



C-ITS Service and Use Case Definitions

Version 2.0.8

C-Roads Platform

Working Group 2 Technical Aspects

Taskforce 2 Service Harmonisation

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 "Signalized Intersections". Some minor editorial changes were made to make it conform with the current layout. Also, as agreed during the same WG2 meeting, the former service section "Other Hazardous Location Notifications" (OHLN) has been changed to "Hazardous Location Notifications" (HLN). This version of the document, the use of gender specific language is avoided. Nonetheless, further review and modification may be required; this will be taken into account for the next release 1.3.	Final
1.3	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

Version	Date	Description, updates and changes	Status
1.4	19-12-2018	<p>This release has the following changes with respect to v1.3:</p> <ul style="list-style-type: none"> - Incorporation of revised paragraph 4.2.2 based on the decision during the SC meeting of 11-12-2018 on the acceptance of the change request on R1.3. (the original paragraph 4.2.2 Signalized Intersections - Public Transport Prioritization, see for details <i>"C_Roads_WG2_TF2_TLM RLT Change Request on R1.3 after WG2 Budapest.doc"</i>). - 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). 	Final
1.5	11-07-2019	<ul style="list-style-type: none"> - This release has the following changes with respect to v1.4, agreed upon during the SCOM meeting of July 2, 2019. - Incorporation of agreed change request for IVS-EVFT use case from Slovenia. - Incorporation of new paragraphs based the acceptance of the new use cases (see for more details: <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. - Some minor editorial changes were made as well as some changes due to the inclusion of the new content (paragraph headers, number). 	Final
1.6	04.02.2020	<ul style="list-style-type: none"> - This release has the following changes with respect to v1.5, agreed upon during the SCOM meeting of December 17, 2019. - Incorporation of the English proofreading improvements (<i>C_Roads_WG2_TF2_Service Descriptions v1.5 - English Proofreading 0.3 after WG2</i>) - Incorporation of the SI improvements (<i>C_Roads_WG2_TF2_Service Descriptions v1.5 - SI improvements 0.3 After WG2 meeting</i>) - Incorporation of the 6 accepted new Use Cases: <ul style="list-style-type: none"> o <i>C_Roads_WG2_TF2_HLN UBR I2V v0.6</i> o <i>C_Roads_WG2_TF2_HLN-AWWD v0.10</i> o <i>C_Roads_WG2_TF2_HLN-PTVC v0.3</i> o <i>C_Roads_WG2_TF2_HLN-PTVS v0.3</i> o <i>C_Roads_WG2_TF2_SWD v1.0.13</i> o <i>C-Roads_WG2_TF2_HLN-EVI v0.6</i> - Some minor editorial changes were made as well as some changes due to the inclusion of the new content (paragraph headers, number). 	Final

Version	Date	Description, updates and changes	Status
1.7.0	24.06.2020	<ul style="list-style-type: none"> - 1.7.0.WG.5 accepted by the SCOM on 24.06.2020. - Incorporated agreed upon additional segments: Acronym List and New Introduction chapter. The numbering of the chapters has changed due to this inclusion. - No new use cases were added to the document 	Final
1.8.0	03.02.2021	<ul style="list-style-type: none"> - Inserted the outcome of the common resolution meetings and the WG2 meeting of November into the document. - No new use cases added in this release - 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. - 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. 	Final
2.0.0	09.07.2021	<ul style="list-style-type: none"> - Reviewed Interoperability requirements for HLN and IVIM use cases were added based on the discussions with C2C-CC. - Improvements based on the change request from Austria were discussed and agreed upon improvements and corrections of errors were incorporated. - 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"> o <i>C_Roads_WG2_TF2_IVS_Traffic Signs Free Text.SC.2 Comment resolution</i> - 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. - 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"> o <i>C_Roads_WG2_TF2_Automated_Vehicle_Guidance_consolidated_SCOM</i> 	Final
2.0.2	21.01.2022	<ul style="list-style-type: none"> - References updated 	Final

Version	Date	Description, updates and changes	Status
2.0.3	01.04.2022	<ul style="list-style-type: none"> - Additional input from TF5 on IVS test cases included - Improvements in the functional descriptions as well as in the interoperability requirements based on the improved C-ITS Infrastructure Mobile ITS G5 Profile [5]. - Included the content of the by the SCOM (23.03.2022) accepted documents: <ul style="list-style-type: none"> o <i>C_Roads_WG2_TF2_Signalized Intersections Reintroduction.SCOM.2</i> o <i>C_Roads_WG2_TF2_Emergency Prioritized Vehicle Approaching_SCOM.10</i> o <i>C_Roads_WG2_TF2_Emergency_and_Recovery_Vehicle_in_Intervention.SCOM.6</i> - 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"> o <i>C_Roads_WG2_TF2_Emergency_and_Recovery_Vehicle_in_Intervention.SCOM.6</i> - Some references needed to be updated due to the change of paragraph numbering in the respective documentation 	Final
2.0.4	07.07.2022	<ul style="list-style-type: none"> - Replacement of the HLN-EPVA use case due to the I2V scenario addition with: <ul style="list-style-type: none"> o <i>EPVA I2V addition.SCOM.3</i> - Updated test cases were added 	Final
2.0.5	26.10.2022	<ul style="list-style-type: none"> - Missing test cases for the HLN-EPVA use case were added 	Final
2.0.6	13.12.2022	<p>Revision of use case description due to change requests</p> <ul style="list-style-type: none"> - HLN-PTVC - HLN-APR - HLN-WCW <p>Added/replaced agreed upon definitions in Acronym list</p>	Final
2.0.7	30.03.2023	<p>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>'</p> <p>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</p>	Final
2.0.8	30.06.2023	<p>HLN-AZ: Added description in the message profile requirements</p> <p>HLN-ERVI: Updated message management based on exchange with C2C-CC; Updated definition of "stationary vehicle"</p> <p>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.</p>	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
C2C	Car 2 Car
CA	Cooperative Awareness
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 realized by a set of hardware and/or software components installed in the backoffice of the C-ITS service provider e.g. a Traffic Management Center or a Fleet Management Center
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
ESC	Electronic Stability Control: a computerized 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-EVA	Hazardous Location Notification – Emergency Vehicle Approaching
HLN-EVI	Hazardous Location Notification – Emergency 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

