory speed information for multiple road segments of the approach of the intersection periodically and in real-time. 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.</li> </ul> <p><u>Scenario 2: Green wave speed advice</u></p> <ul style="list-style-type: none"> <li>○ A sequence of I2V-enabled traffic light-controlled, synchronised 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 advice for passing the intersections.</li> </ul>
Intended Presentation/Alert principle	<p>The speed advice information needs to be provided to the drivers through an HMI early enough, shall be moderately intrusive, and could be a speed value, a speed range, a driving indication like slow down, or something else. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ Current signal phase state and timing of upcoming phase changes from the signalised intersection shall be sufficiently accurate and reliable to ensure high quality speed advisory.</li> <li>○ The signal phase state as indicated by the physical signal heads always outweigh the information provided in the vehicle.</li> <li>○ Traffic conditions, e.g., queues or traffic jams, affect the validity of speed advice information and therefore shall be considered.</li> <li>○ A speed advice shall never exceed the legal speed limit.</li> <li>○ Public Transport Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	<p>Based on SI-SPTI</p>

Interoperability Requirements	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The SPATEM and MAPEM messages for SI-SPTI are profiled in chapter 4.2.3 of [C-Roads MP].</li> <li>○ For this use case: <ul style="list-style-type: none"> <li>○ 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.</li> </ul> </li> <li>○ For scenarios 1b and 2, speeds is mandatory, as are the AdvisorySpeed data elements type, speed, confidence, distance.</li> <li>○ The data frame speeds is not used in scenario 1a.</li> <li>○ The data element type of AdvisorySpeed must be set to greenwave (1) for scenario 2 and set to ecoDrive (2) for scenarios 1b.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = SI-GLOSA</li> <li>○ messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p>

## Test and validation requirements

Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].

[C-Roads\_TV] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from [C-Roads\_TP]:

- ITS-G5 only:
  - TC\_CROADS\_SI\_GENERIC\_ITS-G5\_SPaTEM-MAPEM\_Timing\_01\_R2.0.4
  - TC\_CROADS\_SI-GENERIC\_ITSG5\_MAPEM\_Location\_03\_R2.0.4
  - TC\_CROADS\_SI-GENERIC\_ITSG5\_MAPEM\_SPATEM\_Generic-Relation\_02\_R2.0.4
- Hybrid (IP based only):
  - TC\_CROADS\_SI\_GENERIC\_HYBRID\_SPaTEM-MAPEM\_Timing\_01\_R2.0.4.xlsx
  - TC\_CROADS\_SI-GENERIC\_HYBRID\_MAPEM\_Location\_03\_R2.0.4.xlsx
  - TC\_CROADS\_SI-GENERIC\_HYBRID\_MAPEM\_SPATEM\_Generic-Relation\_02\_R2.0.4
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List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_SI-GLOSA\_ITSG5\_SPaTEM-MAPEM\_speedLimit\_13\_1\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_ITSG5\_SPaTEM-MAPEM\_speedLimit\_13\_2\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_ITSG5\_SPaTEM-MAPEM\_speedLimit\_13\_3\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_ITSG5\_SPaTEM-MAPEM\_speedLimit\_13\_4\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_ITSG5\_SPaTEM-MAPEM\_speedLimit\_13\_5\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_ITSG5\_SPaTEM-MAPEM\_speedLimit\_13\_6\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_ITSG5\_SPaTEM-MAPEM\_speedLimit\_13\_R2.0.4
- Hybrid (IP based only):
  - TC\_CROADS\_SI-GLOSA\_HYBRID\_SPaTEM-MAPEM\_speedLimit\_13\_1\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_HYBRID\_SPaTEM-MAPEM\_speedLimit\_13\_2\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_HYBRID\_SPaTEM-MAPEM\_speedLimit\_13\_3\_R2.0.4
  - TC\_CROADS\_SI-GLOSA\_HYBRID\_SPaTEM-MAPEM\_speedLimit\_13\_4\_R2.0.4

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|  | <ul style="list-style-type: none"> <li>○ TC_CROADS_SI-GLOSA_HYBRID_SPaTEM-<br/>MAPEM_speedLimit_13_5_R2.0.4</li> <li>○ TC_CROADS_SI-GLOSA_HYBRID_SPaTEM-<br/>MAPEM_speedLimit_13_6_R2.0.4</li> <li>○ TC_CROADS_SI-GLOSA_HYBRID_SPaTEM-<br/>MAPEM_speedLimit_13_R2.0.4</li> </ul> |
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### 5.2.3 SI – Imminent Signal Violation Warning (SI-ISVW)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	In this use case, drivers approaching signalised intersections will be provided with imminent signal violation warnings.
Background	Signalised intersections can be complex traffic environments, and occasionally drivers do not stop for a red traffic light, intentionally or unintentionally. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights, as well as imminent signal violation warnings, can be presented to drivers to increase their awareness of red traffic lights and avoid red light violation.
Objective	Reducing the likelihood and severity of collisions and injuries at signalised intersections by warning the drivers of potential violations of a red intersection signal.
Desired behaviour	Drivers react to the imminent red light violation warning, stopping their vehicle in time to avoid red light violation or reducing their speed to minimise the impact of the red-light violation.
Expected benefits	The primary expected benefits are increased awareness of signal phases and their timing, less red-light violations and thereby less collisions at signalised intersections.
<b>Use case description</b>	
Situation	A V2X-equipped vehicle approaches an I2V-enabled signalised intersection, which transmits the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead periodically and in real-time.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road authority:</b> 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).</li> <li>○ <b>Road operator:</b> Provides access to signal phase and timing data.</li> <li>○ <b>Data provider:</b> Processes the signal phase and timing data.</li> <li>○ <b>Service provider:</b> Disseminates imminent red light violation warnings to drivers.</li> <li>○ <b>Drivers:</b> Receive imminent red light violation warning and adapts their driving behaviour according to this information.</li> </ul>
Use case scenario	The I2V-enabled signalised intersection transmits the current phase state and timing of upcoming phase changes of the traffic lights periodically and in real time. The V2X-equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and calculates if red light violation is imminent.

Intended Presentation/Alert principle	The imminent red light violation warning needs to be provided to the drivers through an HMI early enough and shall be intrusive (e.g., supported acoustically). The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ Current signal phase state and timing of upcoming phase changes from the signalised intersection shall be sufficiently accurate and reliable to ensure high-quality red-light violation warnings.</li> <li>○ The time critical nature of this use case requires for a sufficiently low latency system implementation.</li> <li>○ The signal phase state as indicated by the physical signal heads always outweigh the information provided in the vehicle.</li> <li>○ Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance.</li> <li>○ If red light violation is inevitable, another use case comes in play which ensures that other drivers are warned of the presence of a red-light violator at the signalised intersection.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	Based on SI-SPTI.
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ SPATEM and MAPEM messages for SI-ISVW are profiled in chapter 4.2.3 of [C-Roads MP].</li> <li>○ The data frame 'speeds' is not used in this use case.</li> <li>○ One consistent SPATEM/MAPEM message per intersection shall be distributed for this use case</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.

	<p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = SI-ISVW</li> <li>○ messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
<p>Test and validation requirements</p>	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_SI_GENERIC_ITS-G5_SPaTEM-MAPEM_Timing_01_R2.0.4</li> <li>○ TC_CROADS_SI-GENERIC_ITSG5_MAPEM_Location_03_R2.0.4</li> <li>○ TC_CROADS_SI-GENERIC_ITSG5_MAPEM_SPATEM_Generic-Relation_02_R2.0.4</li> </ul> </li> <li>○ Hybrid (IP based only): <ul style="list-style-type: none"> <li>○ TC_CROADS_SI_GENERIC_HYBRID_SPaTEM-MAPEM_Timing_01_R2.0.4.xlsx</li> <li>○ TC_CROADS_SI-GENERIC_HYBRID_MAPEM_Location_03_R2.0.4.xlsx</li> <li>○ TC_CROADS_SI-GENERIC_HYBRID_MAPEM_SPATEM_Generic-Relation_02_R2.0.4</li> </ul> </li> </ul> <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_SI-ISVW_ITSG5_SPATEM_Latency_15_R2.0.4</li> <li>○ TC_CROADS_SI-ISVW_ITSG5_SPATEM_SignalPhaseAndTimingInformation_14_R2.0.4</li> <li>○ TC_CROADS_SI-ISVW_ITSG5_SPATEM_speeds_18_2_R2.0.4</li> <li>○ TC_CROADS_SI-ISVW_ITSG5_SPATEM-MAPEM_oneMessageAvailable_18_3_R2.0.4</li> </ul> </li> <li>○ Hybrid (IP based only):</li> </ul>

- TC\_CROADS\_SI-ISVW\_HYBRID\_SPATEM\_Latency\_15\_R2.0.4
- TC\_CROADS\_SI-ISVW\_HYBRID\_SPATEM\_SignalPhaseAndTimingInformation\_14\_R2.0.4
- TC\_CROADS\_SI-ISVW\_HYBRID\_SPATEM\_speeds\_18\_2\_R2.0.4
- TC\_CROADS\_SI-ISVW\_HYBRID\_SPATEM-MAPEM\_oneMessageAvailable\_18\_3\_R2.0.4

## 5.2.4 SI – Emergency Vehicle Priority (SI-EVP)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	This use case will actively contribute to the phase control of a signalised intersection to aid the passage of an emergency vehicle (EV). It will also provide the prioritisation status to other users approaching and passing signalised intersections.
Background	Traffic light prioritisation for eVs can be distinctly different from normal traffic light prioritisation. Depending on intersection geometry, lanes other than those that the EV intends to use may be cleared, offering the EV an easier approach to and passage through the intersection. Moreover, drivers of other vehicles are often not aware that they can pass through a red light if an emergency vehicle (with sirens and light bar enabled) is approaching and there is no other way to clear a path. This results in drivers blocking the path of the emergency vehicle until the light turns green.
Objective	Interaction between eVs and traffic light controller(s) (either local or central) to reduce the time taken for eVs to cross signalised intersections and increase the safety of these crossings.
Desired behaviour	The traffic light control adapts its signal phases to give priority to the EV, allowing it to pass the signalised intersection safely and with minimum delay. The EV driver responds to the information on the prioritisation status (e.g., active and accepted) and if needed adjusts the EV path to the lane which will be cleared by the traffic light controller.
Expected benefits	Primarily expected benefits are a shorter travel time for EVs and a lower risk of collision. An additional benefit is the increased flexibility to alter the priority lane/signal and use different routes.
<b>Use case description</b>	
Situation	A V2X-equipped EV approaches an I2V-enabled signalised intersection that is serviced by an EV prioritisation system. The EV transmits the current position and the certified right of a prioritised passing at the intersection ahead periodically and in real-time.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Emergency vehicle:</b> Transmits the priority request, receives information about the priority status and gets prioritised passing at the intersection.</li> <li>○ <b>Road operator:</b> Processes the priority request and implements the priority policy at the signalised intersection.</li> <li>○ <b>Road authority:</b> Defines policy and traffic light infrastructure (i.e., assigns authorisation and acceptance of certification for EV prioritisation).</li> </ul>
Use case scenario	The V2X-equipped vehicle approaching the intersection, sends the current

	<p>position and the operational state periodically and in real-time. The I2V-enabled signalised intersection receives the prioritisation request and checks its validity. Depending on the position, the direction of travel, and the distance to the intersection, the traffic light phases are controlled so that conflicting traffic streams are stopped first, then taking into account minimum inter green times, all or selected lanes of the ingress approach of the EV get a green light and are cleared. Based on the prioritisation status information, the EV passes the intersection using the cleared lane(s). After detecting that the EV has successfully passed the intersection, the intersection control switches back to normal operation (i.e., starting with green light for conflicting lanes with high traffic).</p>
Intended Presentation/Alert principle	<p>The driver of the EV receives on an in-vehicle display information about the prioritisation status, early enough and in a moderately intrusive manner (at the vehicle manufacturer's and/or service provider's decision). For example, information on whether the request is accepted or rejected and what lane(s) will be cleared. A combination with the signal phase and timing service can give additional comfort. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ The stationID of the emergency vehicle shall not change during processing of a prioritisation request.</li> <li>○ Authentication and authorisation of emergency vehicles shall be ensured.</li> <li>○ Policy on emergency prioritisation shall be defined, e.g., the level of priority, what locations, which lanes to clear, etc.</li> <li>○ The priority request shall be provided in time to allow the prioritisation system to react on the request.</li> <li>○ Traffic Light Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	<p>This use case could simultaneously be implemented with the HLN-EPVA use case</p>
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The SREM and SSEM message for SI-EVP are profiled in chapter 4.2.4 of [C-Roads MP].</li> <li>○ As inBoundLane the data element 'approach' must be provided.</li> <li>○ As part of RequestorType the 'role' must be set to emergency (6).</li> <li>○ As part of RequestorDescription, the data elements routeName, transitStatus and transitSchedule are not used in this use case.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in</p>

	<p>[C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SREM/SSEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = SI-EVP</li> <li>○ messageType = SREM or SSEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>[C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_SI-GENERIC_ITSG5_SREM-SSEM_REQUEST-ID_23_R2.0.4</li> </ul> </li> <li>○ Hybrid (IP based only): <ul style="list-style-type: none"> <li>○ TC_CROADS_SI-GENERIC_HYBRID_SREM-SSEM_REQUEST-ID_23_R2.0.4</li> </ul> </li> </ul> <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_SI-EVP_ITSG5_SREM_INBOUNDLANE_47_3_R2.0.4</li> <li>○ TC_CROADS_SI-EVP_ITSG5_SREM_REQUESTORDESCRIPTION_47_2_R2.0.4</li> <li>○ TC_CROADS_SI-EVP_ITSG5_SREM_REQUESTORTYPE_47_1_R2.0.4</li> </ul> </li> <li>○ IP based only:</li> </ul>

	<ul style="list-style-type: none"> <li>○ TC_CROADS_SI-EVP_HYBRID_SREM_INBOUNDLANE_47_3_R2.0.4</li> <li>○ TC_CROADS_SI-EVP_HYBRID_SREM_REQUESTORDESCRIPTION_47_2_R2.0.4</li> <li>○ TC_CROADS_SI-EVP_HYBRID_SREM_REQUESTORTYPE_47_1_R2.0.4</li> </ul>
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## 5.2.5 SI – Toll Station Crossing (SI-TSC)

Type of road network	Motorways with a toll station with traffic lights and barriers
Type of vehicle	Automated vehicles (AVs)
<b>Use case introduction</b>	
Summary	After an automated driving system aims for a specific lane at a toll station with traffic lights, the road operator sends information about the topology of the road and the status of the traffic light and the barrier.
Background	In the development of automated vehicles, the automated passing of a toll station is a potential difficult hurdle to take. Once the vehicle has dealt with the choice of the lane, it needs to know the precise configuration of it and the state of both the traffic light and the barrier in order to cross the toll station safely. The information received in C-ITS is a complement to the on-board sensors, which may not be sufficient to deal with this complex situation.
Objective	The objective is to provide to the vehicle information about: <ul style="list-style-type: none"> <li>○ The topology of the road to safely drive towards the appropriate lane;</li> <li>○ The state of the traffic light and the barrier so that it can understand better the situation and determine whether it is allowed and safe to pass the toll gate or not.</li> </ul>
Desired behaviour	The automated driving system must take in consideration the topology information to drive safely towards the appropriate lane. It must then make the appropriate decision, e.g. slow down to a stop, remain stopped, start and pass the gate at the appropriate speed, or e.g. adjust speed and pass the gate at the appropriate speed. Its decisions depend on both the information it receives through connectivity and the information it gets from its sensors, including the detection of obstacles that could prevent it from crossing other lanes or passing the gate.
Expected benefits	<ul style="list-style-type: none"> <li>○ Enhancement of capability to cross a toll station in automated mode, potentially less transitions of control.</li> <li>○ Enhanced traffic safety.</li> <li>○ Fluidity and comfort of the braking and acceleration going through the toll barrier.</li> </ul>
<b>Use case description</b>	
Situation	The automated vehicle is approaching the toll barrier knowing which lane it should go to and is able to proceed to the payment.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ Road operator: the sender is the TCC or the Toll Management Center.</li> <li>○ Automated vehicle: end-user of the service.</li> </ul>
Scenario	<ol style="list-style-type: none"> <li>1. The automated vehicle approaches a toll station that has traffic lights and barriers, knowing which lane it wants to go to.</li> <li>2. The road operator sends the topology of the road upstream and downstream the barrier.</li> <li>3. The automated driving system adapts the trajectory and speed</li> </ol>

	<p>considering the received information and the intended lane.</p> <ol style="list-style-type: none"> <li>The road operator sends information about the status of the barriers (closed or open) and the traffic lights (green or red).</li> <li>The vehicle receives the information and processes it. The automated driving system makes the appropriate decision: slow down to a stop, remain stopped, start and pass the gate at the appropriate speed or adjust speed and pass the gate at the appropriate speed.</li> <li>The automated driving system adapts the trajectory and speed considering the received topology information and the intended direction to leave the toll station.</li> <li></li> </ol>
Display / alert principle	The information may be displayed through the HMI, it is the manufacturer's choice to do so.
Functional Constraints / dependencies	<ul style="list-style-type: none"> <li>The automated driving system needs to know which toll gate it is concerned by.</li> <li>The cartography of the road configuration needs to be predefined and updated often enough by the road operator.</li> <li>Source of information: database of the road operator, up to date, holding the static and dynamic characteristics of the toll station</li> <li>The communication of this message will have to deal with network constraints. Latency must be short enough to let the automated driving system react in time</li> <li>Dependencies with the use case specifying "Toll Station Approaching". The IVI message specified in that use case should be technically specified and developed using the same lane configuration as the one used in the present use case.</li> </ul>
Link to other use cases	This use case is strongly linked to NG-TSA (Navigation Guidance - Toll Station Approaching) use case. These two use cases should work successively.
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>The SPATEM and MAPEM messages for SI-TSC are profiled in chapter 4.2.3 of [C-Roads MP].</li> </ul> <p>Regarding the MAPEM profile used for this use case:</p> <ul style="list-style-type: none"> <li>A toll station is an intersection topography so the DF intersections is used, and roadSegments is not used. In addition, every direction at the tolling station shall be encoded in a dedicated intersection and the numbering of the lanes (DE laneID) shall match the numbering in the IVI message sent at the same toll station when there is one (see Toll station approaching use case).</li> <li>The refPoint should be located at the centre of the toll station.</li> <li>LaneSet shall contain one ingress (lane upstream the barrier) and one egress lane (lane downstream the barrier) for each barrier. Thus, the number of lanes in laneSet shall include at least twice the number of toll lanes. It can also include the lanes and road boundaries, i.e. some types of lane objects used to separate traffic lanes, by using laneType "laneAttributes-Barrier".</li> </ul>