Acronym	Explanation
HLN-TJA	Hazardous Location Notification – Traffic Jam Ahead
HLN-TSR	Hazardous Location Notification – Temporary Slippery Road
HLN-UBR	Hazardous Location Notification – Unsecured Blockage of a Road
HLN-WCW	Hazardous Location Notification – Weather Condition Warning
HMI	Human Machine Interface
HOV	High Occupancy Vehicle
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-DLM	In-Vehicle Signage – Dynamic Lane Management
IVS-DSLI	In-Vehicle Signage – Dynamic Speed Limit Information
IVS-EVFT	In-Vehicle Signage – Embedded VMS “Free Text”
IVS-OSI	In-Vehicle Signage – Other Signage Information
IVS-SWD	In-Vehicle Signage – Shock Wave Damping
km	kilometre
MAP	Topology information for the intersection
MAPEM	MAP Extended Message
ms	millisecond
OBU	On Board Unit
OEM	Original Equipment Manufacturer
OHLN	Other Hazardous Location Notifications
PVD	Probe Vehicle Data
PVD-EDC	Probe Vehicle Data – Event Data Collection
PVD-VDC	Probe Vehicle Data – Vehicle Data Collection
PT	Public Transport
RHS	Road Hazard Signalling
R-ITS-S	Roadside ITS Station (the so-called RSU)

Acronym	Explanation
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-ROVA	Road Works Warning – Road Operator Vehicle Approaching
RWW-ROVI	Road Works Warning – Road Operator Vehicle in Intervention
RWW-WM	Road Works Warning – Winter Maintenance
sCC	subCauseCode
SI	Signalized Intersections
SI-EVP	Signalized Intersections –Emergency Vehicle Priority
SI-GLOSA	Signalized Intersections – Green Light Optimal Speed Advisory
SI-ISVW	Signalized Intersections – Imminent Signal Violation Warning
SI-SPTI	Signalized Intersections – Signal Phase and Timing Information
SI-TLP	Signalized Intersections – Traffic Light Prioritization
SPAT	Signal Phase And Timing
SPATEM	Signal Phase And Timing Extended Message
SREM	Signal Request Extended Message
SSEM	Signal request Status Extended Message
TCC	Traffic Control Centre
TCC-ACC	Traffic Control Centre – Adaptive Cruise Control
TF2	Task Force 2
TF3	Task Force 3
TJ	Traffic Jam
TMC	Traffic Management Centre
TMS	Traffic Management System
TOC	Traffic Operations Centre
UC	Use Case
UK	United Kingdom
V-ITS-S	Vehicle ITS Station
V2I	Vehicle to Infrastructure communication; Information exchange between vehicles and infrastructure.
V2I2V	Vehicle to Infrastructure to Vehicle communication; Information exchange from vehicles to infrastructure to vehicles
V2V	Vehicle to Vehicle Communication; information exchange between vehicles.

Acronym	Explanation
V2X	Vehicle to any communication; X is either infrastructure or car; Including communication between vehicles as well as between vehicles and infrastructure.
Vev2V / V _{ev} 2V	Emergency Vehicle to Vehicle communication; information exchange between emergency vehicles and other vehicles
VDS	Variable Direction Signs
VMS	Variable Message Signs
V _{PT} 2V	Public Transport Vehicle to Vehicle communication; information exchange between public transport vehicles and other vehicles
Vro2V / V _{ro} 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.

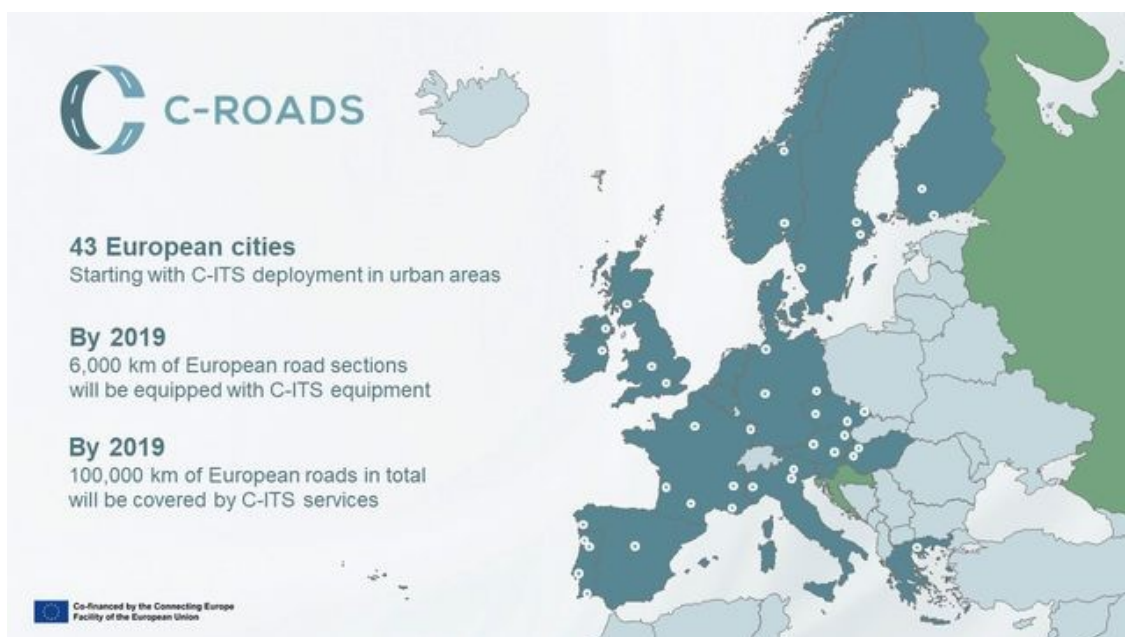


Figure 1: Overview of C-Roads coverage

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 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 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* [1].

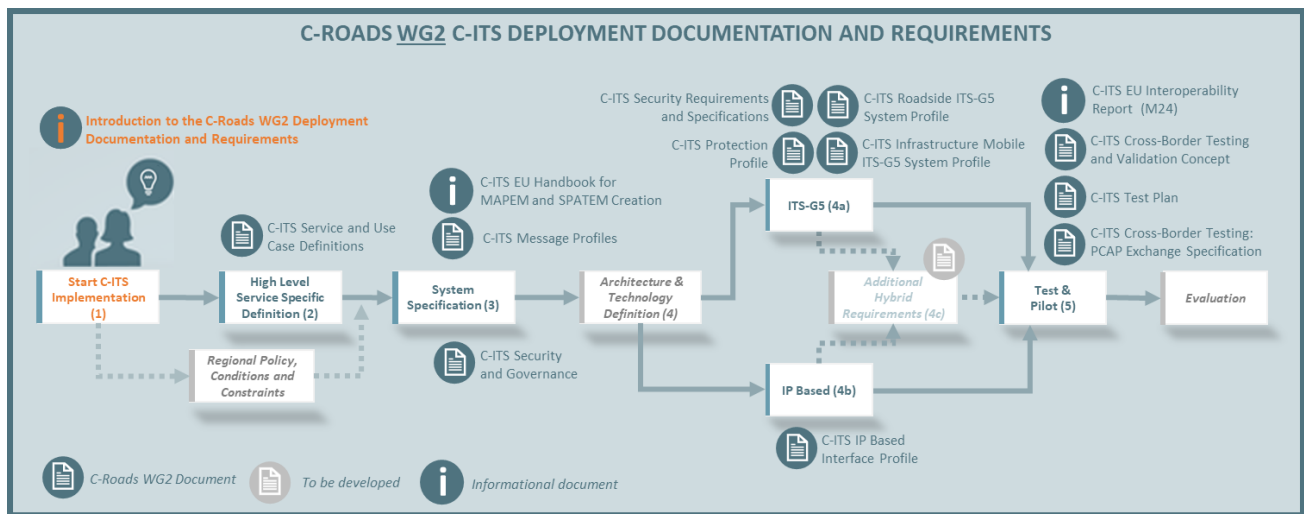


Figure 2: highlight of WG2 document in complete story board

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* [1]. 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 and in this document the services and use cases are described in a functional way. Next to these functional descriptions it contains per use cases the generic reference to needed specific other C-Roads WG2 documentation and it contains the harmonized specific use case settings to reach 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:** describes relevant situation (everything required to describe a static snapshot) considering (driving) function-related goals and values.
- **Scenario:** describes temporal development of a sequence of situations (e.g. initial and after) based on events and actions. It is story telling.
- **Actors:** external (human) entities that interact with the system. The system affects and is affected by the behaviour of actors; these interactions are described in the use case descriptions.

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

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

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

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

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

The following format is used to describe the services:

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

The following format is used to describe the use cases:

Use case introduction	
Summary	A summary of the use cases (one or two lines)
Background	A description of the motivation/rationale of the use case
Objective	The intended outcome of the use case
Desired behaviour	A description of the expected behaviour of the system and the intended behaviour of users
Expected benefits	A description of the expected added value and actor benefits
Use case description	
Situation	A description of one or more situations relevant to the use case
Logic of transmission	The transmission logic to be used (I2V, V2V, V2I, V2I2V... + broadcast / unicast / multicast)
Actors and relations	A list of all relevant actors and their relations/interactions with the system and their role in the use case (incl. sender and receiver). The actors are: road user, road operator, service provider, end user, vulnerable road user and other.
Use case scenario	A description of the story of the use case based on a sequence of situations (e.g., initial and after), events and actions, with illustrations. Sender and receiver should be addressed, in stakeholder neutral manner.
Display / alert principle	The triggering conditions and what is displayed to the user and when.
Functional constraints / dependencies	A description of functional constraints and dependencies that are requirements (if any) related to e.g., business, security, telecommunications, privacy, legal, human behaviour, etc.
Interoperability requirements	
Message profile requirements	Generic reference to the TF3 document "C-ITS Message Profiles" and 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 Prioritized 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
Signalized 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 Prioritization (SI-TLP)	2.0.3
	Emergency Vehicle Priority (SI-EVP)	2.0.3
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

2 In-Vehicle Signage (IVS)

2.1 IVS: Service introduction

Service introduction	
Summary	In-Vehicle Signage (IVS) is an information service to inform road users on actual static or dynamic road signs (or additional information mimicking virtual road signs) via in-car systems. The road signs can be regulatory (mandatory) or informational (advisory).
Background	<p>The In-Vehicle Signage (IVS) service is meant to inform road users via in-car information systems about static and dynamic road signs mirroring physical road signs along the road. Additionally, further information (virtual road signs or additional free text) can be provided. IVS may target information to specific vehicle types or to individual vehicles. The IVS information is sent out by means of Infrastructure-to-Vehicle (I2V) communication. Today, in addition to fixed road signs, VMS systems are used by road operators to provide operational, tactical, or strategic information to road users. Different types of variable or dynamic traffic sign systems are used, with both static pictograms and text and variable pictograms and text on:</p> <ul style="list-style-type: none"> • Variable Message Signs (VMS) • Variable Text Panels (VTP) • Variable Direction Signs (VDS)
Objective	<ul style="list-style-type: none"> • Increase attentive driving • Increase awareness on the content of road signs by providing sign information directly in the vehicle where it can potentially be displayed throughout the period of its entire validity. This will severely reduce observation problems attributed to physical road signs, such as limited line of sight, obstructions obscuring sight of a sign or limited attention by drivers passing signs • To display in driver's own or preferred language potentially
Expected benefits	<ul style="list-style-type: none"> • In-Vehicle Signage allows the driver to be informed earlier and more completely by providing continuous signage information directly in the vehicle. This should result in better adaptation to current regulations and traffic conditions. • The primary expected impact is more attentive driving by providing relevant and continuous information on road signage (e.g., speed limits), which improves traffic safety as it reduces (the severity of) accidents and congestion. • Another benefit is the option to present information in the language as selected by the road user, or to present only information valid for the respective vehicle type (e.g., trucks), improving the relevance of information provided what might result in less distraction.
Use Cases	<ul style="list-style-type: none"> • Traffic Signs • Free Text