	<ul style="list-style-type: none"> <li>○ NodeList shall start at the toll barrier and end where the toll lanes merge to the motorway lanes for both ingress and egress lanes.</li> <li>○ Attributes are set to: <ul style="list-style-type: none"> <li>○ Indicate merging nodes at the end of tolling lanes in both ingress and egress direction,</li> <li>○ Enable/Disable lane changes at the approach of the tolling barrier.</li> </ul> </li> <li>○ dWidth should be used for nodes where physical road markings is present. It should not be used when no road marking exists.</li> <li>○ signalGroup is mandatory for this use case.</li> </ul> <p>Regarding the SPATEM profile used for this use case:</p> <ul style="list-style-type: none"> <li>○ The broadcast communication of this message will have to deal with network constraints. Latency must be short enough to let the automated driving system react in time.</li> <li>○ Possible values for eventState are: <ul style="list-style-type: none"> <li>○ Unavailable (0) if there is a problem for providing information,</li> <li>○ Stop-And-Remain (3) when the traffic light is red and the barrier down (crossing forbidden),</li> <li>○ Pre-Movement (4) when the traffic light is green and the barrier down (crossing forbidden),</li> <li>○ Permissive-Movement-Allowed (5) when the traffic light is red and the barrier up (crossing conditioned),</li> <li>○ Protected-Movement-Allowed (6) when the traffic light is green and the barrier up (crossing authorized).</li> </ul> </li> <li>○ minEndTime shall be set to 36001 when the end time of the current phase is unknown, which is usually the case for toll barriers traffic lights.</li> <li>○ maxEndTime, likelyTime, confidence and nextTime data elements are not used.</li> <li>○ Data frame speeds is not used.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p>

	<p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = SI-TSC</li> <li>○ messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterized by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>[C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_SI_GENERIC_ITS-G5_SPaTEM-MAPEM_Timing_01_R2.0.4</li> <li>○ TC_CROADS_SI-GENERIC_ITSG5_MAPEM_Location_03_R2.0.4</li> <li>○ TC_CROADS_SI-GENERIC_ITSG5_MAPEM_SPATEM_Generic-Relation_02_R2.0.4</li> </ul> </li> <li>○ Hybrid (IP based only): <ul style="list-style-type: none"> <li>○ TC_CROADS_SI_GENERIC_HYBRID_SPaTEM-MAPEM_Timing_01_R2.0.4.xlsx</li> <li>○ TC_CROADS_SI-GENERIC_HYBRID_MAPEM_Location_03_R2.0.4.xlsx</li> <li>○ TC_CROADS_SI-GENERIC_HYBRID_MAPEM_SPATEM_Generic-Relation_02_R2.0.4</li> </ul> </li> </ul> <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_SI-TSC_ITSG5_MAPEM_attributes_54_R2.1.0</li> <li>○ TC_CROADS_SI-TSC_ITSG5_MAPEM_dWidth_55_R2.1.0</li> <li>○ TC_CROADS_SI-TSC_ITSG5_MAPEM_intersections_50_R2.1.0</li> <li>○ TC_CROADS_SI-TSC_ITSG5_MAPEM_laneSet_52_R2.1.0</li> <li>○ TC_CROADS_SI-TSC_ITSG5_MAPEM_nodeList_53_R2.1.0</li> <li>○ TC_CROADS_SI-TSC_ITSG5_MAPEM_refPoint_51_R2.1.0</li> <li>○ TC_CROADS_SI-TSC_ITSG5_MAPEM_signalGroup_56_R2.1.0</li> </ul> </li> </ul>

- TC\_CROADS\_SI-TSC\_ITSG5\_SPATEM\_Latency\_60\_R2.1.0
- TC\_CROADS\_SI-TSC\_ITSG5\_SPATEM\_eventState\_57\_R2.1.0
- TC\_CROADS\_SI-TSC\_ITSG5\_SPATEM\_predictions\_58\_R2.1.0
- TC\_CROADS\_SI-TSC\_ITSG5\_SPATEM\_speeds\_59\_R2.1.0
  
- Hybrid (IP based only):
  - TC\_CROADS\_SI-TSC\_HYBRID\_Latency\_60\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_MAPEM\_attributes\_54\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_MAPEM\_dWidth\_55\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_MAPEM\_intersections\_50\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_MAPEM\_laneSet\_52\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_MAPEM\_nodeList\_53\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_MAPEM\_refPoint\_51\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_MAPEM\_signalGroup\_56\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_SPATEM\_eventState\_57\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_SPATEM\_predictions\_58\_R2.1.0
  - TC\_CROADS\_SI-TSC\_HYBRID\_SPATEM\_speeds\_59\_R2.1.0

## 6. Automated Vehicle Guidance (AVG)

### 6.1 AVG: Service introduction

Service introduction	
Summary	<p>For automated vehicles at various technical levels of automation, guidance and information from road operators provided via C-ITS can be one of the important input sources to help such vehicles in their highly automated decision making processes.</p> <p>Such additional guidance can be specific to certain types of road networks and dynamic traffic conditions, but also to specific vehicle types and their characteristics.</p> <p>The information provided ranges from simple guidance for certain road segments or lanes, but can also recommend parameters for highly automated vehicles not to drive in groups at certain unsuitable sections and/or lanes on the network (e.g., platooning guidance for trucks under certain road and traffic conditions).</p> <p>The service as a whole is strictly guidance and never to be understood as regulation or instruction. Any guidance provided is not a road operator's guarantee for a safe operation of certain modes of automation. It aims to be an additional piece of information for the vehicle's decision-making process while engaging in modes of automation, transporting the road operator's view into the vehicle.</p>
Background	<ul style="list-style-type: none"> <li>○ Road operators face the challenge to be responsible both for an uninterrupted operation of their networks and a dynamic adaption of said network to the future needs of its users and travellers.</li> <li>○ This is particularly true for the introduction of automated vehicles into the traffic situation, where long periods of mixed vehicle fleets can be foreseen: traditional, connected and automated vehicles will be operating in parallel for many years on the same road networks.</li> <li>○ Therefore, it is of high interest for road operators to use all options of connected vehicle communication and C-ITS messages to support this transition to automated traffic with highly dynamic use cases and scenarios targeted to these specific vehicle groups on the road network to enhance safety and efficiency.</li> </ul>
Objective	<ul style="list-style-type: none"> <li>○ Enhanced road safety and traffic efficiency on road networks by giving specific advice and guidance to various vehicle types and groups based on current traffic conditions and the road operator's view.</li> <li>○ Support the introduction of automated vehicles into the transport system by extending the communication to all types of vehicles via standard messages that can be interpreted in a uniform way by all passing vehicle types and can be used for safer and more efficient travel.</li> </ul>

	<ul style="list-style-type: none"> <li>○ Provide additional information and guidance for automated vehicles operating in regular traffic conditions, where most traffic is not yet automated.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Provide more detailed and specifically tailored information in order to generate more uniform and dynamically adapted transport flows on road networks.</li> <li>○ Overall higher energy efficiency and reduced energy consumption, as well as reduced numbers of accidents and delays in transport operations.</li> <li>○ Safety gains and better decision-making processes for early adopters of vehicle automation in mixed traffic situations while transitioning to higher levels and volume of automation in traffic</li> </ul>
Use cases	<ul style="list-style-type: none"> <li>○ SAE Level Guidance (AVG – SAELG)</li> <li>○ Platoon Support Information (AVG – PSI)</li> </ul> <p>Additional Use cases will be defined and added later.</p>

## 6.2 AVG: Use Cases

### 6.2.1 AVG – SAE Level Guidance (AVG-SAELG)

Use case introduction	
Type of road network	All
Type of vehicle (receiver)	Partly Automated Vehicles (at SAE levels 2,3,4)
Summary	<p>The purpose of this use case is to provide guidance and information on the SAE levels of automation road operators consider unsuitable for partly automated vehicles on certain road or lane segments on their network, at a given point in time, considering overall road conditions and the current traffic situation.</p> <p>The use case as a whole is strictly guidance and never to be understood as regulation or instruction. Any guidance provided is not a road operator's guarantee for safe operation of certain modes of automation nor is it a definitive statement that certain modes of automation are possible or impossible, allowed or not allowed.</p> <p>It aims to be an additional piece of information for the vehicle's decision-making process while engaging in modes of automation, transporting the road operator's view into the vehicle. This can result in an increase/decrease of functionalities required from the automated vehicle and a corresponding increase/decrease in what is required from the driver, based on the overall traffic situation, the sensory input from the vehicle itself and the message received by the infrastructure.</p>
Background	<p>Infrastructure based guidance on the unsuitable levels of automation is expected to provide improvements to the efficiency of traffic flow as well as road safety by providing automated vehicles with additional information in their assessment of possible automation.</p> <p>This will be especially useful/necessary in the transitional phase towards completely automated driving, which will include conventional vehicles, connected vehicles as well as autonomous vehicles. This transition phase of mixed vehicle fleets is expected to last at least 20 years, with overall traffic flows growing nonetheless.</p> <p>SAE levels are currently the only clearly defined metric for automation levels supported by standards and thus are utilised for this use case. Road operators are already working on other metrics to better convey support for automated driving on their road network, e.g., Infrastructure Support for Automated Driving (ISAD) levels. Once available in standards, such metrics might update or even replace this use case.</p>
Objective	<ul style="list-style-type: none"> <li>○ Guide and inform vehicles about the road operators' assessment of currently unsuitable SAE automation levels in a specific area.</li> <li>○ Provide detailed geographical information about the affected area as</li> </ul>



Desired behaviour	<p>well as information about vehicles affected by this guidance information</p> <ul style="list-style-type: none"> <li>○ specific road segment</li> <li>○ specific lane</li> <li>○ specific vehicle type</li> <li>○ Inform vehicles about the start and end position of the guidance area.</li> <li>○ Provide additional speed recommendations for the affected road segments and lanes (optionally, if available).</li> <li>○ Vehicles consider the information in their driving plans (e.g., lane selection) or trajectories.</li> <li>○ Automated vehicles consider the information in the selection of the level of automation used.</li> <li>○ Automated vehicle driver/operator is informed about a change in the automation level recommendation from the infrastructure, especially when switching from higher to lower levels of automation (reasoning).</li> </ul> <p>This use case describes guidance principles and information provided to automated vehicles for specific road segments and traffic conditions. It does not describe the behaviour of the automated vehicle, especially not at the end of any guidance information (e.g., how to switch automation levels in that case, guiding the vehicle to a safe place, ...)</p>
Expected benefits	<ul style="list-style-type: none"> <li>○ Drivers of conventional vehicles experience overall safer traffic conditions if automated vehicles select their level of automation based on the best possible inputs from all sources, including infrastructure.</li> <li>○ Automated vehicle guidance and information on the SAE level of automation road operators consider unsuitable for partly automated vehicles on certain road or lane segments on their network, at a given point in time, considering overall road conditions and the current traffic situation. Automated vehicles can include this information in their decision-making process and will be able to adjust their driving plans and trajectories as well as the usage of automation functions if necessary. Additionally, they may be able to inform their drivers in time about any adjustment that might require more attention from the driver.</li> <li>○ Road operator: <ul style="list-style-type: none"> <li>○ Supports a safer and more gradual introduction of automated driving on specific, C-ITS-equipped road segments and/or lanes.</li> <li>○ Brings the road operator's view on automation into the decision-making process of automated vehicles.</li> <li>○ Ensures traffic safety and traffic flow efficiency in the transitional phase towards fully automated driving.</li> <li>○ Reduces costs and congestion related to accidents.</li> </ul> </li> </ul>
<b>Use case description</b>	
Situation	<ul style="list-style-type: none"> <li>○ The road operator monitors the situation on the road and gives road segment and lane specific guidance on the SAE level of automation the road operator considers unsuitable for partly automated vehicles</li> </ul>

	<p>under current traffic conditions.</p> <ul style="list-style-type: none"> <li>○ Following changes in traffic and/or driving conditions (because of accidents, congestion, weather, etc.), a reassessment of the given advice can occur.</li> <li>○ If the assessment leads to a change of the guidance information, vehicles and the drivers need to be informed.</li> <li>○ Therefore, the road infrastructure operator distributes an updated and appropriate follow-up message.</li> </ul>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Generates the use case information at the TCC, considering all available information for the specific road segment and the overall traffic conditions.</li> <li>○ <b>Drivers:</b> Drivers and their C-ITS connected vehicles are the end-users of this use case. They receive the information and include it in their decision-making process in selecting automation levels (for partly automated vehicles) or are simply informed about the guidance given to other vehicles on the road segment they are travelling on (in case of connected vehicles)</li> </ul>
Use case scenario	<p>Road operators monitor their road network, derive triggering conditions for the use case and apply them to specific parts of the road network.</p> <p><u>Scenario 1:</u></p> <ul style="list-style-type: none"> <li>○ Due to road conditions and current traffic on a stretch of the road, guidance information is sent out that vehicles (of type x.y, e.g. weight higher than 3.5 tons) should not use automation levels 3 or 4 on lane 2 of the network within a certain area, indicated by a zone (with start, end and intermediate points).</li> </ul> <p><u>Scenario 2:</u></p> <ul style="list-style-type: none"> <li>○ The guidance on the use of automation levels on a specific part of a road is set in a way that SAE level 4 is unsuitable from the infrastructure's point of view. Due to the overall traffic situation, an accident or weather conditions, the guidance information from the infrastructure on the unsuitable SAE automation levels changes to include levels 3 and 4.</li> </ul> <p>Connected vehicles approaching the section receive the message and consider it in their decision-making process when selecting the level of automation, speed or lane to be used.</p>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The information is sent to the vehicle and is supposed to be considered in the decision-making process when selecting automation levels, speed, and lane usage.</li> <li>○ Presentation of information to the driver when changing automation level is expected, especially when the driver needs to increase driving efforts, but all requirements of in-vehicle visualisation and interaction are of course under the complete responsibility and decision authority</li> </ul>

	<p>of the vehicle manufacturer or operator of the automated vehicle.</p> <ul style="list-style-type: none"> <li>○ This includes the responsibility and decision to make the driver aware in time to be able to take needed actions to comply a change in automation level.</li> <li>○ The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional constraints/dependencies	<ul style="list-style-type: none"> <li>○ There is a need to present information to the driver if the guidance given leads to a change of automation requiring his reaction within a specific time or position on the network.</li> <li>○ How the information is presented to the drivers 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.</li> </ul>
Link to other use cases	none
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The IVI message for AVG-SAELG is profiled in chapter 4.2.2.4 of [C-Roads MP].</li> <li>○ IVI messages for AVG-SAELG shall use message management based on update and cancellation of messages.</li> <li>○ iviStatus shall be set to “new” for new information in the IVIM, to “update” when the IVIM changes and to “cancellation” when the information in the IVIM is no longer valid.</li> <li>○ A cancellation IVIM shall be repeated at least for 5min after its first transmission.</li> <li>○ <i>NOTE: The exact effort to ensure that all vehicles receive the cancellation will be resolved in future releases.</i></li> <li>○ validTo may be used to encode an end time for the overall IVI message, at least 1 hour ahead of the time indicated by the DE timestamp. Providing this end time can serve the purpose of avoiding an issue of perpetually valid IVIM in case cancellation is missed repeatedly. The definition of all geographical zones should be included in as few GlcParts as possible.</li> <li>○ IVIM can contain more than one Geographical Location Container (GLC). An additional GLC should only be included in an IVIM if required zones cannot be defined within the value range constraints of DF DeltaPositions towards the referencePosition.</li> <li>○ IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM.</li> <li>○ For this use case, the DF automatedVehicleRules shall be mandatory while the DF platooningRules shall be absent.</li> <li>○ As this use case informs about SAE levels road operators find unsuitable for automated driving on a selected segment, the respective</li> </ul>

opposite levels shall be encoded in the DE allowedSAEAutomationLevels. If for example SAE levels 4 and 5 are unsuitable from the road operator's point of view, levels 0, 1, 2, and 3 shall be put into allowedSaeAutomationLevels. Any guidance provided is not a road operator's guarantee for safe operation of certain modes of automation nor is it a definitive statement that certain modes of automation are possible or impossible, allowed or not allowed.

- If traffic signs for automated vehicles are present in the SAE Level Guidance:
  - RSCode in RoadSignCodes shall be used to encode up to 4 traffic signs.
  - Temporal restrictions of individual signs (when a sign is either valid or invalid only for a certain time period) shall be encoded with suitable ISO14823Attributes (DTM, EDT) in the DF roadSignCodes and not by using either validFrom or validTo of the overall IVIM.
  - The IVIM shall always correspond to the legal statement as displayed by the static or electronic sign it represents.
  - Signs which indicate the end of a specific or all regulations / restrictions should not be transmitted explicitly as individual signs in an IVIM
  - Within one or multiple IVIMs issued by the same road operator, the same traffic sign should not be assigned more than once to the same relevance zone.
  - Information corresponding to physical signs (either static or electronic) shall as far as possible be encoded using machine-readable message components, via adhering as much as possible to the following rules:
    - Shifting of relevance zone(s) according to subpanel information
    - Extension of relevance zone(s) in case of sign repetition
    - Restriction of signs to certain vehicle types and/or dimensions
    - Encoding of ISO14823Attributes where applicable
      - Validity in time (DMT, EDT)
      - Lane Flow (DFL)
      - Vehicle dimensions (VED)
      - Speed (SPE)
      - Rate of Incline (ROI)
      - Distance between vehicles (DBT)
      - Destination (DDD)
    - Encoding of subpanels using roadSignCodes available in ISO 14823 for subpanels instead of extraText

	<ul style="list-style-type: none"><li>○ If the aim is to inform vehicles on all stretches of road diverging from or converging into a relevance zone, suitable zones for these stretches shall be present in the GLC and referenced in the AVC as necessary.</li><li>○ The RoadConfigurationContainer (RCC) shall be provided, except if the road operator does not have the information, then both RCC and (if signs are present) applicable lanes in the AutomatedVehicleContainer (AVC) should be omitted and only signs valid for all legally drivable lanes on the entire carriageway shall be transmitted.</li></ul>												
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the “Road configuration container” as well as the “Automated Vehicle Container”. The IVIM permissions (SSP) have to be encoded as defined in [ETSI TS 103 301]. These SSPs are encoded in Octets 4-5 within the respective field of the certificate to be used (AT), in addition to the serviceProviderId encoded in Octets 1-3.</p> <table><tr><td></td><td colspan="2">SSP position</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td></tr><tr><td>Road Configuration Container</td><td>5</td><td>1</td></tr><tr><td>Automated Vehicle Container</td><td>5</td><td>5</td></tr></table> <p>The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>		SSP position		CauseCodeType / Container	Octet position	Bit position	Road Configuration Container	5	1	Automated Vehicle Container	5	5
	SSP position												
CauseCodeType / Container	Octet position	Bit position											
Road Configuration Container	5	1											
Automated Vehicle Container	5	5											
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>												
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p>												

Test and validation requirements	<p>For use cases based on IVIM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType= AVG-SAELG</li> <li>○ messageType = IVIM</li> </ul> <p>Geographic area (Quadtree) for IVIM message:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p> <p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GLC_referencePosition_01_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GLC_GlcParts_2_1_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_TIMING_03_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_Update_Cancel_04_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_Status-Update_4_1_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_serviceProviderId_45_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_iviIdentificationNumber_45_1_R2.0.3</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_iviType_75_2_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_detectionZoneIds_110_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_roadSignCodes_111_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GLC_GlcParts_segment_setOfLanes_112_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_extraText_114_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_GIC_GlcParts_116_R2.3.0</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_IVIM_reference position_01_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID_IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID_IVIM_GlcPart_2_1_R2.0.3</li> <li>○ TC_CROADS_GENERIC_HYBRID_IVIM_TIMING_03_R2.0.1</li> </ul> </li> </ul>
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- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Update\_Cancel\_04\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Status-Update\_04\_1\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_serviceProviderId\_45\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_ivIdentificationNumber\_45\_1\_R2.0.3

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_AVG-GENERIC\_ITSG5\_IVIM\_AutomatedVehicleContainer\_55\_R2.0.1
  - TC\_CROADS\_AVG\_GENERIC\_ITSG5\_IVIM\_AutomatedVehicleContainer\_detectionZonelds\_55\_1\_R2.3.0
  - TC\_CROADS\_AVG-SAELG\_ITSG5\_IVIM\_automatedVehicleRules\_59\_R2.0.1
  - TC\_CROADS\_AVG-SAELG\_ITSG5\_IVIM\_AutomatedVehicleRule\_extraText\_59\_1\_R2.3.0
  - TC\_CROADS\_AVG-SAELG\_ITSG5\_IVIM\_allowedSAEAutomationLevels\_60\_R2.0.1
- Hybrid (IP based only):
  - TC\_CROADS\_AVG-GENERIC\_HYBRID\_IVIM\_AutomatedVehicleContainer\_55\_R2.0.1
  - TC\_CROADS\_AVG-SAELG\_HYBRID\_IVIM\_automatedVehicleRules\_59\_R2.0.1
  - TC\_CROADS\_AVG-SAELG\_HYBRID\_IVIM\_allowedSAEAutomationLevels\_60\_R2.0.1

## 6.2.2 AVG – Platoon Support Information (AVG-PSI)

Type of road network	Motorways
Type of vehicle (receiver)	Automated Vehicles that want to engage in platooning situations
<b>Use case introduction</b>	
Summary	<p>The purpose of the use case is to provide road operator-based guidance and information on the unsuitability of “platooning” on specific road or lane segments on the road network, considering different vehicle classes, overall road conditions and the current traffic situation. A platoon is a group of vehicles sharing the same destination, travelling closely together at a common speed.</p> <p>Platooning situations can involve different vehicle classes, including trucks as well as cars. Platoons itself can be either vehicle type specific (e.g., truck platooning) or consist of mixed vehicle types.</p> <p>The use case as a whole is strictly guidance and never to be understood as regulation or instruction. Any guidance provided is not a road operator’s guarantee for safe operation of certain modes of platooning nor is it a definitive statement that the formation of a platoon is possible or impossible, allowed or not allowed.</p> <p>It aims to be an additional piece of information for the vehicle’s decision-making process to enter a platooning situation, transporting the road operator’s view into the vehicle. This can influence the overall decision of the vehicle to enter a platooning situation and the parameters of platooning (number of vehicles, overall speed and distance gap between vehicles) used by these vehicles, based on the overall traffic situation, the sensory input from the vehicle itself and the messages received by the infrastructure.</p>
Background	<p>Infrastructure based guidance on the unsuitability of platooning is expected to provide improvements to the efficiency of traffic flow as well as road safety by providing automated vehicles with additional information in their assessment of possible automation.</p> <p>The legal framework for vehicles of all kinds to enter a platoon situation may be different in individual member states, some having no restrictions at all while others may limit platooning to certain vehicle classes or even dedicated environments only. The use case might therefore differ in national implementations. However, it is undisputed that large groups of automated vehicles driving in a very close distance to each other may pose a challenge for traffic management. A platoon of several automated vehicles may for example “block” the access to ramps for other vehicles due to short distance gaps or have a negative overall impact on traffic flow.</p> <p>This will especially be a topic in the transitional phase towards completely automated driving, which will include conventional vehicles, connected vehicles as well as autonomous vehicles. This transition phase of mixed vehicle fleets is expected to last at least 20 years, with overall traffic flow growing, nonetheless.</p>



	<p>Platooning support information may currently indicate unsuitable SAE levels because they are currently the only clearly defined metric supported by standards. Road operators are already working on other metrics to better convey support for automated driving on the road network, e.g., Infrastructure Support for Automated Driving (ISAD) levels. Once available in standards, such metrics might update or even replace this use case.</p> <p>Further work on a more comprehensive communication stream from road operators to vehicles will be necessary and not be limited to just this use case. The aim would be that vehicles, under certain prerequisites like e.g., functional safety, could potentially act solely based on the guidance received from infrastructure.</p>
Objective	<ul style="list-style-type: none"> <li>○ Guide and inform vehicles about the road operators' assessment of unsuitability of platooning in a specific area.</li> <li>○ Provide detailed geographical information about the affected area as well as information about vehicles affected by this guidance information <ul style="list-style-type: none"> <li>○ specific road segment</li> <li>○ specific lanes</li> <li>○ specific vehicle type</li> </ul> </li> <li>○ Inform vehicles about the start and end position of the guidance area.</li> <li>○ Provide additional guidance regarding platooning parameters (maximum number of vehicles, maximum length of platoon, minimum distance gap, speed limits and speed recommendations) for the affected road segments and lanes (optionally, if available).</li> <li>○ Provide learning possibilities on automated vehicle guidance using cross sector collaboration.</li> </ul>
Desired behaviour	<ul style="list-style-type: none"> <li>○ Vehicles consider the information in their overall driving plans (e.g., lane selection) or trajectories.</li> <li>○ Automated vehicles consider the information in their decision to enter, leave or change a platooning situation.</li> <li>○ Vehicles forming or leaving a platoon perform the desired actions without major disruptions for the other traffic participants.</li> <li>○ Platoons are operated on selected lanes only as indicated by the road operator's guidance on unsuitability.</li> <li>○ Automated vehicle drivers/operators are informed about changes in the platooning situation, in particular when starting or stopping a platoon or changing its core parameters (reasoning), especially when it requires additional attention from the driver.</li> </ul> <p>This use case describes guidance principles and information provided to automated vehicles on platooning for specific road segments and traffic conditions. It does not describe the behaviour of the automated vehicle inside or outside of the platoon, especially not at the end of any guidance information (e.g., how to enter or leave a platoon safely, ...)</p>
Expected benefits	<ul style="list-style-type: none"> <li>○ Drivers of conventional vehicles experience overall safer traffic</li> </ul>

	<p>conditions if automated vehicles base their platooning decisions on the best possible inputs from all sources, including infrastructure.</p> <ul style="list-style-type: none"> <li>○ This use case provides automated vehicle guidance and information on the unsuitability of platooning on certain SAE automation levels for automated vehicles on certain road or lane segments on the road operator's network, at a given point in time, considering overall road conditions and the current traffic situation. Automated vehicles can include this information in their decision-making process and will be able to adjust their driving plans and trajectories as well as their platooning activities if necessary. Additionally, they may be able to inform their drivers in time about any adjustment that might require more attention from the driver.</li> <li>○ Road operator: <ul style="list-style-type: none"> <li>○ Supports a safer and more gradual introduction of automated driving on specific, C-ITS-equipped road segments and/or lanes.</li> <li>○ Brings the road operator's view on platooning into the decision-making process of automated vehicles.</li> <li>○ Ensures traffic safety and traffic flow efficiency in the transitional phase towards fully automated driving.</li> <li>○ Reduces costs and congestion related to accidents.</li> </ul> </li> </ul>
<b>Use case description</b>	
Situation	<ul style="list-style-type: none"> <li>○ The road operator monitors the situation on the road and gives road segment and lane specific guidance on the unsuitability of platooning as well as appropriate platooning parameters under current traffic conditions.</li> <li>○ Following changes in traffic and/or driving conditions (as a result of traffic density, accidents, congestion, weather, etc.), a reassessment of the given advice can occur.</li> <li>○ If the assessment leads to a change of the guidance information, vehicles and drivers need to be informed.</li> <li>○ Therefore, the road infrastructure operator distributes an updated and appropriate follow-up message.</li> </ul>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Generates the use case information at the TCC, considering all available information for the specific road segment and the overall traffic conditions.</li> <li>○ <b>Drivers:</b> Drivers and their C-ITS connected vehicles are the end-users of this use case. They receive the information and include it in their decision when entering, leaving or maintaining platooning situations (for automated vehicles) or are simply informed about the guidance given to other vehicles on the road segment they are travelling on and select a different lane or segment to avoid interference with the platoon (in case of connected vehicles).</li> </ul>
Use case scenario	Road operators monitor the road network, derive triggering conditions for the use case and apply them to specific parts of the road network.

	<p><u>Scenario 1:</u></p> <ul style="list-style-type: none"> <li>○ The road operator wants to give guidance information that new platooning situations should not be created, or existing platooning situations should be dissolved, regardless of the SAE level, due to overall difficult traffic or environmental situations, e.g., in an area with multiple ramps and intersections given high traffic.</li> </ul> <p><u>Scenario 2:</u></p> <ul style="list-style-type: none"> <li>○ Due to road conditions and current traffic on a stretch of the road, guidance information is sent out that certain vehicle classes (e.g., vehicles with a weight higher than 3.5 tons) should not engage in platooning on the network within a certain area and certain lanes, indicated by a zone (with start, end, and intermediate points).</li> </ul> <p><u>Scenario 3:</u></p> <ul style="list-style-type: none"> <li>○ The guidance on the use of platooning on a specific part of a road is set in a way that platooning is unsuitable from the infrastructure's point of view under certain conditions. Due to the overall traffic situation, an accident or weather conditions, the conditions for platooning change in the view of the road operator and the guidance information from the infrastructure shall be updated in certain parameters (e.g., length of guidance zone, type of vehicles, affected lanes, level of automation (SAE), ...).</li> </ul> <p>Connected vehicles approaching the section receive the message and consider it in their decision-making process of engaging or maintaining platooning and their selection of number of vehicles or overall length of the platoon, speed, distance gap or lane selected.</p>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The information is sent to the vehicle and is supposed to be considered in the decision-making process or the parameters of platooning of said vehicle when engaging or maintaining platooning situations.</li> <li>○ Presentation of information to the driver when engaging or disengaging platooning is expected, especially when the driver needs to increase driving efforts, but all requirements of in-vehicle visualisation and interaction are of course under the complete responsibility and decision authority of the vehicle manufacturer or operator of the automated vehicle. This includes the responsibility and decision to make the driver aware in time to be able to take needed actions to comply to change in the overall platooning situation or the parameters of platooning.</li> </ul>
Functional constraints/dependencies	There is a need to present information to the driver if the given guidance leads to a change of the platooning situation or its parameters requiring his reaction within a specific time or position on the network.
Link to other use cases	none

## Interoperability Requirements

### Message profile requirements

- The IVI message for AVG-PSI is profiled in chapter 4.2.2.4 of [C-Roads MP].IVI messages for AVG-PSI shall use message management based on update and cancellation of messages.
- iviStatus shall be set to “new” for new information in the IVIM, to “update” when the IVIM changes and to “cancellation” when the information in the IVIM is no longer valid.
- A cancellation IVIM shall be repeated at least for 5min after its first transmission.
- *NOTE: The exact effort to ensure that all vehicles receive the cancellation will be resolved in future releases.*
- validTo may be used to encode an end time for the overall IVI message, at least 1 hour ahead of the time indicated by the DE timestamp. Providing this end time can serve the purpose of avoiding an issue of perpetually valid IVIM in case cancellation is missed repeatedly.
- The definition of all geographical zones should be included in as few GlcParts as possible.
- IVIM can contain more than one Geographical Location Container (GLC). An additional GLC should only be included in an IVIM if required zones cannot be defined within the value range constraints of DF DeltaPositions towards the referencePosition.
- IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM.
- For this use case, the DF automatedVehicleRules shall be mandatory while the DF platooningRules shall be absent.
- As this use case may include information about SAE levels road operators find unsuitable for platooning on a selected segment, the respective opposite levels shall be encoded in this DE. If for example SAE levels 4 and 5 are unsuitable for platooning from the road operator’s point of view, levels 0, 1, 2, and 3 shall be put into allowedSaeAutomationLevels. Any guidance provided is not a road operator’s guarantee for safe operation of certain modes of automation nor is it a definitive statement that certain modes of automation are possible or impossible, allowed or not allowed.
- If traffic signs for automated vehicles are present in the Platoon Support Information:
  - RSCode in RoadSignCodes shall be used to encode up to 4 traffic signs.
  - Temporal restrictions of individual signs (when a sign is either valid or invalid only for a certain time period) shall be encoded with suitable ISO14823Attributes (DTM, EDT) in the DF roadSignCodes and not by using either validFrom or validTo of the overall IVIM.

	<ul style="list-style-type: none"> <li>○ The IVIM shall always correspond to the legal statement as displayed by the static or electronic sign it represents.</li> <li>○ Signs which indicate the end of a specific or all regulations / restrictions should not be transmitted explicitly as individual signs in an IVIM</li> <li>○ Within one or multiple IVIMs issued by the same road operator, the same traffic sign should not be assigned more than once to the same relevance zone.</li> <li>○ Information corresponding to physical signs (either static or electronic) shall as far as possible be encoded using machine-readable message components, via adhering as much as possible to the following rules: <ul style="list-style-type: none"> <li>▪ Shifting of relevance zone(s) according to subpanel information</li> <li>▪ Extension of relevance zone(s) in case of sign repetition</li> <li>▪ Restriction of signs to certain vehicle types and/or dimensions</li> <li>▪ Encoding of ISO14823Attributes where applicable <ul style="list-style-type: none"> <li>• Validity in time (DMT, EDT)</li> <li>• Lane Flow (DFL)</li> <li>• Vehicle dimensions (VED)</li> <li>• Speed (SPE)</li> <li>• Rate of Incline (ROI)</li> <li>• Distance between vehicles (DBT)</li> <li>• Destination (DDD)</li> </ul> </li> <li>▪ Encoding of subpanels using roadSignCodes available in ISO 14823 for subpanels instead of extraText</li> </ul> </li> <li>○ If the aim is to inform vehicles on all stretches of road diverging from or converging into a relevance zone, suitable zones for these stretches shall be present in the GLC and referenced in the AVC as necessary.</li> <li>○ The RoadConfigurationContainer (RCC) shall be provided, except if the road operator does not have the information, then both RCC and (if signs are present) applicable lanes in the AutomatedVehicleContainer (AVC) should be omitted and only signs valid for all legally drivable lanes on the entire carriageway shall be transmitted.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p>

This use case is based on the “Road configuration container” as well as the “Automated Vehicle Container”. The IVIM permissions (SSP) have to be encoded as defined in [ETSI TS 103 301]. These SSPs are encoded in Octets 4-5 within the respective field of the certificate to be used (AT), in addition to the serviceProviderId encoded in Octets 1-3.

CauseCodeType / Container	SSP position	
	Octet position	Bit position
Road Configuration Container	5	1
Automated Vehicle Container	5	5

The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf.

*NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.*

Communication technology requirements: ITS-G5

For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.

For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements of C-Roads, [C-Roads MSP] shall apply.

Communication technology requirements: IP based

For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.

For use cases based on IVIM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:

- serviceType= AVG-PSI
- messageType = IVIM

Geographic area (Quadtree) for IVIM message:

The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].

Test and validation requirements

[C-Roads\_TVC] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from [C-Roads\_TP]:

- ITS-G5 only:
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GLC\_referencePosition\_01\_R2.3.0
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_ZONES\_02\_R2.0.1
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GLC\_GlcParts\_2\_1\_R2.3.0
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_TIMING\_03\_R2.0.1
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_Update\_Cancel\_04\_R2.0.1
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_Status-Update\_4\_1\_R2.0.1
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_serviceProviderId\_45\_R2.0.1
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_ivIdentificationNumber\_45\_1\_R2.0.3
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_iviType\_75\_2\_R2.3.0
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_detectionZoneIds\_110\_R2.3.0
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_roadSignCodes\_111\_R2.3.0
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GLC\_GlcParts\_segment\_setOfLanes\_112\_R2.3.0
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_extraText\_114\_R2.3.0
  - TC\_CROADS\_GENERIC\_ITSG5\_IVIM\_GIC\_GlcParts\_116\_R2.3.0
- IP based only:
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_reference position\_01\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_ZONES\_02\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_GlcPart\_2\_1\_R2.0.3
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_TIMING\_03\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Update\_Cancel\_04\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Status-Update\_04\_1\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_serviceProviderId\_45\_R2.0.1
  - TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_ivIdentificationNumber\_45\_1\_R2.0.3

List of applicable specific test cases:

- ITS-G5 only:

- TC\_CROADS\_AVG-  
GENERIC\_ITSG5\_IVIM\_AutomatedVehicleContainer\_55\_R2.0.1
- TC\_CROADS\_AVG-PSI\_ITSG5\_IVIM\_platooningRules\_61\_R2.0.1
- TC\_CROADS\_AVG-  
PSI\_ITSG5\_IVIM\_platooningRules\_extraText\_61\_1\_R2.3.0
- TC\_CROADS\_AVG-  
PSI\_ITSG5\_IVIM\_platooningRules\_roadSignCodes\_61\_2\_R2.3.0
- TC\_CROADS\_AVG-  
PSI\_ITSG5\_IVIM\_allowedSAEAutomationLevels\_62\_R2.0.1
- TC\_CROADS\_AVG-  
PSI\_ITSG5\_IVIM\_AutomatedVehicleRule\_roadSignCodes\_62\_1\_R2.3.0
- Hybrid (IP based only):
  - TC\_CROADS\_AVG-  
GENERIC\_HYBRID\_IVIM\_AutomatedVehicleContainer\_55\_R2.0.1
  - TC\_CROADS\_AVG-PSI\_HYBRID\_IVIM\_platooningRules\_61\_R2.0.1
  - TC\_CROADS\_AVG-  
PSI\_HYBRID\_IVIM\_allowedSAEAutomationLevels\_62\_R2.0.1





## 7. Navigation Guidance (NG)

### 7.1 NG: Service introduction

Service introduction	
Summary	This service aims to provide accurate navigation guidance in complex and dynamic traffic situations in order to support a human driver or an automated driving system when approaching or passing these situations on the route to their destination.
Background	<p>For human drivers, navigating towards and through specific (dynamic) complex traffic situations can be challenging. Additional digital supporting information to anticipate the navigation in these specific (dynamic) situations could help to reduce the number of accidents and smoothen traffic.</p> <p>Approaching these (dynamic) situations is also an important challenge to tackle for vehicles with automated driving systems (ADS). Humans are (still) able to collect and process the necessary information when approaching (dynamic) complex situations and able to adapt to any unpredicted situations. The automated driving system and its sensors may have more difficulties and might/will need this additional information.</p>
Objective	The objective is to guide drivers in such a way that the automated driving system or the human driver adapts its speed, trajectory or route, in order to navigate correctly and safely through the (dynamic) complex traffic situation to their destination.
Expected benefits	<ul style="list-style-type: none"> <li>○ Improved safety (less accidents or potential unsafe situations) and improved throughput by providing accurate information / guidance</li> <li>○ To enable automated vehicles to get through these (dynamic) complex situations without deactivating the automated driving system which means that no transition of control to a human driver is necessary.</li> </ul>
Use Cases	<ol style="list-style-type: none"> <li>1. Toll Station Approaching</li> <li>2. Smart Routing</li> <li>3. Route Advice</li> </ol> <p>Other Navigation Guidance use cases may be added in future releases</p>