2.2 IVS: Use cases

2.2.1 IVS – Traffic Signs (IVS-TS)

Use case introduction	
Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	The Vienna Convention on Road Signs makes a distinction between danger warning signs, regulatory signs and informative signs. This use case is meant to inform drivers via in-car information systems about all static and dynamic signs that are part of the Vienna Convention on Road Signs and are represented in the ISO 14823 graphic data dictionary for road traffic signs, as indicated on either physical road signs along the road or the notion of virtual VMS i.e. where a physical VMS is not present/
Background	<p>This use case enables the road operator to optimize the management of warnings, information and regulations knowing the real-time traffic characteristics.</p> <p>Currently, the dynamic signs need to be clearly identified in the field by signalization, for instance with lane control signs located on (mobile) gantries. With this use case, it would be possible to easier apply/implement the use of dynamic regulations on the networks. The current description of this use case describes the situation with physical signs present and represented in a digital way.</p>
Objective	<ul style="list-style-type: none"> The aim is to inform the road users about the current valid and applicable (dynamic) signage. To improve traffic safety by using additional means and communication channels to inform drivers about traffic regulations and traffic advice otherwise provided via conventional signage
Desired behaviour	<p>The road users can:</p> <ul style="list-style-type: none"> adapt their driving behaviour to be compliant to the applicable driving regulations. adapt their driving behaviour / position on the road according to the information given. drive more attentive based on the warnings given. <p>In the future the information may be used by Advanced Driver Assistance Systems for supported or automated driving.</p>
Expected benefits	<ul style="list-style-type: none"> More convenience for road users, resulting in better compliance to regulatory signs speed limits, improved safety and potential environmental benefits. The virtual VMS allows display of a message exactly in the zones of application, enhancing for example the compliance with regulations.
Use case description	
Situation	The aim of In-Vehicle Signage (IVS) is to relay the information presented on (electronic) traffic signs into the vehicle. To that end, variable or dynamic message sign (VMS) systems have been deployed on sensitive parts of the motorway network all over Europe. They are being used in conjunction with monitoring systems to enforce traffic regulations (such as speed control and lane management).

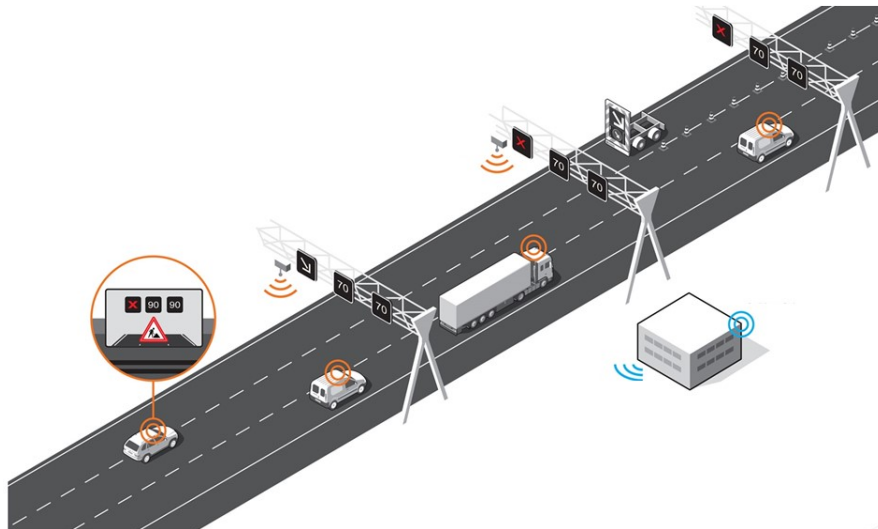


Figure 1 Example of In-vehicle information: status information of dynamic speed limit signs on a variable message system also sent as in-vehicle signage service



Figure 2 Example of dynamic regulatory signs



Figure 3 Example of dynamic regulatory signs

Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> • Road operator: The source of a majority of the traffic signage is the road operator via the Traffic Control Centre (TCC). The road operator is expected to have validated the content of the message before sending this message into the system. • Road user: The traffic sign information is continuously received by all C-ITS equipped vehicles and displayed to the road user. The exact details of the presentation (how and when) is based on the individual application designer's decision. The road user can use the information to better comply with the current traffic regulations or drive more attentively. • Service provider: disseminates the signage information to the road user.
Scenario	<ul style="list-style-type: none"> • The Traffic Operations Centre (TOC) sends a message with the applicable traffic signs. The signage information can target all vehicles as well can be targeted to a specific vehicle type (e.g. heavy goods vehicle). The signage information can be applicable for all lanes, but also specific per lane (see examples). • The message is received in the vehicle and displayed to the driver if relevant to that road user. • The road user can act accordingly.
Display / alert principle	<ul style="list-style-type: none"> • IVS information shall be displayed to the road user and shall be consistent with the current valid (dynamic) traffic signs. • The information needs to be displayed to the driver early enough and in the appropriate location. • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional Constraints / dependencies	<ul style="list-style-type: none"> • 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 has to be used. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle Information system with HMI how information is presented. Information may be translated to the preferred language of the driver. • The information presented by means of I2V is not legally binding: Information should be handled as 'convenience information' and presented accordingly to the road user, as currently done within navigation systems.

Interoperability Requirements

<p>Message profile requirements</p>	<ul style="list-style-type: none"> • The IVI message for IVS-TS is profiled in chapter 4.2.2.2 of C-Roads, C-ITS Message Profiles [4]. • IVI messages for IVS-TS shall use message management based on update and cancellation of messages. • <code>iviStatus</code> 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. • <code>validTo</code> 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 <code>GlcParts</code> 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 <code>DeltaPositions</code> towards the <code>referencePosition</code>. • IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM. • One <code>GicPart</code> in the <code>GeneralIviContainer</code> 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 <code>RSCode</code>. • <code>extraText</code> 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. <code>extraText</code> is ordered, so the first line of <code>extraText</code> corresponds to the first <code>RSCode</code> and so on. If a traffic sign does not have extra text, a string with a single NULL character (ASCII 0x00) shall be added. <code>extraText</code> 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 <code>roadSignCodes</code> and not by using either <code>validFrom</code> or <code>validTo</code> of the overall IVIM. • 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"> ○ 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 <ul style="list-style-type: none"> ▪ 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 <code>roadSignCodes</code> available in ISO 14823 for subpanels instead of <code>extraText</code> • The <code>RoadConfigurationContainer</code> (RCC) shall be provided, except if the road operator does not have the information, then both RCC and applicable lanes in the <code>GeneralIviContainer</code> (GIC) should be omitted and only signs valid for all legally drivable lanes on the entire carriageway shall be transmitted
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Security and data protection requirements

Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].