## 7.2 NG: Use Cases

### 7.2.1 NG – Toll Station Approaching (NG-TSA)

Type of road network	Motorways
Type of vehicle	All, adapted for automated driving systems
<b>Use case introduction</b>	
Summary	As a vehicle is approaching a toll station, a specific message is sent by the road operator, helping to orient the driver/vehicle towards the appropriate toll collection lane(s). Multiple information elements are provided within this message, amongst others the availability and authorized means of payment for each lane.
Background	<p>For human drivers, navigating towards the appropriate lane can be challenging. Having the necessary information to anticipate the navigation in the toll station area can reduce the number of accidents and smoothen traffic.</p> <p>Approaching a toll station correctly is also an important challenge for automated vehicles to tackle. While humans are able to collect and process the necessary information approaching a toll station and to adapt to any unpredicted situations, the automated driving system and its sensors may have more difficulties and will need this additional information.</p>
Objective	The objective is to help anticipating the navigation towards the most appropriate lane for the vehicles according to the configuration of the toll station.
Desired behaviour	The automated driving system or the human driver adapts its speed and trajectory in order to approach the toll station safely and in the correct direction depending on the different types of lanes.
Expected benefits	<ul style="list-style-type: none"> <li>○ To improve the traffic flow of all traffic at the toll platform and upstream.</li> <li>○ To enable automated vehicles to get through toll stations without deactivating the automated driving system.</li> <li>○ To improve the security at the approach of toll stations.</li> </ul>
<b>Use case description</b>	
Situation	A driver or vehicle approaches a toll station on a motorway and receives information about the upcoming toll lanes in order to facilitate the selection and navigation process towards the most appropriate one. Multiple information elements characterizing the lanes can be provided such as their availability and the authorized means of payments but also other specificities that may apply (e.g. authorized categories of vehicles, maximum height, maximum crossing speed, etc.)"
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ Road Operator: the sender of the information is the TCC or the Toll Management Center (TMC).</li> </ul>

Scenario	<ul style="list-style-type: none"> <li>○ Automated driving system or human driver: end-user of the service.</li> <li>○ The TCC, knowing the configuration of the toll station, sends information about the static and dynamic characteristics and the state of each lane to all vehicles.</li> <li>○ Vehicles receive the toll information and processes it. The information given is anticipated enough to permit the drivers/vehicles to adapt their speed and trajectory towards the selected toll lane in advance.</li> <li>○ The automated driving system or the human driver use the received information to identify the most appropriate toll lane to navigate towards. The selection can either be made automatically, manually on the HMI or even mentally for human drivers, depending on the vehicle implementation.</li> </ul>
Display / alert principle	<p>It is important that the vehicle gets the information in time (upstream of the toll station) so that it can process the information in time and act accordingly.</p> <p>The information may be displayed through the HMI, it is the manufacturer's choice to do so. It is not specifically required for automated vehicles.</p>
Functional Constraints / dependencies	<ul style="list-style-type: none"> <li>○ If the automated driving system cannot manage to reach the selected toll station, it reacts accordingly in order to prevent any risk for the vehicle or other road users.</li> <li>○ In case of an automated driving system, it is required that the automated driving systems has all the other necessary information to select the appropriate toll station, e.g. the means of payment.</li> </ul>
Link to other use cases	<ul style="list-style-type: none"> <li>○ This use case is strongly linked to SI-TSC (Signalized Intersections - Toll Station Crossing) use case. These two use cases should work successively.</li> <li>○ Dependencies with the use case specifying "SI-TSC". The MAP and SPAT messages specified in that use case should be technically specified and developed using the same lane configuration as the one used in the present use case.</li> </ul>
<b>Interoperability Requirements</b>	
<p>Message profile requirements</p> <p><i>NOTE: The current use case specific message profile requirements are based on an older release of C-ROADS IVIM profiles and are therefore outdated and no longer correct with regards to topic of message management and the use of time-based message elements (e.g. validTo).</i></p>	<ul style="list-style-type: none"> <li>○ The IVI message for NG-TSA is profiled in chapters 4.2.2.1 &amp; 4.2.2.2 of C-Roads, C-ITS Message Profiles.</li> <li>○ Only the toll lanes concerning a common direction shall be described in a IVI message, different IVI messages shall be used to describe the 2 different directions of the toll station.</li> <li>○ validTo is either mandatory or optional, depending on the mechanism for message management used <ul style="list-style-type: none"> <li>○ Message management via a continuous update of the IVIM <ul style="list-style-type: none"> <li>▪ validTo is mandatory and actively used to indicate the validity duration</li> </ul> </li> <li>○ Message management via active cancellation of IVIM <ul style="list-style-type: none"> <li>▪ validTo is optional and may be used to indicate the validity duration, but only if there is a specific temporal</li> </ul> </li> </ul> </li> </ul>

They will be updated in a future release.

restriction and validTo is not set to a shorter validity than that restriction

- connectedIviStructures should be used only if the number of toll lanes is equal or more than 10.
  - The index of lane cited in the attribute ivi.gic.applicableLanes for each IVI message shall start at 1 (from the inner to the outer side of the road). An example is shown below
  - If 2 or more IVI are used to describe the toll station in the same direction, the attribute connectedIviStructures shall be filled with the values of iviIdentificationNumber of the linked IVI messages.
  - The connected IVI messages shall be sent and updated respecting the order, i.e from the inner to the outer side of the road.
  - The lowest iviIdentificationNumber of the group always describes the most 9 inner lanes. The highest iviIdentificationNumber of the group always describes the last outer lanes (1 to 9 lanes for the last iviIdentificationNumber). This latter can describe less than 9 lanes. Consequently, at reception, V-ITS-S receiving the messages shall be able to process the linked IVI messages.
- iviStatus shall be used differently, depending on the mechanism for message management used
  - Message management via a continuous update of the IVIM
    - iviStatus shall be set to “new” for new information in the IVIM and to “update” when either the IVIM changes or the validity in time has fallen below a certain threshold while the IVIM is still valid
  - Message management via active cancellation of IVIM
    - iviStatus shall be set to “new” for new information in the IVIM, to “update” when the IVIM changes and to “cancellation” when the information in the IVIM is no longer valid
- referencePosition is at the start of the approach transition zone (end of the standard section) and transverse position is at the middle of the carriageway.
- The relevanceZone shall be described as an area covering the entire area of the toll approaching zone, rather than a segment (see figure below).

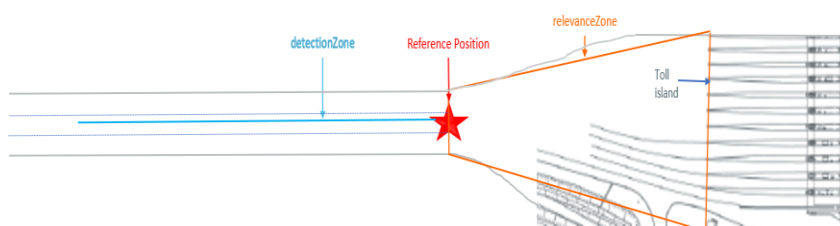











Figure 7:1 Example of a toll approaching zone

This latter is a polygonalLine defined as a list of absolute positions. It

shall start from the end of the standard section of the highway and shall end at the toll island (the beacons at the entrance of lanes). The relevanceZone area could have an accuracy between 5 to 10 metres around the defined area.

- Each GicPart in the GeneralIviContainer shall be used to encode one traffic sign (main sign) and up to three additional signs (subsigns) that may be associated to the main sign using DF RSCode. The different roadSignCodes (nature-serialNumber combination) identified for this use case are :
  - RSC #1: always present for ETC lanes, with the associated extraText specifying the means of payment
  - RSC #2: lane availability: must be one alternative among the following options: 6-59, 6-60, 9-99, 9-98
  - RSC #3 and #4: any other information as it applies to describe the lane: e.g. 5-11, 5-57, 1-34
  - 6-59 for a red cross 
  - 6-60 for a green arrow 
  - 9-99 when a danger is identified (e.g. lane open but vehicle temporarily blocked) 
  - 8-33 completed with text information as extraText to describe the possible means of payment 
  - 5-57 when a maximum speed limit traffic sign is given, e.g. 30km/h 
  - 5-11 when the lane is prohibited for vehicles of a certain height, e.g. 2 meters 
  - 9-98  or 4-12  when the reversible lane is closed in the concerning direction
  - 1-34 for HOV reserved lane 
- applicableLanes and RoadConfigurationContainer may not be filled only when all the lanes have the same traffic signs. Otherwise, concerned toll lanes for each GicPart shall be provided in applicableLanes.
- extraText shall be used to present additional text associated to a sign (subpanel text), to describe the available means of payment for example.
- For the toll stations with reversible lanes, the numbering of lanes shall consider all the possible concerned lanes. Hence, it shall be fixed whatever the affectation of the lanes (see example in the figure below).

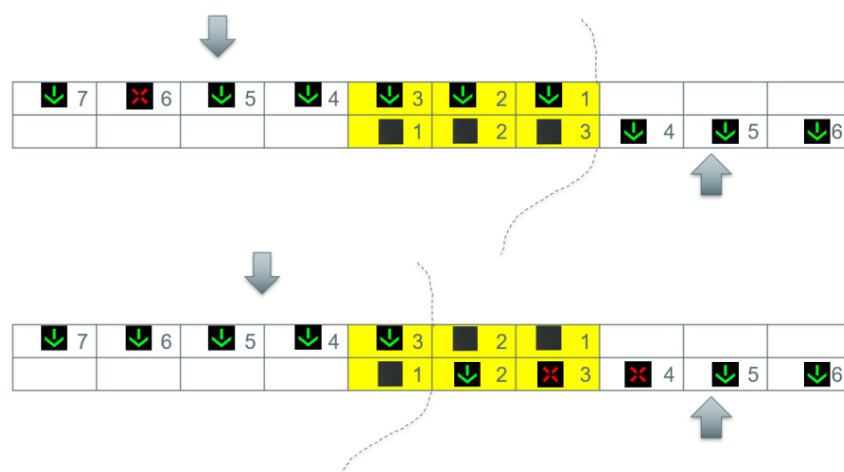


Figure 7:2 Examples of open/closed toll stations

Security and data protection requirements

Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].

An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.

This use case is based on the “General IVI Container” including lane status and all types of ISO/TS 14823 signs, the “Road configuration container” as well as the “Text container”. The IVIM permissions (SSP) shall be encoded as defined in [ETSI TS 103 301]. These SSPs are encoded in Octets 4-5 within the respective field of the certificate to be used (AT), in addition to the serviceProviderId encoded in Octets 1-3.

CauseCodeType / Container	SSP position	
	Octet position	Bit position
General IVI Container / ISO 14823 / Danger Warning	4	1
General IVI Container / ISO 14823 / Regulatory	4	2
General IVI Container / ISO 14823 / Informative	4	3
General IVI Container / ISO 14823 / Public Facilities	4	4
General IVI Container / ISO 14823 / Ambient Condition	4	5
General IVI Container / ISO 14823 / Road Condition	4	6
General IVI Container / Lane Status	5	0
Road Configuration Container	5	1
Text Container	5	2

	<p>The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf.</p> <p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>
<p>Communication technology requirements: ITS-G5</p> <p>Communication technology requirements: IP-Based</p>	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p> <p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on IVIM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = NG-TSA (Navigation Guidance – Toll Station Approaching)</li> <li>○ messageType = IVIM</li> </ul> <p>Geographic area (Quadtree) for IVIM: The event is characterized by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>[C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_reference position_01_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_Timing_03_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_Update_Cancel_04_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_Status-Update_4_1_R2.0.1</li> <li>○ TC_CROADS_Generic_ITSG5-IVIM_serviceProviderId_45_R2.0.1</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_reference position_01_R2.0.1</li> </ul> </li> </ul>



- TC\_CROADS\_GENERIC\_HYBRID-IVIM\_ZONES\_02\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID-IVIM\_Timing\_03\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID-IVIM\_Update\_Cancel\_04\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Status-Update\_4\_1\_R2.0.1
- TC\_CROADS\_Generic\_HYBRID-IVIM\_serviceProviderId\_45\_R2.0.1

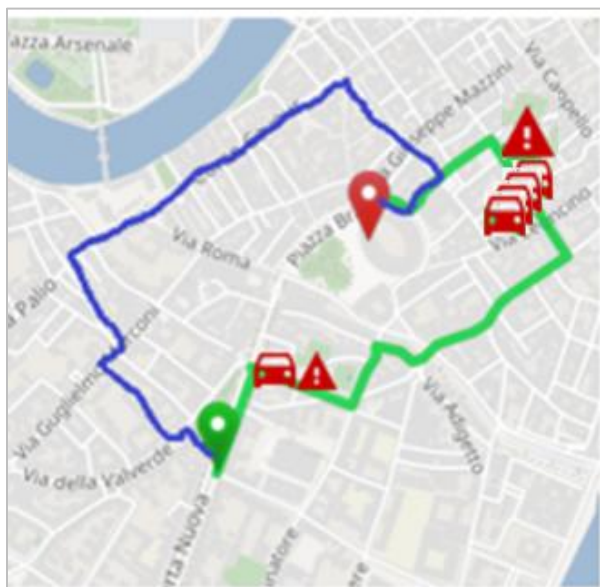
List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_direction\_91\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_validTo\_92\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_connectedIviStructures\_93\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_iviStatus\_94\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_referencePosition\_95\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_relevanceZone\_96\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_GicPart\_97\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_applicableLanes\_98\_R2.3.0
  - TC\_CROADS\_NG-TSA\_ITSG5\_IVIM\_extraText\_99\_R2.3.0
- Hybrid (IP based only):
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_direction\_91\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_validTo\_92\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_connectedIviStructures\_93\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_iviStatus\_94\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_referencePosition\_95\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_relevanceZone\_96\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_GicPart\_97\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_applicableLanes\_98\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_extraText\_99\_R2.3.0
  - TC\_CROADS\_NG-TSA\_HYBRID\_IVIM\_laneNumber\_100\_R2.3.0

## 7.2.2 NG – Smart Routing (NG-SR)

Type of road network	Major non-urban roads / Urban roads
Type of vehicle	Passenger vehicles
<b>Use case introduction</b>	
Summary	Optimizes traffic flows by providing dynamic travel time to key landmarks and traffic hubs (e.g. airport or train station) in response to traffic congestion levels caused by events such as jams, road closure and adverse weather conditions, etc. The information can be used to provide either simple travel time display on HMI or re-routing advice if an integrated navigation system is available.
Background	As the urban areas are getting more congested, it is important to provide drivers with adaptive route proposals that take into consideration the real-time travel time to destination based on current traffic congestion levels. This not only saves time and resources for the individual driver but ensures a balanced congestion levels and intended use of the network in various parts of the urban areas. This can also benefit traffic management plans (TMPs) by road or city authorities.
Objective	The use case is to provide to drivers the comprehensive information related to their travel time to destination, guiding the users to take the optimized route based on current levels of the traffic congestion.
Desired behaviour	The driver can adapt the route to the destination on the basis of perceived limitations and congestion levels on alternative options
Expected benefits	<p>The expected benefit of the service is better traffic management and support based on a more comprehensive and up-to-date picture of the state of the road network and of the traffic situation. This includes, among others</p> <ul style="list-style-type: none"> <li>○ For drivers, more efficient route choices based on the real travel time to destination</li> <li>○ For the Traffic Control Centre, better balance traffic flows in urban areas and/or on non-urban network with less impact on the environment and saving resources. This also gives the possibilities to issue information on traffic management plans or strategic routes as well as to guide traffic around sensitive areas such as residential areas.</li> </ul>
<b>Use case description</b>	
Situation	<p>The driver plans to travel from an origin to a destination in an urban area and/or on non-urban road network.</p> <p>While travelling the driver gets notified real-time through HMI of the expected travel time to destination with several alternative route options or be suggested of the optimal route by the integrated navigator if available.</p>

For example, the driver travelling to an airport in Verona may be notified of several expected travel time to destination depending on which street he or she may take (e.g. 30 minutes via street A, 20 minutes via street B). If there is an integrated navigation system, the user may be notified of the best route to take based on the travel time information received, as shown in below.



*Figure 7:3: Example of Traffic Information and Smart Routing in urban area. User is provided with an alternative route (blue) instead of the usual route (green)*

Logic of transmission

I2V

Actors and relations

- **TCC:** Receives traffic congestion and situation information. The sources can be sensors in the field, incident detection system, vehicle-detected events or 3<sup>rd</sup> party content provider such as meteorological service. The TCC then sends out travel time information via Roadside units and/or IP communication channel.
- **Service Provider:** receives information messages on the travel time to destinations from TCC via RSU or IP channel and presents the information via the HMI.
- **Driver:** receives travel time to destination information and can adjust the travel itinerary.

**OR**

- **Service Provider:** receives travel time and situation information from TCC and calculates optimized routes based on the vehicle's position and displays them on the smartphone app (or similar)
- **Driver:** receives travel time to destination information presented through an HMI or best route suggested from the trip planner if an integrated navigation system is available via HMI or smartphone application. And can adjust the travel itinerary.

Scenario	<p>Scenarios can be divided into two: vehicles simply displaying travel time information or providing the best route based on the information received.</p> <p>Scenario 1: Dynamic travel time to destinations</p> <ul style="list-style-type: none"> <li>a) Drivers receive travel time to destinations such as famous landmarks or travel hubs while driving.</li> <li>b) Different travel times to the same destination via different routes are also provided on the HMI so drivers can choose the best option.</li> </ul> <p>Scenario 2: Dynamic smart routing to destinations</p> <ul style="list-style-type: none"> <li>a) Navigation system (e.g. HMI, smartphone app): The vehicle sends origin, destination, (vehicle type and planned stops if applicable) to Service Provider (OEM or a 3<sup>rd</sup> party). Service Provider then receives real time travel time to destinations and provides the dynamic optimal route based on travel time and other traffic events and also provide updates on the route if there is a significant change in the traffic situation along the way. Optionally, the vehicle may send its current location frequently to receive dynamically adapted route information.</li> <li>b) The drivers adapt their route to optimize the trip.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>1. Drivers are informed via HMI in the car or a dedicated app (e.g. Smartphone)</li> <li>2. Drivers should be informed early enough of the routes to take (but not too early to forget) to take action and be moderately intrusive for immediate attention</li> </ul>
Functional Constraints / dependencies	<p>Constraints</p> <ul style="list-style-type: none"> <li>1. The provision of information and its quality (validity, confidence, up-to-date).</li> <li>2. HMI / Smartphone constraints to correctly display information.</li> </ul> <p>Dependencies</p> <ul style="list-style-type: none"> <li>3. The availability and accessibility of real-time travel time to destination from TMC based on traffic congestion /traffic events.</li> <li>4. The accuracy of the route information also depends on the computational model used to calculate the route by the service provider.</li> </ul> <p>How the optimal route is calculated is not part of the use case description. It is left to the service provider. The service provider also decides how often the routes are re-calculated.</p> <p>How the information is presented to the driver is not part of the service description. It is left to the provider of HMI how information is presented. Information may be translated to the preferred language of the driver.</p>

	<p>The route information presented is not obligatory but a guidance: Information should be handled as ‘convenience information’ and presented accordingly to the driver, as currently done within navigation systems.</p>
Link with other Use Cases	<p>This use case loosely linked to the other use case “Route Advice”. While this use case is focused on providing dynamic route information based on travel time to the destination, “Route Advice” provides route information following TCC / TMC’s strategic guidance under different traffic conditions and events and/or vehicle types</p>
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The IVI message for Destination Travel Time is profiled in chapter 4.2.2.6 of [C-Roads MP].</li> <li>○ The settings mentioned below, apply to scenario 1 and 2.</li> <li>○ IVI messages for NG-SR shall use message management based on update and cancellation of messages.</li> <li>○ iviStatus shall be set to “new” for new information in the IVIM, to “update” when the IVIM changes and to “cancellation” when the information in the IVIM is no longer valid.</li> <li>○ A cancellation IVIM shall be repeated at least for 5min after its first transmission NOTE: The exact effort to ensure that all vehicles receive the cancellation will be resolved in future releases.</li> <li>○ validTo may be used to encode an end time for the overall IVI message, at least 1 hour ahead of the time indicated by the DE timestamp. Providing this end time can serve the purpose of avoiding an issue of perpetually valid IVIM in case cancellation is missed repeatedly.</li> <li>○ The definition of all geographical zones should be included in as few GicParts as possible.</li> <li>○ IVIM can contain more than one Geographical Location Container (GLC). An additional GLC should only be included in an IVIM if required zones cannot be defined within the value range constraints of DF DeltaPositions towards the referencePosition.</li> <li>○ IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM.</li> <li>○ One GicPart in the GeneralIviContainer shall be used to encode one traffic sign (main sign) and up to three additional signs (subsigns) that may be associated to the main sign using DF RSCode.</li> <li>○ extraText shall be used to present additional text associated to a traffic sign (sub-panel text) only if there is no subpanel code available in ISO 14823. extraText is ordered, so the first line of extraText corresponds to the first RSCode and so on. If a traffic sign does not have extra text, a string with a single NULL character (ASCII 0x00) shall be added. extraText may be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data.</li> </ul>

	<ul style="list-style-type: none"><li>○ For this use case, ISO14823 DF is set with appropriate serviceCategoryCode, nature, serialnumber and attributes<ul style="list-style-type: none"><li>○ serviceCategory = informative (13), nature = 1 and serialNumber = 11 shall be used</li><li>○ ddd [InternationalSign-destinationInformation] attribute shall be used</li></ul></li></ul>																														
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>This use case is based on the “General IVI Container” and a specific attribute of IOS/TS 14823 signs - informative. The IVIM permissions (SSP) have to be encoded as defined in [ETSI TS 103 301]. These SSPs are encoded in Octets 4-5 within the respective field of the certificate to be used (AT), in addition to the serviceProviderId encoded in Octets 1-3.</p> <table><tr><th></th><th colspan="2">SSP position</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th></tr><tr><td>General IVI Container / ISO 14823 / Danger Warning</td><td>4</td><td>1</td></tr><tr><td>General IVI Container / ISO 14823 / Regulatory</td><td>4</td><td>2</td></tr><tr><td>General IVI Container / ISO 14823 / Informative</td><td>4</td><td>3</td></tr><tr><td>General IVI Container / ISO 14823 / Public Facilities</td><td>4</td><td>4</td></tr><tr><td>General IVI Container / ISO 14823 / Ambient Condition</td><td>4</td><td>5</td></tr><tr><td>General IVI Container / ISO 14823 / Road Condition</td><td>4</td><td>6</td></tr><tr><td>General IVI Container / Lane Status</td><td>5</td><td>0</td></tr><tr><td>Road Configuration Container</td><td>5</td><td>1</td></tr></table> <p>The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf.</p>		SSP position		CauseCodeType / Container	Octet position	Bit position	General IVI Container / ISO 14823 / Danger Warning	4	1	General IVI Container / ISO 14823 / Regulatory	4	2	General IVI Container / ISO 14823 / Informative	4	3	General IVI Container / ISO 14823 / Public Facilities	4	4	General IVI Container / ISO 14823 / Ambient Condition	4	5	General IVI Container / ISO 14823 / Road Condition	4	6	General IVI Container / Lane Status	5	0	Road Configuration Container	5	1
	SSP position																														
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General IVI Container / ISO 14823 / Public Facilities	4	4																													
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General IVI Container / Lane Status	5	0																													
Road Configuration Container	5	1																													

	<p><i>NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.</i></p>
Communication technology requirements: ITS-G5	For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on IVIM messages the AMQP filtering tables in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType= NG-SR</li> <li>○ messageType = IVIM</li> </ul> <p>Geographic area (Quadtree) for IVIM message: The event is characterized by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS Actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p>
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_reference position_01_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_Timing_03_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_Update_Cancel_04_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_Status-Update_4_1_R2.0.1</li> <li>○ TC_CROADS_Generic_ITSG5-IVIM_serviceProviderId_45_R2.0.1</li> <li>○ TC_CROADS_AVG- GENERIC_ITSG5_IVIM_AutomatedVehicleContainer_55_R2.0.1</li> </ul> </li> <li>○ Hybrid (IP based only): <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_reference position_01_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_Timing_03_R2.0.1</li> </ul> </li> </ul>

- TC\_CROADS\_GENERIC\_HYBRID-IVIM\_Update\_Cancel\_04\_R2.0.1
- TC\_CROADS\_GENERIC\_HYBRID\_IVIM\_Status-Update\_4\_1\_R2.0.1
- TC\_CROADS\_Generic\_HYBRID-IVIM\_serviceProviderId\_45\_R2.0.1
- TC\_CROADS\_AVG-GENERIC\_HYBRID\_IVIM\_AutomatedVehicleContainer\_55\_R2.0.1

The following test cases have to be renamed from IVS-SR to NG-SR.

Afterwards, they must be updated here:

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_GDDAttributes\_104\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_GicPart\_101\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_ISO14823\_102\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_PictogramCode\_103\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_destinationPlace\_105\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_destinationRoad\_106\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_distanceToDestinationPlace\_107\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_durationMinutesOfTime\_108\_R2.1.0
  - TC\_CROADS\_IVS-SR\_ITSG5\_IVIM\_extraText\_109\_R2.1.0
- Hybrid (IP based only):
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_GDDAttributes\_104\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_GicPart\_101\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_ISO14823\_102\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_PictogramCode\_103\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_destinationPlace\_105\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_destinationRoad\_106\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_distanceToDestinationPlace\_107\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_durationMinutesOfTime\_108\_R2.1.0
  - TC\_CROADS\_IVS-SR\_HYBRID\_IVIM\_extraText\_109\_R2.1.0



### 7.2.3 NG – Route Advice (NG-RA)

Type of road network	Motorways, dual carriageways, rural roads, urban roads
Type of vehicle	All
<b>Use case introduction</b>	
Summary	The goal of route advice is to inform all road users of a detour route recommendation (collective routing) provided by road operators according to special circumstances (e.g., major event). It enables road users to receive the route recommendations through in-vehicle information as a supplement to existing physical variable message signs (VMS) or as an extension in the form of a virtual VMS (no existing physical VMS) on locations, where relevant route decisions can be made.
Background	With the help of route recommendations and traffic information provided by VMSs, large concentrations of traffic can be effectively managed. Providing in-vehicle information can enhance this by offering continuous routing updates, independent of the fixed VMS locations. When many road users converge, for instance during public events, potential overloads at motorway exits and linked rural or urban roads can emerge. Using in-vehicle information, continuous route advice can be provided with redirection recommendations to alternative georeferenced routes regardless of fixed VMS locations, enabling smoother traffic flows.
Objective	<ul style="list-style-type: none"> <li>Machine readably coded georeferenced routing information so that the Route Advice can be processed by the vehicles, e.g. by their navigation systems, to provide more precise and comprehensive information to the road users to achieve the desired behaviour of the road operator.</li> <li>Agreed and consistent traffic strategies at the interface between urban and interurban areas to guide road users seamlessly</li> </ul>
Desired behaviour	By providing road users with up-to-date route advice, their route selection can be supported
Expected benefits	Optimised utilisation of the entire road network, including motorways, urban, and interurban roads, can be achieved by providing road users with routing based on traffic management strategies. This approach improves traffic efficiency by avoiding congestion and reducing the risk of accidents caused by congestion. Furthermore, traffic routing strategies can minimise the environmental impact by reducing CO2 and noise emissions
<b>Use case description</b>	
Situation	<p>On the road network, for which the road operator is responsible on, a road closure (restricted to all or specific vehicles), a delay or another cause the road operator wants to reroute, takes place. Specific situations can be:</p> <ol style="list-style-type: none"> <li>(1) <b>Recommendation to use neighbouring motorway exits/access:</b> Overload of motorway sections or rural/urban roads. Using route advice, large-scale routing advice can be given with a shift recommendation to neighbouring exits or accesses.</li> <li>(2) <b>Routing for motorway bypasses:</b> Routing in case of an incident. In general, according to the related static and dynamic traffic signs with the possibility of</li> </ol>

further bypass optimizations depending on the current traffic situation and road conditions.

- (3) **Route advice for events:** Route recommendations in the context of events can be broadcasted to vehicles.
- (4) **Restrictions for vehicle types:** Route recommendations in case of restrictions for vehicle types (e.g. critical bridges).



Figure 7:4 - Example illustration of route advice in the TCC



Figure 7:5 - Example illustration of route advice in the vehicle

Logic of transmission

I2V

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.
- **Driver:** The route advice information is continuously received by all C-ITS equipped vehicles and displayed to the drivers. Drivers can choose the route according to this information. The exact details of the presentation (how and when) is based on the individual application designer's decision. The route advice information from

	TCC might also be processed by service providers to leverage the dissemination to the drivers.
Scenario	<ul style="list-style-type: none"> <li>• If VMS is available, VMS display information about route recommendations at single locations and the TCC sends the coherent C-ITS information on the corresponding route to the road users. The information is based on TCC strategies.</li> <li>• If VMS is not available, the TCC can independently send a C-ITS information to the road users. The information is based on TCC strategies.</li> </ul>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>• IVS information shall be presented to the drivers and shall be consistent with the current valid (dynamic) traffic signs.</li> <li>• The information shall be presented to the driver early enough and in the appropriate location on the road.</li> <li>• The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</li> </ul>
Functional Constraints / dependencies	To enable a cooperative traffic management supported by coordinated route advice, the involved road operators need to develop a coordination process to harmonise the respectively relevant strategy and thereby the information content to be published. This includes the definition of joint traffic strategies and measures in the first place, a matching of the data basis, a common triggering approach, and a cooperative interface.
Link with other use cases	TBD
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The IVI message for NG–RA is profiled in chapter 4.2.2.2 of [C-Roads MP].</li> <li>• IVI messages for IVS-TS shall use message management based on update and cancellation of messages</li> <li>• iviStatus shall be set to “new” for new information in the IVIM, to “update” when the IVIM changes and to “cancellation” when the information in the IVIM is no longer valid</li> <li>• A cancellation IVIM shall be repeated at least for 5min after its first transmission <i>NOTE: The exact effort to ensure that all vehicles receive the cancellation will be re-solved in future releases</i></li> <li>• validTo may be used to encode an end time for the overall IVI message, at least 1 hour ahead of the time indicated by the DE timestamp. Providing this end time can serve the purpose of avoiding an issue of perpetually valid IVIM in case cancellation is missed repeatedly.</li> <li>• The definition of all geographical zones should be included in as few GlcParts as possible. The following zones exist: <ul style="list-style-type: none"> <li>○ detectionZone: all zones that run to the decision point</li> <li>○ relevanceZone: all zones that run from the decision point to the merge point</li> </ul> </li> <li>• The DF zone must be created with the DF segment and the DF line grouped below it</li> </ul>

- IVIM can contain more than one Geographical Location Container (GLC). An additional GLC should only be included in an IVIM if required zones cannot be defined within the value range constraints of DF DeltaPositions towards the referencePosition.
- IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM.
- One GicPart in the GeneralIviContainer shall be used to encode one traffic sign (main sign) and up to three additional signs (subsigns) that may be associated to the main sign using DF RSCode.
- Information shall as far as possible be encoded using machine-readable message components, via adhering as much as possible to the following rules:
  - Restriction of signs to certain vehicle types and/or dimensions
  - Encoding of subpanels using roadSignCodes available in ISO 14823 for sub-panels instead of extraText
- For this use case, ISO14823 DF is set with appropriate serviceCategoryCode, nature, serialnumber and attributes and referenced to two or more relevanceZone:
  - Main route (relevanceZone 1)
    - closed

closed for	service Category	nature	serial Number
all vehicles	12	4	15
goods vehicle	12	4	21
goods vehicle with trailer	12	4	22
vehicles carrying dangerous goods for which special sign plating is required	12	4	76
for vehicles carrying more than a certain quantity of substances liable to cause water pollution	12	4	77
for vehicles having an overall width exceeding X	12	4	99
for vehicles having an overall height exceeding specified height	12	5	11
for vehicles exceeding specified weight	12	5	12
for vehicles having a weight exceeding specified axial weight on one axle	12	5	13
for vehicles or combinations of vehicles exceeding specified length X in length	12	5	14

or other suitable traffic sign

- disabled

disabled, because of	service Category	nature	serial Number
Traffic congestion	32	1	11

or other suitable traffic sign

- Detour route (relevanceZone 2+)

detour	service Category	nature	serial Number
detour	13	6	18

- extraText may be used to present additional textual information.

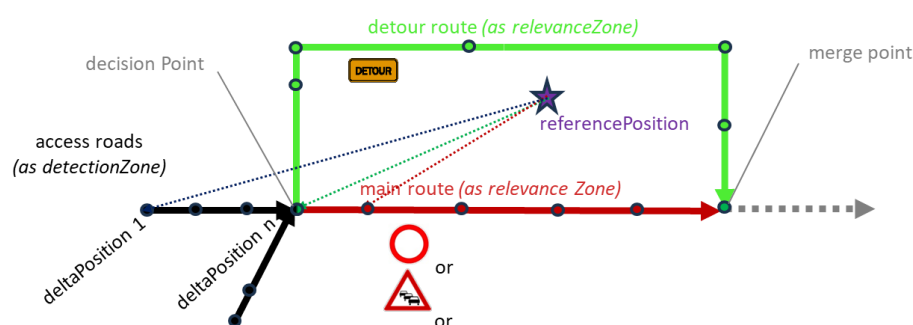


Figure 3: Illustration of the glc and giv container in the IVIM

Security and data protection requirements

Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].

An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.

This use case is based on the “General IVI Container” including lane status and all types of ISO/TS 14823 signs, the “Road configuration container” as well as the “Text container”. The IVIM permissions (SSP) shall be encoded as defined in [ETSI TS 103 301]. These SSPs are encoded in Octets 4-5 within the respective field of the certificate to be used (AT), in addition to the serviceProviderId encoded in Octets 1-3.

	SSP position	
CauseCodeType / Container	Octet position	Bit position
General IVI Container / ISO 14823 / Danger Warning	4	1
General IVI Container / ISO	4	2

14823 / Regulatory		
General IVI Container / ISO 14823 / Informative	4	3
General IVI Container / ISO 14823 / Public Facilities	4	4
General IVI Container / ISO 14823 / Ambient Condition	4	5
General IVI Container / ISO 14823 / Road Condition	4	6
General IVI Container / Lane Status	5	0
Road Configuration Container	5	1

The here listed SSP shall be granted only for C-ITS stations used by road operators or any contractor on their behalf.

*NOTE: The user in this sentence is not the station operator (as defined in the SP) who goes through the enrolment process and requests the necessary SSPs. The user is the party responsible for the use case (can be the same) which uses the C-ITS stations for it and therefore needs the respective SSPs.*

Communication technology requirements: ITS-G5	For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.  For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.
Communication technology requirements: IP-Based	For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply. For use cases based on IVIM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply: <ul style="list-style-type: none"> <li>• serviceType = NG-RA</li> <li>• messageType = IVIM</li> </ul>

	<p>Geographic area (Quadtree) for IVIM:</p> <p>The event is characterized by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p>
Test and validation requirements	<p>[C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_reference position_01_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_Timing_03_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5-IVIM_Update_Cancel_04_R2.0.1</li> <li>○ TC_CROADS_GENERIC_ITSG5_IVIM_Status-Update_4_1_R2.0.1</li> <li>○ TC_CROADS_Generic_ITSG5-IVIM_serviceProviderId_45_R2.0.1</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_reference position_01_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_ZONES_02_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_Timing_03_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID-IVIM_Update_Cancel_04_R2.0.1</li> <li>○ TC_CROADS_GENERIC_HYBRID_IVIM_Status-Update_4_1_R2.0.1</li> <li>○ TC_CROADS_Generic_HYBRID-IVIM_serviceProviderId_45_R2.0.1</li> </ul> </li> </ul>

## 8. Collective Perception (CP)

### 8.1 CP: Service introduction

Service introduction	
Summary	Collective Perception (CP) is an information service to share information about objects that may influence road traffic with vehicles.
Background	<p>Collective Perception is a concept where perception data is shared among vehicles as well as between infrastructure and vehicles. Infrastructure sensors (e.g. radar, lidar and smart cameras) are often mounted at elevated positions, providing an extension of the electronic horizon of a vehicle. This is beneficial on motorways, especially at tunnel entries and in merging situations. In urban environment, it is beneficial in complex and crowded traffic situations, where perception data covers vehicles, cyclists and pedestrians, especially at intersections.</p> <p>Information about the objects such as obstacles/pedestrians are shared via the CP service when they have a potential influence on the traffic. For example, pedestrians are included only when they are on the road or about to enter the road, and static cargo is included only when it disturbs the traffic flow.</p> <p>The CP service is meant to extend the electronic horizon of a vehicle by sharing the data about objects in the form of object lists rather than interpreting the data and deriving as hazardous location notifications. In this sense, the CP service delivers abstract object data, where the interpretation whether it is a normal or a hazardous situation is left to the receiving end in the vehicle. The CP service is generally designed for perception data sharing among all ITS stations, where vehicle ITS stations and roadside ITS stations can be both sender and receiver. C-ROADS focuses on the infrastructure-based variant, where infrastructure sensors provide sensor perceptions in form of object lists to surrounding vehicles.</p>
Objective	<ul style="list-style-type: none"> <li>○ Safe driving by extending the “electronic horizon” of the vehicle through sensor perceptions beyond the range of a vehicle’s own capabilities.</li> <li>○ Collision avoidance by providing obstacle and vulnerable road user (VRU) information in poor visibility and obstructed line of sight conditions.</li> <li>○ Increased awareness on static and dynamic obstacles and vulnerable road users by providing object data directly to the vehicle where it can be presented to the driver, processed automatically in driver assistance systems, or trigger crash avoidance mechanisms. It has the potential to greatly reduce problems in locations which are attributed to higher risks of accidents because of limited line of sight, obstruction or complex traffic situations.</li> </ul>
Expected benefits	<ul style="list-style-type: none"> <li>○ Improved road safety through extended awareness for the vehicles or drivers at heavy traffic or accident-prone locations: Infrastructure-based Collective Perception provides sensor perception beyond the capability of a</li> </ul>



	<p>vehicle's onboard sensors, and the sight of a driver, especially from the infrastructure sensors mounted at elevated positions can help to overcome the limitations of on-board sensors which might be obstructed by the landscape or other vehicles.</p> <ul style="list-style-type: none"> <li>○ Improved in-vehicle information and application services: The extended awareness/visibility provided by the CPS object data could be used to show hidden dangerous situations to the driver via traditional HMI or head-up display or it could also be automatically processed in advanced assistance systems or become part of automated driving functions.</li> </ul>
Use cases	<ul style="list-style-type: none"> <li>○ Collective Perception on Motorways (CP-MW)</li> <li>○ Collective Perception at Urban/interurban Intersections (CP-UI)</li> </ul>

## 8.2 CP: Use Cases

### 8.2.1 CP – Collective Perception on Motorways (CP-MW)

Type of road network	Motorway
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	Collective Perception on Motorways delivers perception data from infrastructure sensors to vehicles on the motorway. Infrastructure sensors can be mounted at elevated position, such as overhead gantries or posts, providing an extension of the electronic horizon of a vehicle. This is beneficial especially at tunnel entries and in merging situations, where the additional awareness can contribute to safe driving and collision avoidance. In linear, open range motorway sections, CP is generally not required.
Background	There are locations on motorways, where the vehicles' sensor capabilities are limited, either by obstruction or by a change of the environment – e.g. when entering or exiting a tunnel. The tunnel entry is a challenging environment for camera systems as well as for radar sensors, because the environment changes significantly. In this case, the CP service provides object detections where the vehicles' own sensors are limited.
Objective	The aim is to increase the perception of drivers by providing additional information on static and dynamic obstacles present in its immediate environment. Which will contribute to improving road safety.
Desired behaviour	<p>Drivers can:</p> <ul style="list-style-type: none"> <li>○ be made aware of any kind of static or dynamic obstacle on the road ahead</li> <li>○ drive more attentive based on objects beyond their line of sight.</li> </ul> <p>The vehicle's perception can be extended and/or augmented by the object detections provided by the infrastructure and extend their electronic horizon. The information may be used by Advanced Driver Assistance Systems for assisted or automated driving.</p>
Expected benefits	<ul style="list-style-type: none"> <li>○ Enhanced traffic safety</li> <li>○ Reduction of accidents or near accidents and critical driving situations</li> </ul>
<b>Use case description</b>	
Situation	<p>In general, all situations where an obstructed line of sight and a change of environment could lead to a decreased awareness of the situation. We focus on two situations in particular:</p> <p>1. <u>Motorway tunnel entry</u></p>

In this situation the vehicle is about to enter a tunnel, and besides obstructions of other vehicles, the view of its own sensors into the tunnel is limited.