An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 IOS/TS 14823 signs, as well as the “Road configuration container”. The IVIM permissions (SSP) have to be encoded as defined in ETSI TS 103 301 [11]. 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		SSP value per station type				
	Octet position	Bit position	6 (Bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)
General IVI Container / ISO 14823 / Danger Warning	4	1	-	1	-	-	1
General IVI Container / ISO 14823 / Regulatory	4	2	-	1	-	-	1
General IVI Container / ISO 14823 / Informative	4	3	-	1	-	-	1
General IVI Container / ISO 14823 / Public Facilities	4	4	-	1	-	-	1
General IVI Container / ISO 14823 / Ambient Condition	4	5	-	1	-	-	1
General IVI Container / ISO 14823 / Road Condition	4	6	-	1	-	-	1
General IVI Container / Lane Status	5	0	-	1	-	-	1
Road Configuration Container	5	1	-	1	-	-	1

SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.

Communication technology requirements: ITS-G5

For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of C-Roads, C-ITS Roadside ITS G5 System Profile [6] shall apply.

For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.

Communication
technology
requirements: IP-
Based

For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply

For use cases based on IVIM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:

- serviceType= IVS-TS
- messageType = IVIM

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.

Please be aware that the exact details of specification are defined in chapter 3.3 of [7].

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-IVIM_reference position_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02_R2.0.1
 - 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
- 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_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_IVS-TS_ITSG5_IVIM_GenerallviContainer_74_R2.0.1
 - TC_CROADS_IVS-TS_ITSG5_IVIM_extraText_75_R2.0.1
- Hybrid (IP-based only):
 - TC_CROADS_IVS-TS_HYBRID_IVIM_GenerallviContainer_74_R2.0.1
 - TC_CROADS_IVS-TS_HYBRID_IVIM_extraText_75_R2.0.1

2.2.2 IVS - Free Text (IVS-FT)

Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	The goal of this use case is to display to the road user in-vehicle information of type "Free Text". The information will either reproduce what is displayed on a physical VMS (e.g., variable text panel) or display a completely new message that does not mirror a physical VMS (a virtual VMS).
Background	<ul style="list-style-type: none"> • Rather than conveying completely new information, the value of this use case is to provide already existing information, enhancing its visibility by enabling continuous displaying in the vehicle, reducing the need to perceive and comprehend rather complex information in the few seconds that the VMS panel is visible to the road user during transit. • Another added value would be to enable the information to be displayed in the driver's preferred language, if available. • Compared to traffic signs, it is possible to display additional content (text, images). • Compared to physical VMS: there is a greater possibility to send more contextualized information than can be presented on a physical VMS; there is more time to read and comprehend the information that is shown directly in the vehicle. Note, presenting more information should not lead to more distraction of the driver.
Objective	<ul style="list-style-type: none"> • Transmit to road users information in "Free Text" that is not provided by the other (in-vehicle signage) use case "Traffic Signs". • Add details (in preferred language) to existing messages in order to provide more precise and comprehensible information to the road users to achieve the desired behaviour. • The information may already be displayed on a physical VMS or other means of signalling on the road.
Desired behaviour	The road user adapts their driving behaviour compliant to the applicable driving regulations, warnings, information, advice or guidance provided.
Expected benefits	<ul style="list-style-type: none"> • Traffic management: the use case permits greater traffic management control (e.g., regulation, smart routing, etc.), because information can potentially be transmitted on the scale of the complete network, beyond the limited coverage of the physical VMS. • Comfort: the use case allows continuous display of information in the vehicle compared to the short-term awareness provided by the physical VMS, thus limiting stress for the road user to comprehend the content of the information and react accordingly. • In case of also regulatory information, the virtual VMS allows display of a message exactly in the zones of application, enhancing the compliance with regulations.
Use case description	
Situation	<ul style="list-style-type: none"> • Traffic management plan • Pollution • Amber alert

- Special events (sports, demonstration...)
- Travel time
- Available parking spaces on highway rest areas
- Information on services available on highway parking areas



Figure 4 Example of a warning sign and free text



Figure 5 Example of a regulatory sign and free text

Logic of transmission	I2V Broadcast
Actors and relations	<ul style="list-style-type: none"> • Road operator: The source of this information is the road operator via the Traffic Operation Centre (TOC). The road operator is expected to have validated the content of the message before sending this message into the system. • Road user: The Free Text information is continuously received by all C-ITS equipped vehicles and displayed to the road user. The exact details of the presentation (how and when) is based on the individual application designer's decision. The road user will benefit from the information contained in the Free Text information and act accordingly. • Service provider: disseminates the "Free Text" information to the road user.
Scenario	<ul style="list-style-type: none"> • The road operator wants to send information to road users. The virtual VMS is a possible means, as well as physical VMS, radio, the internet, etc. • The road operator sends information via all or selected information channels

Display / alert principle	<ul style="list-style-type: none"> Free text information shall be displayed to the road user and shall be consistent with the actual dynamic signs. If presented, the information needs to be displayed to the driver early enough and at the appropriate location. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional Constraints / dependencies	<ul style="list-style-type: none"> "Free Text" is used whenever a VMS is displaying textual information that is not directly applicable to a sign (like e.g., sub-text under a sign) but additional information that cannot be encoded via traffic signs. Please note that "Free Text" information may still include additional traffic signs (as shown in Figure 4 and 5)" How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information may be translated to the preferred language of the driver. The In-Vehicle information system cannot determine the content of the "Free Text" message. Therefore, it is the responsibility of the road operator to determine when and at what location(s) this message should be available for displaying in the vehicle. The information presented by means of I2V is not legally binding: Information should be handled as 'convenience information' and presented accordingly to the road user, as currently done within navigation systems.