Figure 8:1 Motorway tunnel entry situation

## 2. Motorway merge situation

In this situation, the vehicle is merging into motorway traffic and the location is characterised by obstructed line of sight, due to topology or artificial structures such as noise barriers.



Figure 8:2 Motorway merge situation

**Triggering conditions:** The CP service is continuously monitoring the environment and generating continuously perception data.

Logic of transmission	12V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road operator / service provider:</b> The source of the data is a sensor system maintained by the road operator/service provider. The road operator / service provider is expected to ensure the data quality of the content of the messages is consistent when sending CPMs.</li> <li>○ <b>Drivers:</b> The CP information is continuously received by C-ITS equipped vehicles and can be presented to the drivers or processed by assistance systems. The exact details of the presentation (how and when) is based on the individual application designer's decision.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The infrastructure sensors detect dynamic and static objects within the sensor perception region. The perceptions are used to generate an object list, potentially with classifications of the objects. The object list is included into a CP</li> </ul>

	<p>message and broadcasted at the location which is relevant for the detected objects.</p> <ul style="list-style-type: none"> <li>○ The message is received in the vehicle and presented to the driver, if relevant. It may also be automatically processed by driver assistance systems, which trigger braking or a speed decrease.</li> <li>○ The drivers can act accordingly.</li> </ul>
	<p>Figure 8:3 Sensor setup and principle of the tunnel entry scenario</p>
Intended Presentation/Alert principle	<ul style="list-style-type: none"> <li>○ The vehicle (driver or driving system) receives the obstacle information early enough to act accordingly and ensure a safe traffic operation.</li> <li>○ The HMI presentation is at the vehicle manufacturer's own responsibility.</li> </ul>
Functional constraints/dependencies	<p>The use case depends on inputs of sensor systems.</p>
Link to other use cases	<p>HLN-OR and HLN-APR are closely related use cases, where the object has been identified as being an obstacle, or an animal or a person on the road. Also stationary vehicles (HLN-SV) are static objects.</p> <p>The main difference between CPM and DENM (HLN) is the fact that with the HLN service the infrastructure evaluates the object as a hazard to all of the vehicles and decides to send out a specific warning instead of general perception data (CPM).</p>
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The CP message for CP-MW is profiled in the chapter 4.2.6 of [C-Roads MP].</li> <li>○ ObjectInclusionConfig shall be set to "0".</li> <li>○ The sets of CPMs shall include all objects which are located on the driveable carriageway and whose object perception quality exceeds ObjectPerceptionQualityThreshold = 3.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p>

<p>Communication technology requirements: ITS-G5</p> <p>Communication technology requirements: IP based</p> <p>Test and validation requirements</p>	<p>The CPM permissions (SSP) shall be encoded as defined in [ETSI TS 103 324] where the bitmap SSP consists of version field.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p> <p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply, using SCH1 for dissemination (as defined in RS_RSP_113(1)).</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p> <p>Channel offload procedures are not recommended.</p> <p>For CP-MW, sets of CPMs (containing at least one CPM) shall be generated at a constant rate. It is recommended to use a rate of 1Hz.</p> <p><i>NOTE: Currently, no IP implementation is known of this use case. Specific interoperability requirements will be added after evaluation of an IP implementation.</i></p> <p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_sensorRegionShape_01_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_sensorRegionConfidence_02_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_PRC-sensorIdList_03_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_numberOfPerceivedObjects_04_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_objectAge_05_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_objectPerceptionQuality_06_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_POC-sensorIdList_07_R2.3.0</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_CPM_sensorRegionShape_01_R2.3.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_CPM_sensorRegionConfidence_02_R2.3.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_CPM_PRC-sensorIdList_03_R2.3.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_CPM_numberOfPerceivedObjects_04_R2.3.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_CPM_objectAge_05_R2.3.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_CPM_objectPerceptionQuality_06_R2.3.0</li> <li>○ TC_CROADS_GENERIC_HYBRID_CPM_POC-sensorIdList_07_R2.3.0</li> </ul> </li> </ul> <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only:</li> </ul>
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- TC\_CROADS\_CP-MW\_ITSG5\_CPM\_PercievedObjectContainer\_09\_R2.3.0
- Hybrid (IP based only):  
TC\_CROADS\_CP-MW\_HYBRID\_CPM\_PercievedObjectContainer\_09\_R2.3.0

## 8.2.2 CP – Collective Perception on Urban/Interurban Intersections (CP-UI)

Type of road network	Urban Area and Interurban Area
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	Collective Perception on urban/interurban intersections delivers object perception data from infrastructure sensors to vehicles on intersections. Infrastructure sensors can detect vulnerable road users, but also obstacles on the road. This is beneficial especially in situations where vehicles are turning at intersections and crossing the paths of pedestrians and cyclists.
Background	Vulnerable Road Users (VRU) are defined in the ITS directive as “non-motorised road users, such as pedestrians and cyclists as well as motor-cyclists and persons with disabilities or reduced mobility and orientation”. A main motivation of this use case is to create awareness on cyclists and pedestrians as VRU. But also other traffic participants such as powered two-wheelers as well as or not clearly visible obstacles can be part of it.
Objective	The aim is to increase the perception of drivers by providing additional information on static and dynamic obstacles present in its immediate environment. Which will contribute to improving road safety. The use case is particularly valuable when the driver is distracted or visibility is poor.
Desired behaviour	Approaching vehicles (drivers or driving systems) are able to adjust their speed and driving trajectory accordingly (including emergency stop) to avoid collisions with VRU.
Expected benefits	<ul style="list-style-type: none"> <li>○ Enhanced traffic safety by avoiding accidents between vehicles and VRU or other obstacles.</li> <li>○ Improved attractivity for cycling and walking by the reduction of dangerous situations with vehicles.</li> </ul>
<b>Use case description</b>	
Situation	The situation is characterised by vehicles approaching and entering an urban or interurban intersection where VRUs are present. Especially the situation where the paths of pedestrian and cyclists cross the paths of turning vehicles are considered dangerous.





Figure 8:4 VRU paths at an urban intersection

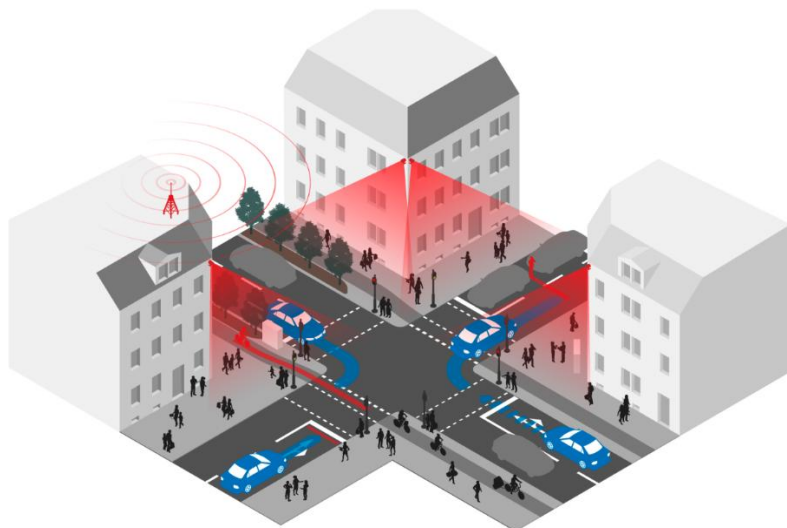
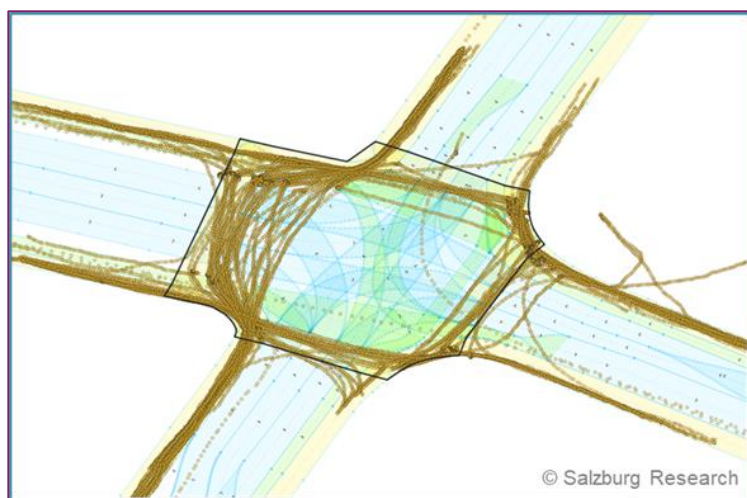


Figure 8:5 Vulnerable road users and vehicles at an urban intersection





	<p><i>Figure 8:6 Sensor perception of pedestrian paths at an intersection</i></p> <p><b>Triggering Conditions:</b> The CP service is continuously monitoring the environment and generating continuously perception data.</p>
<p>Logic of transmission</p> <p>Actors and relations</p>	<p>I2V</p> <ul style="list-style-type: none"> <li>○ <b>Road operator / service provider:</b> The source of the data is a sensor system maintained by the road operator/service provider. The road operator / service provider is expected to ensure a continuous data quality of the content of the messages when sending CPMs.</li> <li>○ <b>Drivers:</b> The CP information is continuously received by C-ITS equipped vehicles and can be presented to the drivers or processed by assistance systems. The exact details of the presentation (how and when) is based on the individual application designer's decision.</li> <li>○ <b>VRUs:</b> The locations and movements of VRUs are perceived by the sensor system.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The infrastructure sensors detect dynamic and static objects within the sensor perception region. The perceptions are used to generate an object list, potentially with classifications of the objects. The object list is included into a CP message and broadcasted at the location which is relevant for the detected objects.</li> <li>○ The message is received in the vehicle and presented to the driver, if relevant. It may also be automatically processed by driver assistance systems, which trigger braking or a speed decrease.</li> </ul>
Presentation/Alert principle	The vehicle (driver or driving system) receives the information of the VRU early enough to act accordingly and ensure a safe traffic operation (e.g. turning operation).
<p>Functional constraints/dependencies</p> <p>Link to other use cases</p>	<p>The use case depends on inputs of sensor systems.</p> <ul style="list-style-type: none"> <li>○ The use case can also be accompanied by a warning system that detects potentially hazardous situations with VRU and generates and sends out HLN messages to approaching vehicles (drivers or driving systems).</li> <li>○ There are related HLN use cases, which provide an event position for a hazardous situation, whereas CP delivers the abstract object data. As an example, HLN-OR and HLN-APR are related, where the object has to be identified as being an obstacle or person, before sending the respective message.</li> <li>○ The main difference between CPM and DENM (HLN) is the fact that with the HLN service the infrastructure evaluates the object</li> </ul>

	as a hazard to all of the vehicles and decides to send out a specific warning instead of general perception data (CPM).
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The CP message for CP-UI is profiled in the chapter 4.2.6 of [C-Roads MP].</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p>The CPM permissions (SSP) shall be encoded as defined in [ETSI TS 103 324] where the bitmap SSP consists of version field.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply using SCH1 for dissemination (as defined in RS_RSP_113(1)).</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p> <p>For CP-MW, sets of CPMs (containing at least one CPM) shall be generated at a constant rate. It is recommended to use a rate of 1Hz.</p>
Communication technology requirements: IP based	<p><i>NOTE: Currently, no IP implementation is known of this use case. Specific interoperability requirements will be added after evaluation of an IP implementation.</i></p>
Test and validation requirements	<p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_sensorRegionShape_01_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_sensorRegionConfidence_02_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_PRC-sensorIdList_03_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_numberOfPerceivedObjects_04_R2.3.0</li> <li>○ TC_CROADS_GENERIC_ITSG5_CPM_objectAge_05_R2.3.0</li> </ul> </li> </ul>

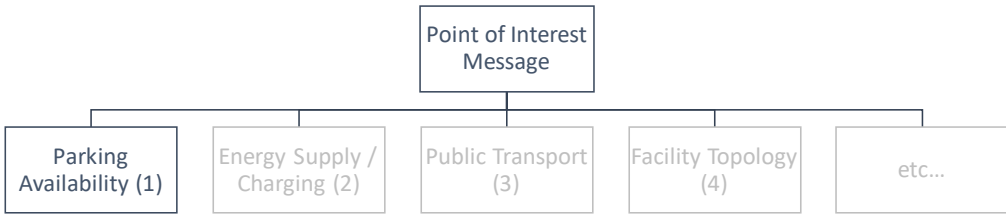
- TC\_CROADS\_GENERIC\_ITSG5\_CPM\_objectPerceptionQuality\_06\_R2.3.0
- TC\_CROADS\_GENERIC\_ITSG5\_CPM\_POC-sensorIdList\_07\_R2.3.0
- IP based only:
  - TC\_CROADS\_GENERIC\_HYBRID\_CPM\_sensorRegionShape\_01\_R2.3.0
  - TC\_CROADS\_GENERIC\_HYBRID\_CPM\_sensorRegionConfidence\_02\_R2.3.0
  - TC\_CROADS\_GENERIC\_HYBRID\_CPM\_PRC-sensorIdList\_03\_R2.3.0
  - TC\_CROADS\_GENERIC\_HYBRID\_CPM\_numberOfPerceivedObjects\_04\_R2.3.0
  - TC\_CROADS\_GENERIC\_HYBRID\_CPM\_objectAge\_05\_R2.3.0
  - TC\_CROADS\_GENERIC\_HYBRID\_CPM\_objectPerceptionQuality\_06\_R2.3.0
  - TC\_CROADS\_GENERIC\_HYBRID\_CPM\_POC-sensorIdList\_07\_R2.3.0

List of applicable specific test cases:

- ITS-G5 only:
  - TC\_CROADS\_CPM-MW\_ITSG5\_CPM\_PercievedObjectContainer\_09\_R2.3.0
- Hybrid (IP based only):
  - TC\_CROADS\_CPM-MW\_HYBRID\_CPM\_PercievedObjectContainer\_09\_R2.3.0

# 9. Functional Description of Points of Interest

## 9.1 Points of Interest service introduction

Service introduction	
Summary	<p>The Points of Interest (POI) service can provide up-to-date information of points of interests along the road, being e.g. free parking spaces/places, gas stations or EV charging points, park-and-ride facilities and more. Providing this information from the infrastructure helps vehicles to plan routes accordingly and therefore increases traffic flow and efficiency as well as reducing emissions on the trip.</p> <p>The POI service makes use of the Point of Interest Message (POIM) and its container structure. Each container may be used to describe one or more Use-Cases. The following figure shows the current draft with the Parking Availability (POIM-PA) container and future examples.</p>  <p style="text-align: center;"><i>Figure 9:1 ETSI POIM structure</i></p>
Background	<p>Route planning can be challenging for drivers and vehicles due to the absence of up-to-date POI information along the roads. For instance, truck drivers often struggle to find available parking spaces for (mandatory) rest during their long journeys, leading to situations where trucks are parked at breakdown bays or the hard shoulder. Similarly, EVs require information about charging points along their routes. The C-ITS POI service can significantly enhance route decision making by providing accurate and timely information about relevant POIs, resulting in more efficient and informed journeys.</p>
Objective	Providing detailed information about points of interest, e.g. parking spaces, along the road, resulting in better traffic flow and efficiency.
Expected benefits	Improved traffic flow and efficiency as well as reduced emissions.
Use Cases	<ul style="list-style-type: none"> <li>○ Parking Availability (POI – PA)</li> </ul>

## 9.1.1 Parking Availability Information (POI-PA)

Type of road network	All
Type of vehicle	All
<b>Use case introduction</b>	
Summary	<p>The use case aims to provide to drivers of all vehicles (real-time) information related to parking places (location, availability, services, rates, etc) as well as potential specific information on parking spaces. This could be about parking lots on the highway as well in urban areas. In this use case there is a distinction between information on the aggregated area/facility level versus specific parking spot information by scenario. For further clarity in this use case description the following definitions are used:</p> <ul style="list-style-type: none"> <li>○ Parking place (a.k.a. parking lot, parking facility) = a place or location used for parking, loading, unloading, standing, or some other mobility or transport related activity. Place typically identifies a parking structure, surface lot or on street parking zone.</li> <li>○ Parking space (a.k.a. parking spot) = a single space for parking, usually designed for one vehicle, which may, but not necessarily, be denoted by painted or other road surface marker.</li> </ul>
Background	<p>Today, there are announcements for parking places/spaces via static and variable message signs. This use case brings the information into the vehicle.</p> <p>The core value of this service is to create and share the same display for this type of information, by being independent of the sources of information (which are numerous and have different communication means). Above all, it is a matter of bringing more comfort to the road user. However, this information can also bring more safety by helping the road users manage/minimize their driving time.</p> <p>For passenger cars, the information on accessible park-and-ride facilities has value itself because some park-and-ride facilities are not accessible to all users as they are restricted to subscribers.</p> <p>The urban on-street parking spaces are generally scattered with no clear indication of the available parking places, which makes it challenging for drivers to search for an available space. For traffic control centres, it is important to maximize the utilization of on-street parking spaces by providing the real-time availability to the drivers, also as to guide users to park in available spaces out of the congested city centres.</p> <p>The following figure shows an example of on-street parking in an urban area, where the parking spaces are grouped as parking areas (zones) with color-</p>

coded occupancy rates. Each parking area contains information about the availability of each parking space, and it is also possible to indicate the reserved spaces for loading and unloading of the goods, for disabled or women drivers, to name a few.



Figure 9.2: Example of on-street parking area and space

On highways, especially trucks benefit from real-time parking information to plan their routes and rest times. This leads to better traffic flow and less traffic on smaller roads close to highway ramps.

Figure 9.3 below shows the idea of the levels of parking facility. The facility itself can consist of multiple areas of different vehicle types. The areas consist of spaces, the share the characteristics, e.g. the same dimensions or heading. The spaces itself show the most detailed level of information, providing if a space is free or not. Each level can be used to inform vehicles about the status of the parking facility, area or space. Hence, road operators are able to adapt the information according to their technical possibilities when it comes to detect free spaces.