Interoperability Requirements

Message profile requirements	<ul style="list-style-type: none"> The IVI message for IVS – FT is profiled in chapter 4.2.2.3 of C-Roads, C-ITS Message Profiles [4]. IVI messages for IVS-FT 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. 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. "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.
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	<ul style="list-style-type: none">• If traffic signs are present:<ul style="list-style-type: none">○ 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.○ 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">▪ 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<ul style="list-style-type: none">• 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• 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.																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 IOS/TS 14823 signs, the “Road configuration container” as well as the “Text container”. The IVIM permissions (SSP) have to be encoded as defined in ETSI TS 103 301 [X]. 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><th colspan="5">SSP value per station type</th></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td><td>6 (Bus)</td><td>9 (trailer)</td><td>10 (special vehicles)</td><td>11 (tram)</td><td>15 (road side unit)</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (Bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)								
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (Bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		

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

SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.

Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of C-Roads, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p>
Communication technology requirements: IP-Based	<p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply</p> <p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p>
	<p>For use cases based on IVIM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> • serviceType= IVS-FT • messageType = IVIM <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> <p>Please be aware that the exact details of specification are defined in chapter 3.3of [7].</p>
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-IVIM_reference position_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02_R2.0.1 ○ 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 • IP-based only: <ul style="list-style-type: none"> ○ 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_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 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_IVS-FT_ITSG5_IVIM_TextContainer_84_R2.0.1 ○ TC_CROADS_IVS-FT_ITSG5_IVIM_GenerallviContainer_85_R2.0.1 ○ TC_CROADS_IVS-FT_ITSG5_IVIM_GicPart_86_R2.0.1 ○ TC_CROADS_IVS-FT_ITSG5_IVIM_extraText_87_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_IVS-FT_HYBRID_IVIM_TextContainer_84_R2.0.1 ○ TC_CROADS_IVS-FT_HYBRID_IVIM_GenerallviContainer_85_R2.0.1 ○ 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 HLN	
Summary	This C-ITS service describes an I2V warning message related to one or a series of potentially hazardous events on the road, where the approaching road users get information and therefore warning about the location and type of hazard they are approaching and – if available – also the duration of the event.
Background	Hazardous locations/situations create a risk for road users potentially causing (more) accidents resulting in injuries/fatalities. This C-ITS service has the potential to directly inform involved and relevant road users so they can adapt their driving behaviour accordingly.
Objective	To inform road users of hazardous locations on their route in order to enhance overall road safety by providing in-vehicle information about hazards, including the location and type of hazard, possibly also the remaining distance to the location, the duration of the events creating the hazard and lane and speed advice.
Expected benefits	More attentive driving while approaching and passing a hazardous location. Minimize risk of collisions/accidents resulting in less incidents / injuries / fatalities amongst road users.
Use Cases	<p>The events and therefore the use cases of the C-ITS service group HLN –Hazardous Location Notifications are:</p> <ul style="list-style-type: none"> • Accident Zone, (Abbreviation: HLN – AZ) • Traffic Jam Ahead, (HLN – TJA) • Stationary Vehicle, (HLN –SV) • Weather Condition Warning, (HLN – WCW) • Temporarily Slippery Road (I2V), (HLN – TSR) • Animal or Person on the Road (I2V), (HLN – APR) • Obstacle on the Road (I2V), (HLN – OR) • Emergency or Rescue/Recovery Vehicle in Intervention (HLN-ERVI) • Emergency or Prioritized Vehicle Approaching (HLN-EPVA) • Railway Level Crossing, (HLN-RLX) • Unsecured Blockage of a Road (HLN-UBR) • Alert Wrong Way Driving (HLN-AWWD) • Public Transport Vehicle Crossing (HLN-PTVC) • Public Transport Vehicle at a Stop (HLN-PTVS) <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 HLN-AZ	
Type of road network	All
Type of vehicle	All
Use case introduction HLN-AZ	
Summary	The road operator detects that an accident has happened on the network and broadcasts the information to road users who can benefit from this information.
Background	<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"> ○ Sending event information from the TCC to the vehicles <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	To warn road users of accident zones ahead and around their position in order to enhance overall road safety.
Desired behaviour	Precisely and correctly inform drivers to adapt their driving behaviour (e.g., reduce the approaching speed, drive more cautiously, etc.) before and whilst passing of the accident zone.
Expected benefits	<ul style="list-style-type: none"> • Enhanced road safety for the society and lower numbers of persons killed or injured by traffic accidents • Lower numbers of incidents and secondary damages following a dangerous situation on the road for road operators and drivers • Higher quality of traffic information services for service providers • More relaxed/comfortable driving for drivers
Use case description	
Situation	The driver gets informed about an accident zone in their vicinity, and according to their driving direction and validity is informed about the warning message.
Logic of transmission	I2V broadcast
Actors and relations	<ul style="list-style-type: none"> • Road operator: provides information about the accident zone detected on the road network mentioned in the use cases specifications and distributes respective warnings as C-ITS messages • Service provider: distributes C-ITS messages actively and dynamically to the subscribers (end users) • Road user: The road user is informed about the accident zone ahead on their route by their chosen channel of information.
Use case scenario	<ul style="list-style-type: none"> • An accident is detected and confirmed in the TCC, the warning message is coded according to the specified definition and send via defined channels to a ITS station which broadcasts the information.

Display / alert principle	<ul style="list-style-type: none"> • The road operator generates the event information within the TCC and distributes it via various channels with one message ID to vehicles - e.g. I2V broadcast • The service provider collects and distributes the AZ C-ITS message from his active users in the area. • The road user is informed ahead of the accident zone. • Sending event information from the road operators back-office systems in the TCC to a C-ITS system which then creates and broadcasts C-ITS messages based on that content (I2V broadcast). When the road user approaches an accident zone, the vehicle receives C-ITS messages which allow the driver to adjust behaviour (e.g., speed and position) on the road to reduce risk. • The information can then be displayed on the In-Vehicle HMI early enough and should be only moderately intrusive (at the manufacturer's decision). • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> • The information quality of the “Accident Zone” use case mostly depends on the accurate detection of the event and the confirmation level / maturity of the information in the back-office systems / TCC of road operators. • For service providers the overall speed and latency in message generation and transmission as well as the selection of the geographical dissemination area, including a single warning message ID, is a major dependency to implement this use case successfully. • Various sensor measurements and procedures for traffic detection are needed in the back-office systems of the road operators in order to generate accurate information for the “Accident Zone” use case. Therefore, restrictions towards the availability of the service according to the limitations of the sensors used for events detection could apply. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> • The DENM message for HLN-AZ is profiled in chapters 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. • For this use case, causeCode shall be 2 (accident) and subCauseCode shall be one of the following (the road operator selects the best fitting value): <ul style="list-style-type: none"> ○ 0 unavailable: used, if no further information is available ○ 1 multiple vehicles accident: for accidents with at least two vehicles involved ○ 2 heavy accident: serious injury or fatal accident ○ 3 accident involving lorry: used if a HGV/lorry is involved ○ 4 accident involving bus: used if a bus is involved ○ 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) ○ 7 unsecured accident: used if the accident area is unprotected ○ SCC 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. • stationType:15 • eventSpeed shall not be used • eventPositionHeading is optional • traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].