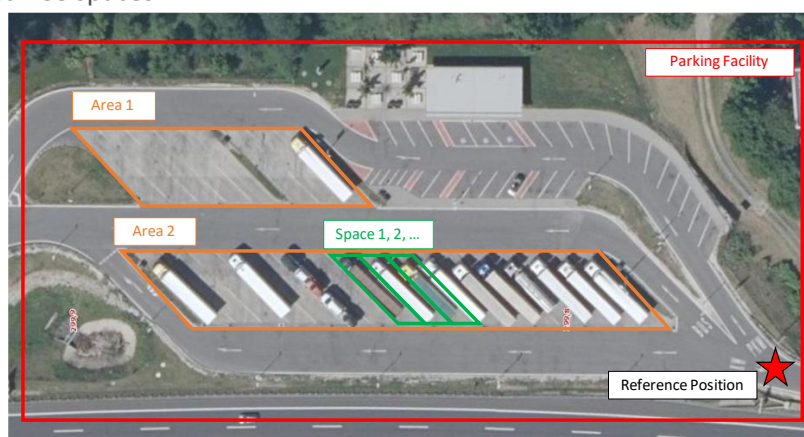


Figure 9.3: Parking facility, area and space

#### Objective

- Allow drivers to manage their driving time according to the availability of parking places and spaces and associated services;
- This use case also applies to HGV drivers who are subject to regulations on the maximal time of driving, as well as to light vehicles drivers;
- To prevent overcrowded (truck) parking and illegal parking on hard shoulders (or other places that are not suitable as parking spaces);

	<ul style="list-style-type: none"> <li>○ To prevent (truck) drivers searching for an available parking space, causing unnecessary traffic movements from (heavy goods) vehicles;</li> <li>○ To facilitate urban delivery by making them find more easily an available space and deliver without staying on the road.</li> </ul>
Desired behaviour	Drivers adapt their journey based on the received information.
Expected benefits	<ul style="list-style-type: none"> <li>○ Safety: As the driver will have the information upstream, it will allow the driver to plan his stop accordingly, especially for an HGV driver. Thus, the driver will be able to drive more safely;</li> <li>○ Traffic management;</li> <li>○ Better parking place/space management;</li> <li>○ Comfort (information on services at the parking place/space).</li> </ul>
<b>Use case description</b>	
Situation	<p>The information provided can be:</p> <ul style="list-style-type: none"> <li>○ The location of parking places/spaces;</li> <li>○ Opening hours;</li> <li>○ If the parking place is open or closed (can be closed due to maintenance, roadworks, event in the area);</li> <li>○ The number of their available spaces. If not known, information provided is just “full” or “free”. Additionally, a complete or partial set of information on the availability and location of each space can be provided;</li> <li>○ The location of spaces for people with reduced mobility;</li> <li>○ The location spaces reserved for on/off loading goods;</li> <li>○ The occupancy trend;</li> <li>○ Information about the service provider, including an address, phone number or website address;</li> <li>○ Vehicle Types and/or transported goods permitted to be parked;</li> <li>○ Services provided in the parking place, and associated rates;</li> <li>○ If there is a charging point for electric vehicles;</li> <li>○ Multimodal facilities in the vicinity;</li> <li>○ The type of parking for each space, including detailed information e.g. the position, the layout, the orientation a.o.;</li> <li>○ The lanes, how to access certain areas.</li> </ul> <p>Additional information (e.g. signage, navigation support) can be sent via a message that is linked to the parking information message.</p>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ Parking operators: The parking operator sends the parking information to road operator or the TCC;</li> <li>○ Road operator / TCC: The road operator /TCC is the sender of the information, being the parking operator or after obtaining the</li> </ul>



Scenario	<p>information from the parking operator or from embedded sensors in parking spaces;</p> <ul style="list-style-type: none"> <li>○ Drivers are the end-users of the use case.</li> </ul> <p>(1) <u>Place information (aggregate level information)</u></p> <ul style="list-style-type: none"> <li>○ The road operator / TCC gets the information by his own means or through his data/service provider/parking operator. The information may be in the form of the exact number of vacant spaces or the probability of finding an available space;</li> <li>○ The road operator / TCC sends it to all the vehicles, in a relevant area;</li> <li>○ Vehicles receive the information and pending the implementation display it directly or on request by the driver;</li> <li>○ The information is displayed in the vehicle on the HMI, adapted, if possible, to the type of vehicle (e.g., Light Vehicle or Heavy Goods Vehicle);</li> <li>○ Drivers adapt their trip and choose a parking place/space according to their needs;</li> <li>○ Eventually, the driver could put his itinerary in the guidance system of the vehicle that is connected to the C-ITS system to go to the parking place/space.</li> </ul> <p>(2) <u>Space information (individual spot information)</u></p> <ul style="list-style-type: none"> <li>○ The road operator / TCC gets the information by his own means or through his data/service provider. This is specific information about 1 individual parking space;</li> <li>○ The road operator / TCC sends it to all the vehicles, in a relevant area. The road operator / TCC can send information about multiple individual parking spaces in the message;</li> <li>○ Vehicles receive the information and pending the implementation display it directly or on request by the driver;</li> <li>○ The information is displayed in the vehicle on the HMI, adapted, if possible, to the type of vehicle (e.g., Light Vehicle or Heavy Goods Vehicle);</li> <li>○ Drivers adapt their trip and choose a parking space according to their needs;</li> <li>○ Eventually, the driver could put his itinerary in the guidance system of the vehicle that is connected to the C-ITS system to go to the parking space.</li> </ul>
Presentation/Alert principle	<p>Information is provided to drivers automatically or who request it via the HMI or a dedicated app (e.g., smartphone).</p> <p>How the information is presented to the driver is not part of the service description. It is left to the provider of the HMI how information is presented. Information may be translated to the preferred language of the road user</p>



Functional Constraints / dependencies	<p>Constraints</p> <ul style="list-style-type: none"> <li>○ The provision of information and its quality (validity, confidence, up to date) should be available early enough to act. Depending on the type of parking, the timing of the information is essential (e.g. receiving parking information for trucks on motorways versus parking information in an urban environment).</li> </ul> <p>Dependencies</p> <ul style="list-style-type: none"> <li>○ The availability and accessibility of real-time on-street parking availability information from TMC in case of the space information.</li> </ul> <p>How the information is presented to the road user is not part of the service description. It is left to the provider of HMI how information is presented. Information may be translated to the preferred language of the road user.</p> <p>The parking information presented is not obligatory but a guidance: Information should be handled as ‘convenience information’ and presented accordingly to the road user.</p>
Link with other use cases	
<b>Interoperability Requirements</b>	
Message profile requirements	<p>For this use case, the POIM-PA shall be sent according to the POIM-PA message for Parking Availability Facility Layer Service (PA-FLS) as profiled in chapters 4.2.7 of [C-Roads MP].</p> <p>Triggering conditions:</p> <p>The PA-FLS is managed in cooperation between the PA-FLS provider (Roadside equipment or a central system) and users of the service which can be vehicles controlled by human (SAE levels 0 to 3) or which can be fully automated vehicles (SAE level 4 and 5) or motorized VRUs searching for a dedicated parking. The PAS is triggered by a parking management application which provides the service. At the level of the service provider, the POIMs-PA dissemination is controlled via several triggering conditions relatively to the type of ITS communication profile being used:</p> <ul style="list-style-type: none"> <li>○ Continuous broadcast from a Roadside Unit: In this case, the POIM-PA is continuously broadcasted at a predefined frequency which can be adjusted according to the used channel congestion management. Local users are then constantly receiving the broadcasted POIMs-PA and then filter them according to their local mobility application needs.</li> <li>○ Push unicast mode from a central station: The unicast mode is used by long range communication systems, in this case directly addressing a</li> </ul>

	<p>user which has a service contract with the parking management service operator. Then, the dissemination of POIMs-PA to the user is under the initiative of the service operator which may infer, according to some received information, that the user needs to be informed about local parking' availabilities.</p>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on POIM the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = POIM – PA</li> <li>○ messageType = POIM</li> </ul> <p>Geographic area (Quadtree) for POIM:</p> <p>The event is primarily characterized by the DF “position” in the placeinfo of the ParkingAvailabilityBlock. If the optional DF “detailedStatus” in ParkingAvailabilityBlock is available and used, then “location” and the optional “boundary” set within the sequence of “ParkingArea” should be considered as well. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned. Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>List of applicable generic test cases from [C-Roads_TP]:</p> <ul style="list-style-type: none"> <li>○ ITS-G5 only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_ITSG5_POIM_ParkingStatusContainer_01_R2.3.0</li> </ul> </li> <li>○ IP based only: <ul style="list-style-type: none"> <li>○ TC_CROADS_GENERIC_HYBRID_POIM_ParkingStatusContainer_01_R2.3.0</li> </ul> </li> </ul> <p>List of applicable specific test cases:</p>

- ITS-G5 only:
  - TC\_CROADS\_POI-PA\_ITSG5\_POIM\_countryCode\_02\_01\_R2.3.0
  - TC\_CROADS\_POI-PA\_ITSG5\_POIM\_OpeningStatus\_04\_01\_R2.3.0
  - TC\_CROADS\_POI-PA\_ITSG5\_POIM\_OccupancyInformation\_04\_02\_R2.3.0
  - TC\_CROADS\_POI-PA\_ITSG5\_POIM\_ParkingStatusList\_04\_03\_R2.3.0
  - TC\_CROADS\_POI-PA\_ITSG5\_POIM\_ParkingSupplyCapabilitiesContainer\_5\_R2.3.0
- Hybrid (IP based only):
  - TC\_CROADS\_POI-PA\_HYBRID\_POIM\_countryCode\_02\_01\_R2.3.0
  - TC\_CROADS\_POI-PA\_HYBRID\_POIM\_OpeningStatus\_04\_01\_R2.3.0
  - TC\_CROADS\_POI-PA\_HYBRID\_POIM\_OccupancyInformation\_04\_02\_R2.3.0
  - TC\_CROADS\_POI-PA\_HYBRID\_POIM\_ParkingStatusList\_04\_03\_R2.3.0
  - TC\_CROADS\_POI-PA\_HYBRID\_POIM\_ParkingSupplyCapabilitiesContainer\_5\_R2.3.0

# 10. Probe Vehicle Data (PVD)

## 10.1.1 PVD: Service introduction

Service introduction	
Summary	<p>Probe Vehicle Data (PVD) is a C-ITS service that provides vehicle or event data from a vehicle to other vehicles (V2V service) and also to the road traffic management infrastructure (V2I service). The PVD service can either be an automatic collection by the in-vehicle system (i.e., vehicle C-ITS station) or a manual reporting by the drivers via the in-vehicle system.</p> <p>This service description specifies the requirements of V2I PVD service <b>from the perspective of the road operators and the service providers active in C-Roads</b>. V2V service requirements are out of the scope of this description.</p> <p>Since the PVD service provides data that can be related to vehicles/drivers (e.g., location data), it creates concerns about the traceability of the vehicles/drivers when this service is used by road operators and service providers. Therefore, appropriate measures need to be taken for the implementation and use of the PVD service to protect the privacy of both the drivers using the service and the other drivers concerned by the data in compliance with the GDPR. This specification adopts the current view of C-Roads as detailed in [C-ITS Privacy – Concluding Memo] by C-Roads WG1.</p>
Background	<p>Today's vehicles know at any time their own position, speed, direction, vehicle type, length, etc. Moreover, sensors/embedded technologies in the vehicles can detect and report specific events affecting driving performance, road conditions etc. For events (e.g., animal on the road) that may be not detected by the vehicle itself, the driver may visually detect and report them. This data can be used by the road operators to get a more comprehensive knowledge of the road network (especially in areas not equipped with road sensors, such as loop detectors, CCTV etc.). It can also be used to enhance the road operator's knowledge of events, complementing road sensors, patrol and other existing sources.</p>
Objective	<p>The objective of this service is to collect data from vehicles and/or drivers on public road networks for improving road traffic management and safety operations. The PVD service will provide data:</p> <ul style="list-style-type: none"> <li>○ to improve knowledge of traffic conditions, traffic flow and incidents,</li> <li>○ to improve knowledge of road and weather conditions,</li> <li>○ to improve existing traffic management operations,</li> <li>○ to enable innovations in traffic management and safety operations,</li> <li>○ to improve or enable I2V use cases,</li> <li>○ to improve traffic management strategies and policies (e. g., through exploitation of new information), and</li> <li>○ for statistical and modelling purposes (e.g., digital twin).</li> </ul>

Expected benefits	<p>Expected benefits of the PVD service include, but are not limited to:</p> <ul style="list-style-type: none"> <li>○ faster, more accurate and more efficient event detection on the road network,</li> <li>○ improved network operations and event management,</li> <li>○ improved safety of public drivers,</li> <li>○ improved air quality and environmental performance,</li> <li>○ enhanced road network and event impact knowledge,</li> <li>○ a possible cost reduction of the installation and maintenance of event detection infrastructure, and</li> <li>○ new or enhanced C-ITS services: <ul style="list-style-type: none"> <li>○ Location-based provisioning of C-ITS messages/services by service providers</li> <li>○ (Centralised) collision risk warning or signal violation warning</li> <li>○ Optimisation of signalised intersections</li> <li>○ (Dangerous) End of queue warning</li> <li>○ Extreme weather warning</li> <li>○ Travel time estimation and information</li> <li>○ Hazardous Location Notification</li> </ul> </li> </ul>
Use cases	<ul style="list-style-type: none"> <li>○ Vehicle Data Collection (PVD-VDC)</li> <li>○ Event Data Collection (PVD-EDC)</li> </ul> <p><i>NOTE: the current description reflects the view and requirements of C-Roads members and probably will be updated/enhanced following the discussion with other stakeholders e.g., C2C-CC.</i></p>

## 10.2 PVD: Use Cases

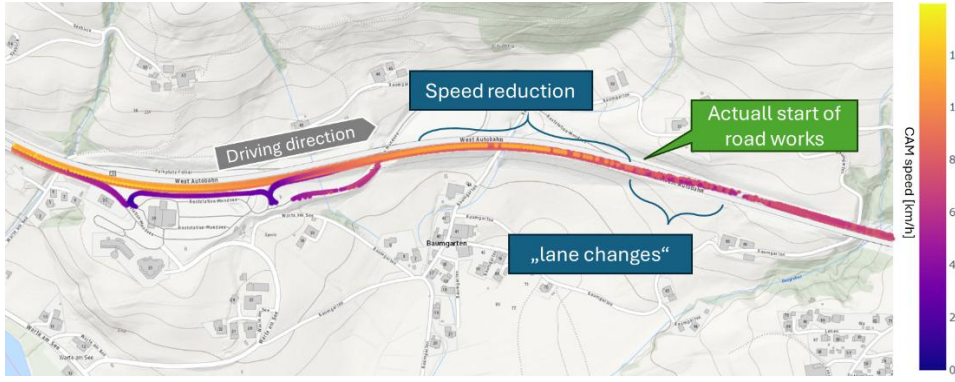
### 10.2.1 PVD – Vehicle Data Collection (PVD-VDC)

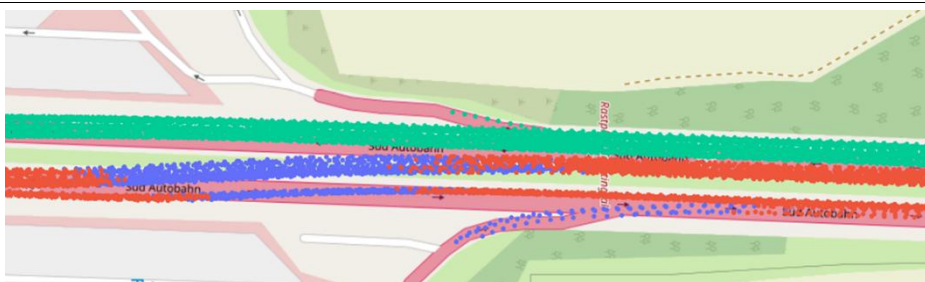
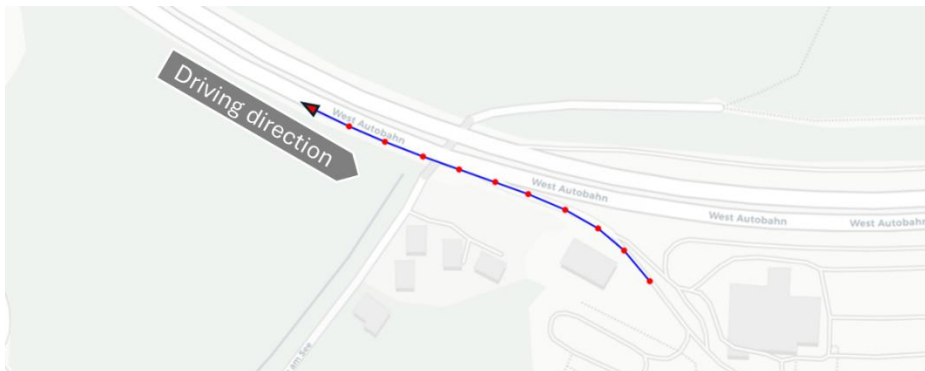
Type of road network	All
Type of vehicle (sender)	All C-ITS equipped vehicles
<b>Use case introduction</b>	
Summary	Vehicle data is automatically sent out by the in-vehicle system (i.e., vehicle C-ITS station). The road operator collects and processes the vehicle data sent out by vehicle C-ITS stations to improve traffic management and safety operations on the corresponding public road network.
Background	Vehicle data is a first-hand or original source of traffic information for road operators and service providers. Vehicle data from an adequate number of vehicles on the road network can provide valuable insight to the road operators and service providers regarding the current status of traffic conditions, network status etc. Therefore, this use case is intended to improve traffic management and safety operations, generate traffic information and enable new services for drivers by the road operators and service providers.
Objective	The objective of this use case is to collect data from vehicles on the public road network to improve traffic management and safety operations for drivers.
Expected vehicle data for traffic management operations	<p>The following vehicle data is expected by the road operators from the vehicles on the road network in (near) real-time for improving traffic management and safety operations:</p> <ul style="list-style-type: none"> <li>○ Timestamp</li> <li>○ (Temporary) Station ID</li> <li>○ Vehicle location (geo location coordinates with confidence level)</li> <li>○ Station type</li> <li>○ Vehicle role</li> <li>○ Speed</li> <li>○ Heading</li> <li>○ Vehicle length</li> <li>○ Vehicle width</li> </ul> <p>The following vehicle data may also be useful for traffic management applications, if the V-ITS-S can provide them (e.g., by connecting to the vehicle CAN bus):</p> <ul style="list-style-type: none"> <li>○ Longitudinal acceleration</li> <li>○ Drive direction</li> <li>○ Yaw rate</li> <li>○ Light/siren bar status (e.g., for emergency vehicles)</li> </ul>

	<ul style="list-style-type: none"> <li>○ Exterior light status (e.g., for detecting visibility conditions)</li> </ul>
Expected benefits	See PVD service introduction
<b>Use case description</b>	
Situation	The V-ITS-S installed in a vehicle automatically sends out vehicle data as C-ITS messages to the service provider and/or the road operator via the communication infrastructure.
Logic of transmission	V2I
Actors and relations	<ul style="list-style-type: none"> <li>○ The vehicle driver may need to give consent for automatic sharing of vehicle data with the road operator or the service provider.</li> <li>○ The V-ITS-S sends out vehicle data as a C-ITS message regularly.</li> <li>○ The road operator collects, anonymises and processes vehicle data and may share processed data (in anonymised and/or aggregated form) with other road operators and service providers for improving traffic management and safety operations.</li> <li>○ Optional: A service provider collects and processes vehicle data and shares processed data with the road operators and other service providers for improving traffic management and safety operations.</li> <li>○ The TCC uses the (processed) data/information of the vehicles on the road network for improving traffic management and safety operations for drivers.</li> </ul>
Use case scenario	<ul style="list-style-type: none"> <li>○ The driver may provide consent via an activation switch in the V-ITS-S to share vehicle data with the road operator or the service provider for improving traffic management and safety operations on the public road network.</li> <li>○ The V-ITS-S automatically generates and sends out vehicle data as C-ITS messages.</li> <li>○ The Roadside C-ITS Station (R-ITS-S) or the service provider collects the data from the vehicles. The collected data from the vehicles might be sampled, aggregated or anonymised by the R-ITS-S before forwarding it to the Central C-ITS Station (C-ITS-S).</li> <li>○ The R-ITS-S or service provider may forward vehicle data/information to the C-ITS-S.</li> <li>○ The C-ITS-S may process the vehicle data.</li> <li>○ The C-ITS-S may forward (processed) vehicle data/information to the TCC (or to other service providers).</li> </ul> <p>Collected vehicle data shall be deleted by the R-ITS-S, C-ITS-S and the service provider as soon as they are processed for gathering information/insight needed for improving traffic management and safety operations on the public road network.</p>

Intended Presentation/Alert principle	<p>An indication of vehicle data transmission or consent status may be presented on the HMI.</p> <p>No other alert or information needs to be presented on the HMI.</p>
Functional constraints/dependencies	<p>Vehicle data collection and processing with or without the combination of other data available to the road operator/service provider shall be compliant with the GDPR and local legislation.</p> <p>Key issues, dependencies and assumptions related to the implementation of this use case are:</p> <ul style="list-style-type: none"> <li>(i) Compliance to GDPR and national regulations: <ul style="list-style-type: none"> <li>○ anonymisation of personal information for private vehicles</li> <li>○ anonymisation of personal information for operator/special purpose vehicles: when and how to track road operator vehicles and other special vehicles</li> </ul> </li> <li>(ii) Dependencies: <ul style="list-style-type: none"> <li>○ sufficient penetration of vehicles equipped with C-ITS</li> <li>○ willingness of drivers to share vehicle data (i.e., sending out CAM to the road operators and/or service providers)</li> <li>○ trust level of road operators and service providers</li> </ul> </li> <li>(iii) A low frequent change of Authorisation Tickets (aTs) may be considered by implementations of operator and/or special purpose vehicles' C-ITS stations for operational purposes</li> <li>(iv) CAM aggregation/processing at R-ITS-S or C-ITS-S may limit/prevent availability of (raw) vehicle data for certain applications (e.g., travel time estimation)</li> </ul> <p><i><u>NOTE this document does not specify how to be compliant with the GDPR and national regulations. Please refer to C-Roads WG1 work on this issue.</u></i></p>
Link to other use cases	None
<b>Expected usage of collected vehicle data by the road operator / service provider</b>	
Introduction	<p>Among the C-Roads road operators the following common usages of vehicle data have been identified for improving traffic management operations.</p>
Aggregated vehicle data for traffic management operations	<p>Aggregated vehicle data could create information similar to and/or compatible with the information collected using existing loop detectors and road sensors. The aggregated data can be used for traffic analyses, traffic modelling, traffic information, traffic regulation (e.g., speed advice/limit) etc. to enhance traffic management and safety operations on public roads.</p> <p>Aggregated vehicle data can provide the following in time and space:</p> <ul style="list-style-type: none"> <li>○ number of vehicles</li> <li>○ average speed</li> <li>○ average speed per vehicle type/class</li> <li>○ (average) length of the vehicles on the road</li> <li>○ classification (data per vehicle type) of vehicles on the road</li> </ul>



	<ul style="list-style-type: none"> <li>○ minimum and maximum speeds during a specified interval e.g., 1 min, 5 min, 30 min, 1 hour.</li> </ul>
Vehicle counting	This processing detects or counts the presence of vehicles in specific areas. The resulting data is used in e.g., tunnels and parking areas.
Traffic signal optimisation	This processing results in data to be used to optimise traffic signal timings. Applications include queue and delay measurement, signalised intersection manoeuvres analysis, verification of signal timings and sensor failings.
Event detection	<p>This processing detects events or trends in the vehicle data resulting in queue, congestion or event information.</p> <p>The processed data could provide:</p> <ul style="list-style-type: none"> <li>○ acceleration/deceleration</li> <li>○ speed and direction</li> <li>○ number of vehicles with headlights on</li> <li>○ number of vehicles with daytime running lights on</li> <li>○ number of vehicles with fog lights on</li> <li>○ specific vehicle roles (for e.g., emergency vehicle warning)</li> <li>○ positions of start and/or end of congested areas or queues</li> <li>○ positions of stationary vehicles</li> </ul>
Travel time estimation	<p>Vehicle data is processed in multiple locations to determine or estimate the travel time. The resulting data is used for traffic analyses, traffic modelling and traffic information.</p> <p>To be able to make the estimate, matches for vehicles in the different locations should be possible with sufficient confidence during a sufficiently large time interval.</p>
Construction zone and road works location validation	<p>Vehicle data is processed to validate or improve location information of construction and road works zones such as start, end and lane availability. Here, CAM speed and location indicate slowdowns and “lane changes”:</p>  <p>CAM location and heading indicate lane changes and lane separation:</p>

	 <p>Vehicles providing CAMs with location, speed and heading information contribute to the validation of road works location data.</p>
Wrong-way driver	<p>Vehicles providing CAMs with location and path history contribute to the detection of wrong way drivers.</p>  <p>The road operator might use such an incident to send a wrong way driver warning, see HLN-AWWD.</p> <p>Once the wrong-way driver makes a turn and continues in the right driving direction, the road operator and other vehicles immediately detect that the wrong-way driver is not there anymore, the wrong way driver warning can be cancelled.</p>
Poor weather condition	<p>Vehicle data from CAMs could indicate poor weather conditions:</p> <ul style="list-style-type: none"> <li>○ Fog lights could indicate low visibility (from CAM low frequency container)</li> <li>○ Low beam light at daytime might also indicate restricted visibility (rain), , unless low beam lights are generally recommended or mandatory at the location of data collection.</li> <li>○ Windshield wiper status (from the low frequency container of CAM Release 2) might also serve as a weather condition indicator.</li> </ul>
Actual performance indication of roads	<p>Vehicle data is processed into information of actual performance of roads or road systems compared to regular, expected or optimal performance.</p>
<b>Privacy-preserving measures</b>	
Introduction	<p>The following measures are recommended for preserving privacy in probe vehicle data processing. The measures do not guarantee compliance with the GDPR, therefore GDPR and local legislation needs to be considered.</p>

Anonymisation of personal data before processing	Generally, it supports the minimum availability of personal data in C-ITS stations, if the principle is applied that for every C-ITS message received, anonymisation is performed at the first point of message reception in the network and processing of message details is done only after the anonymisation step.
<b>C-Roads expectations with regards to interoperability requirements</b>	
Introduction	The following provides interoperability and harmonisation requirements of C-Roads for implementation of the PVD-VDC use case (i.e., collection of vehicle data from vehicles on the road network) by road operators. The requirements (expectations) specified here need to be discussed and agreed with the C2C-CC.
Security and data protection requirements	<p>Senders should comply to L1 or L2 specifications in the CPOC protocol.</p> <p>Receivers should maintain a trust list containing all trusted senders (e.g., L1, L2 and bilateral trust).</p> <p>All incoming C-ITS messages should be verified according to Annex B of [C-ITS Security Requirements and Specifications].</p>
Message profile requirements	<p><u>Case 1: Ordinary vehicles that are equipped with C-ITS stations covered by [C2C CC Vehicle C-ITS station profile]</u></p> <p>The list of CAM data frames (DFs) and data elements (Des) that are expected from ordinary vehicles for supporting traffic management operations applications by road operators (i.e., C-Roads members) is provided in Annex PVD-VDC of this document.</p> <p><i>NOTE: This list needs to be discussed and any relevant interoperability and harmonisation requirements are to be agreed with the C2C-CC, for making sure that those data will be provided by ordinary vehicles for supporting traffic management operations applications.</i></p> <p><u>Case 2: Special purpose vehicles that are equipped with C-ITS stations covered by C-Roads Specifications</u></p> <p>The CAM profile for special purpose vehicles that are covered by C-Roads specifications is provided in chapter 4.2.5 of [C-Roads MP].</p>
Communication technology requirements: ITS-G5	<p>For the implementation of the PVD-VDC use case using ITS-G5 based communication, the mobile C-ITS stations equipped in ordinary vehicles are expected to comply with [C2C CC Vehicle C-ITS station profile].</p> <p>For the implementation of the PVD-VDC use case using ITS-G5 based communication, the mobile C-ITS stations equipped in special purpose vehicles shall comply with [C-Roads MSP].</p>
Communication technology requirements: IP based	<p><u>Back end (IP based):</u></p> <p>Compliance to the GDPR and local legislation should be checked and validated by the respective data providers.</p>

	<p>C-Roads C-ITS IP-based Interface Profile [C-ITS IP Based Interface Profile] shall be used for communication of PVD-VDC use case messages based on CAM between C-ITS actors, in the backend. The Basic Interface (BI) of the C-ITS IP-based Interface Profile [C-ITS IP Based Interface Profile] shall be used for exchanging the CAM between the actors.</p> <p>For exchanging PVD-VDC messages based on CAM via the BI, the AMQP filtering tables specified in Chapter 3.3 of C-ITS IP Based Interface Profile [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = PVD-VDC</li> <li>○ messageType = CAM</li> </ul>
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## 10.2.2 PVD – Event Data Collection (PVD-EDC)

Type of road network	All
Type of vehicle (sender)	All C-ITS equipped vehicles
<b>Use case introduction</b>	
Summary	Event data is generated by C-ITS equipped vehicles based on certain conditions that indicate an event, in contrast to probe data, which refers to the status of the vehicle (location, speed etc.). The in-vehicle system (i.e., V-ITS-S) sends out event data that was detected by the vehicle itself or manually by the drivers. Drivers may also report event data via their personal devices (e.g., smartphones). The road operator (or the service provider) collects and processes the event data sent out by the in-vehicle systems or reported by the drivers to improve traffic management and safety operations on the public road network.
Background	Today's vehicles are equipped with sensors and embedded technologies to detect events that might affect the safety and driving experience of the user (e.g., windscreen wiper status, ABS, ESC, collision sensors, etc.). These event notifications directly reach other vehicles. They are also a valuable data source for the road operator and complement other data sources used in traffic management. Some events may not be detected automatically by the vehicle itself (e.g., animal on the road, unmanaged blockage of road, etc.). The drivers may also visually detect some events (e.g., animal on road) and report them to the road operator or service provider via the in-vehicle system. Maintenance workers or road operator personnel can be seen as specific types of drivers, who can detect and manually report events via in-vehicle system. These data collected from the vehicles on the road directly can be used to enhance the road operator's or service provider's knowledge of events, complementing the event data collected from the existing legacy sources such as CCTVs, vehicle detection loops, roadside radars etc.
Objective	See PVD service introduction
Expected event notifications from the vehicles or the drivers, to be used by the road operators to improve traffic management operations	<p>The following events (e.g., based on DENM messages) are collected by the road operators from the vehicles and the drivers on the road network in (near) real time for improving traffic management and safety operations:</p> <ul style="list-style-type: none"> <li>○ Temporary slippery road</li> <li>○ Stationary vehicle</li> <li>○ Vehicle breakdown</li> <li>○ Vehicle in accident (post crash)</li> <li>○ Reduced visibility</li> <li>○ Emergency braking</li> <li>○ End of queue (traffic jam)</li> </ul>

	<ul style="list-style-type: none"> <li>○ Adverse weather conditions</li> <li>○ etc.</li> </ul>
Desired behaviour	<ul style="list-style-type: none"> <li>○ In the automatic event detection and reporting case, no specific behaviour is expected from the drivers (i.e., the driver) for whom the operation of the service is totally invisible unless the HMI is programmed to present the events declared by the in-vehicle system (choice of the OEM).</li> <li>○ In the manual event reporting case, the drivers need to be able to detect and report the event safely and quickly if allowed by the national regulation/law.</li> <li>○ For the road operator, the collected data may give insight regarding the current traffic situation and surroundings. These can be used as input for traffic performance monitoring &amp; evaluation, traffic modelling (e.g., for policy making) as well as to trigger some I2V use cases such as traffic condition warning, hazardous location notification and adverse weather condition.</li> </ul>
Expected benefits	See the PVD service introduction
<b>Use case description</b>	
Situation	A vehicle is driving along the road. A vehicle or a driver detects a specific event and reports it via its V-ITS-S to the road operator or the service provider. The roadside communication infrastructure receives the message sent out by the V-ITS-S and forwards it to the C-ITS-S.
Logic of transmission	V2I
Actors and relations	<ul style="list-style-type: none"> <li>○ The V-ITS-S gathers event data automatically from the vehicle's sensors and sends out event data.</li> <li>○ The drivers may also manually declare specific events or feedback via the HMI of the V-ITS-S.</li> <li>○ The drivers are the owners of the information and might need to give consent for automatic sharing of event data by the V-ITS-S.</li> <li>○ The road operator collects, anonymises and processes the event data from vehicles and may share processed data/information (in anonymised and/or aggregated form) regarding the event with other service providers for improving traffic management and safety operations.</li> <li>○ Optional: A service provider collects and processes data and may share processed data/information regarding the event with the road operators and/or the other service providers for improving traffic management and safety operations.</li> <li>○ The TCC uses the (processed) data/information regarding the event for traffic management and safety operations as well as to communicate with public drivers.</li> </ul>

Use case scenario	<ul style="list-style-type: none"> <li>○ Either the V-ITS-S automatically gathers event data from vehicle sensors/embedded technologies, or the drivers visually detect an event (or the absence of an event) and report it via the HMI of the V-ITS-S.</li> <li>○ The V-ITS-S automatically generates and sends out event data as a C-ITS message.</li> <li>○ The R-ITS-S or the service provider collects the event data sent out by the vehicles.</li> <li>○ The collected data from the vehicles may be anonymised or aggregated by the R-ITS-S before forwarding them to the C-ITS-S.</li> <li>○ The R-ITS-S or service provider may forward event data/information to the C-ITS-S.</li> <li>○ The C-ITS-S may process the event data.</li> <li>○ The C-ITS-S may forward (processed) event data/information to the TCC (or to other service providers).</li> <li>○ The TCC (or the service provider) may validate, process or consolidate the event data collected from the vehicles, use them for traffic management and safety operations and share them with service providers and drivers.</li> <li>○ Collected (raw) event data (with any personal information) shall be deleted by the R-ITS-S, C-ITS-S and the service provider as soon as they are processed for gathering information/insights needed for traffic management and safety operations on the public road network.</li> </ul>
Intended Presentation/Alert principle	<p>When drivers manually report a specific event on the HMI of the V-ITS-S, a confirmation of sending out the event may be presented on the HMI.</p> <p>When triggered automatically by the vehicle, the use case may be totally invisible for the driver. No alert or information will be presented on the vehicle's HMI unless the HMI is programmed to present the events declared by the vehicle automatically (choice of the OEM).</p>
Functional constraints/dependencies	<p>See PVD-VDC</p> <p>Additionally:</p> <p>In the manual reporting case: the drivers should be able to safely report the event on the HMI (manual reporting is not permitted while driving in some member states).</p>
Link to other use cases	none
<b>C-Roads expectations with regards to interoperability requirements</b>	
Introduction	<p>The following provides interoperability and harmonisation requirements of C-Roads for implementation of PVD-EDC use case (i.e., collection of event data from vehicles on the road network) by road operators. The requirements (expectations) specified here need to be discussed and agreed with the C2C-CC.</p>

Security and data protection requirements	All incoming C-ITS messages should be verified according to Annex B in [C-ITS Security Requirements and Specifications].
Message profile requirements	<p>With respect to the triggering conditions for certain event data, these are specified in [C2C CC Vehicle C-ITS station profile], e.g.:</p> <ul style="list-style-type: none"> <li>○ Stationary vehicle, breakdown and post-crash: Triggering Conditions and Data Quality Stationary Vehicle Warning</li> <li>○ Emergency braking etc.: Triggering Conditions and Data Quality Dangerous Situation</li> <li>○ Poor weather conditions and slippery road: Triggering Conditions and Data Quality Adverse Weather Conditions</li> <li>○ Traffic jam: Triggering Conditions and Data Quality Traffic Condition</li> </ul>
Communication Requirements: ITS-G5	<p>For the implementation of the PVD-EDC use case using ITS-G5 based communication, the mobile C-ITS stations equipped in ordinary vehicles are expected to comply with [C2C CC Vehicle C-ITS station profile].</p> <p>For the implementation of the PVD-EDC use case using ITS-G5 based communication, the mobile C-ITS stations equipped in special purpose vehicles shall comply with [C-Roads MSP].</p>
Communication technology requirements: IP based	To be determined



## References

All References (in square brackets) refer to the global reference document WG2 REFERENCES 2.3.0 (3/2025).

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## Annex PVD

### Annex PVD-VDC

The following table provides CAM DFs and DEs that are expected from ordinary vehicles (i.e., the vehicles covered by [C2C CC Vehicle C-ITS station profile]) on the road network by C-Roads members for traffic management operations applications. The CAM DFs and DEs are based on [ETSI TS 103 900].

Level	Name	Type	Mandatory /Optional	Expected by C-Roads	Comment
0.0	Header	DF (ItsPDUHeader)	Mandatory	YES	
1.0	CAM	DF (payload)	Mandatory	YES	
1.1	generationDeltaTime	DE	Mandatory	YES	
2.0	basicContainer	DF (container)	Mandatory	YES	
2.1	stationType	DE	Mandatory	YES	
2.2	referencePosition	DE	Mandatory	YES	
3.0	highFrequency Container	DF (container)	Mandatory	YES	
3.1	basicVehicleContainer HighFrequency	DF (container)	Mandatory	YES	
3.1.1	heading	DE	Mandatory	YES	
3.1.2	speed	DE	Mandatory	YES	
3.1.3	driveDirection	DE	Mandatory	YES	
3.1.4	vehicleLength	DF	Mandatory	YES	
3.1.5	vehicleWidth	DE	Mandatory	YES	
3.1.6	curvature	DF	Mandatory	YES	

3.1.7	curvatureCalculation Mode	DE	Mandatory	YES	
3.1.8	yawRate	DF	Mandatory	YES	
3.1.9	accelerationControl	DE	Optional	YES	
3.1.10	lanePosition	DE	Optional	YES	
3.1.11	steeringWheelAngle	DF	Optional	YES	
3.1.12	lateralAcceleration	DE	Optional	nice-to-have	
3.1.13	verticalAcceleration	DE	Optional	nice-to-have	
3.1.14	performanceClass	DE	Optional	nice-to-have	
3.1.15	cenDsrcTollingZone	DE	Optional	No	
3.2	rsuContainer HighFrequency	DF (container)	N/A	N/A	
4.0	lowFrequency Container	DF (container)	Optional	YES	
4.1	basicVehicleContainer LowFrequency	DF (container)	Optional	YES	
4.1.1	vehicleRole	DE	Mandatory	YES	
4.1.2	exteriorLights	DE	Mandatory	nice-to-have	
4.1.3	pathHistory	DF	Mandatory	nice-to-have	
5.0	specialVehicle Container	DF (container)	Optional	N/A	
5.1	publicTransport Container	DF (container)	Optional	N/A	
5.2	specialTransport Container	DF (container)	Optional	N/A	
5.3	dangerousGoods Container	DF (container)	Optional	N/A	

5.4	roadWorks ContainerBasic	DF (container)	Optional	N/A	
5.4	rescueContainer	DF (container)	Optional	N/A	
5.5	emergency Container	DF (container)	Optional	N/A	
5.6	safetyCar Container	DF (container)	Optional	N/A	

## Annex PVD-EDC

To be determined