	<ul style="list-style-type: none">• a point based or single linear relevance zone shall be sent. It shall be represented as:<ul style="list-style-type: none">○ The eventPosition shall be set to the location or the upstream start of the accident zone.• awarenessDistance shall not be provided<ul style="list-style-type: none">○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].○ For point based events: eventZone shall not be present○ For linear events: eventZone shall be present and reflect the geographical extent of the accident area• traces represented by pathHistory elements shall be provided.• informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4].• Message management shall be done by either providing short validity durations or by actively terminating messages. <p>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</p>																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 2 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>accident(2)</td><td>1</td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	accident(2)	1	1	-	-	-	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
accident(2)	1	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">• serviceType = HLN-AZ• messageType = DENM <p>Geographic area (Quadtree) for DENM message:</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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>
<p>Test and validation requirements</p>	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-AZ_ITSG5_DENM_CC-sCC_05_R2.0.1 ○ TC_CROADS_HLN-AZ_ITSG5_DENM_stationType_05_1_R2.0.1 ○ TC_CROADS_HLN-AZ_ITSG5_DENM_eventSpeed_05_2_R2.0.1 ○ TC_CROADS_HLN-AZ_ITSG5_DENM_eventHistory_05_3_R2.0.1 • Hybrid (IP-based only): <ul style="list-style-type: none"> ○ TC_CROADS_HLN-AZ_Hybrid_DENM_CC-sCC_05_R2.0.1 ○ TC_CROADS_HLN-AZ_Hybrid_DENM_stationType_05_1_R2.0.1 ○ TC_CROADS_HLN-AZ_Hybrid_DENM_eventSpeed_05_2_R2.0.1 ○ TC_CROADS_HLN-AZ_Hybrid_DENM_eventHistory_05_3_R2.0.1

3.2.2 HLN - Traffic Jam Ahead (HLN-TJA)

Use case introduction HLN-TJA	
Summary	A road operator detects a traffic jam and sends the information to the road user (mentioning the position, the length of the traffic jam and the section/ lanes concerned if the information is available).
Background	With C-ITS, the availability and the precision of the traffic jam ahead warning is better than conventional means, and therefore drivers are warned with higher information quality, including the accuracy of the road segments, possibly lanes involved and the vehicle speeds.
Objective	<p>The objective of this use case is to inform about a queue but more importantly to inform about a potentially dangerous end of queue. The drivers can modify their driving approach (speed, lanes) towards the end of the queue.</p> <p>The precision of the end of queue is usually very low. This use case could help to improve it since it can be signalled by vehicles encountering it, if they are adapting their speed and/or vehicle trajectory nearby the end of traffic jam zone.</p>
Desired behaviour	<ul style="list-style-type: none"> Well informed drivers adapting their driving behaviour (e.g. reduce their approaching speed, before arriving at the end point of the traffic jam and while passing it). Precisely and correctly informed drivers also drive more cautiously or concentrated nearby the end of traffic jam area. The constant speed adaptation of single vehicles when approaching the end of queue area has also an impact on the overall traffic flow.
Expected benefits	<p>More homogenous traffic flows with less congestion, caused by accidents, leading to:</p> <ul style="list-style-type: none"> Economic benefits: saving resources, money and time for all stakeholders Social benefits: traffic safety, reduced number of incidents Personal benefits: more comfortable driving. Environment benefits: reduced CO2 emissions and environmental pollution.
Use case description	
Situation	<p><u>I2V</u></p> <ul style="list-style-type: none"> the traffic jam could be on one specific lane (e.g., at an exit of a motorway) of a motorway section or on the whole section <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 identity.</p>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> The road operator discovers and confirms TJA situations and forwards them to the C-ITS System The operator in the TCC or (one or several) equipped vehicles breaking is/are the sender of the TJA warning Service provider: disseminates TJA related information, to/from vehicles/drivers End receiver is the mobile C-ITS station in the vehicle (and in the future possibly ACC system) or the driver Sources of information can be: <ul style="list-style-type: none"> Cameras (incident detection ones as well) traffic loops

Use case scenario	<ul style="list-style-type: none"> ○ Operating agents/road operator equipped patrol vehicles ○ Other vehicles which have detected the danger <p>The TJA warning message for the respective lane of the vehicle or road section is sent out to end users approaching the area.</p> <p><u>I2V</u></p> <ol style="list-style-type: none"> 1. The operator in the TCC gets informed about a traffic jam on the road network 2. The operator puts the information in his TCC, confirms it with its length and/or lane and the message is then broadcasted to the road users. 3. The vehicles nearby the traffic jam area receive the information and display it to their drivers. 4. The driver adapts driving behaviour. 5. In future the in-vehicle TCC-ACC system could follow the warning message related advice directly. 6. The road operator can have a system to automatically update the length and/or lane of the traffic jam, and communicates the end of the traffic jam area, when regular travelling speed is confirmed.
Display principle / alert logic	<ul style="list-style-type: none"> • The in-vehicle information should be adapted to the relative position between the vehicle and the TJA warning positions. • The display could be different according to the position of the receiving vehicles or not even happen if the other vehicle is too close to the end of queue. • The in-vehicle information could inform the driver that TCC-ACC is active and working according to the driver's set of preferences. • The user is provided with related information, displayed on the dashboard. Layout and sequence of presentation is left to specific implementation. • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / Dependencies	<ul style="list-style-type: none"> • The precision of the information of the end of queue from the road operator can be low depending on the systems to update them and the available information sources used by the road operator, e.g., if these are single sensor networks like loop detectors, the highest precision will be the road section length between two installed loop detectors, which would mean low quality of localization of the end of the queue. • The equipped vehicles as probe data (or source of information) could enhance the quality of localization and improve awareness of drivers which are approaching the traffic jam zone. For high accuracy of this use case it needs to have a high percentage of equipped vehicles included in the message generation at the end of the traffic jam area. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> • The DENM message for HLN-TJA is profiled in chapters 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. • In case the extension of the traffic jam is not known, <ul style="list-style-type: none"> ○ the causeCode 27 (dangerous end of queue) and subCauseCode 0 (unavailable) shall be used ○ a point based relevance zone shall be sent. It shall be represented as:

Security and data protection requirements

- The eventPosition shall be set to the upstream end of queue and the positionConfidenceEllipse based on available data or to "unavailable" if no data is available.
 - awarenessDistance shall not be provided
 - awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
 - eventZone shall not be provided
- In Case the extension of the traffic jam is known,
 - causeCode 1 (traffic condition) and subCauseCode 0 (unavailable) shall be used.
 - a single linear relevance zone shall be sent. It shall be represented as:
 - The eventPosition shall be set at the upstream end of the queue or even further upstream of the upstream end of queue.
 - awarenessDistance shall not be provided
 - awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
 - eventZone shall be provided as specified in the Message Profiles document, starting at the eventPosition, continuing downstream describing the extent of the accident zone to the point, where vehicles can progress freely at the allowed speed.
- stationType: 15
- traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
- informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4].
- Validity duration should be set to maximum 12 minutes, because an end of queue can appear and reappear frequently.
- Message management shall be done by either providing short validity durations or by actively terminating messages.

NOTE for both scenarios (27/0 and 1/0): 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.

Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].

An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 27 or 1 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):

CauseCodeType / Container	SSP position		SSP value per station type				
	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)
dangerousEndOfQueue(27)	2	6	-	-	-	-	1
trafficCondition(1)	1	0	-	-	-	-	1

SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.

Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of C-Roads, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <p>serviceType = HLN-TJA messageType = DENM</p> <p>Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-TJA_ITSG5_DENM_CC-sCC_06_R2.0.1

	<ul style="list-style-type: none"> ○ TC_CROADS_HLN-TJA_ITSG5_DENM_stationType_06_1_R2.0.1 ○ TC_CROADS_HLN-TJA_ITSG5_DENM_eventPosition_06_2_R2.0.1 ○ TC_CROADS_HLN-TJA_ITSG5_DENM_validityDuration_06_3_R2.0.1 ○ TC_CROADS_HLN-TJA_ITSG5_DENM_eventHistory_06_4_R2.0.1 <ul style="list-style-type: none"> • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-TJA_Hybrid_DENM_CC-sCC_06_R2.0.1 ○ TC_CROADS_HLN-TJA_Hybrid_DENM_stationType_06_1_R2.0.1 ○ TC_CROADS_HLN-TJA_Hybrid_DENM_eventPosition_06_2_R2.0.1 ○ TC_CROADS_HLN-TJA_Hybrid_DENM_validityDuration_06_3_R2.0.1 ○ TC_CROADS_HLN-TJA_Hybrid_DENM_eventHistory_06_4_R2.0.1
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3.2.3 HLN – Stationary vehicle (HLN – SV)

Type of road network	All road networks, forwarding mainly on motorways
Type of vehicle	All vehicles
Use case introduction HLN-SV	
Summary	<ul style="list-style-type: none"> Stationary Vehicle(s) service warn approaching drivers about stationary/broken down vehicles ahead, which may represent obstacles in the road. It is a preventive safety service, as drivers will have advanced notice and more time to prepare for the hazard. The road operator could have an event management system and insert also a conventional (non-C-ITS) vehicle broken down, and trigger an I2V message to warn other vehicle drivers. In line with the ETSI ITS standard, this service could rely on V2V ITS G5 communication, and in particular, on the messages broadcast by the stationary vehicle and processed/filtered by nearby receiving vehicles. An interesting variant of use case, which adds to the quality of the information, is when the stationary vehicle information is also processed by a nearby roadside unit and then, to further distribute the same warning via the roadside infrastructure, other RSU's connected via the road operator distribute the SV warning via resending it.
Background	<ul style="list-style-type: none"> While the C-ITS platform presents a single entry for this use case, ETSI TR 102 638 V1.1.1 [2] includes two distinct use cases: Slow vehicle warning as a use case of cooperative awareness application, and stationary vehicle as a use case of road hazard warning application. The Stationary Vehicle warning is achieved through a DENM message (event notification) by the sender vehicle application which, based on the vehicle state (broken, stopped with emergency lights on, etc.) which broadcasts to nearby vehicles a notification with a specific Stationary Vehicle cause code. The variant of I2V information about stationary vehicle was tested concerning the I2V part, i.e. infrastructure informs vehicles of a stationary vehicle. So far, no thorough and operative scenario demonstration has been done, where stationary vehicle, roadside unit(s) and incoming vehicles share all the same hazard in a fully cooperative manner, so that as many interested vehicles as possible are informed.
Objective	To avoid collisions (mostly rear-end) with stationary vehicles on the road and enhance road safety.
Desired behaviour	<ul style="list-style-type: none"> The vehicle driver adapts their driving behaviour, slowing down or changing lane. Because the I2V warning is targeted and accurate from the event management system of the road operator the reliability is high and improves the driver attention near to these traffic situations or areas. In the future the information may be used by Advanced Driver Assistance Systems for supported and automated driving. In addition, the driver awareness is raised to the possible presence of vulnerable road user(s) (VRU) on the road.
Expected benefits	<ul style="list-style-type: none"> As reported in the Study of the Deployment of C-ITS in Europe [1] summarizes, main benefit is expected on road safety, minimal impact expected in traffic efficiency and fuel consumption.


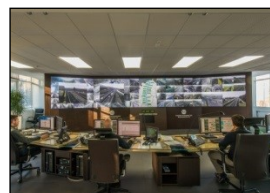
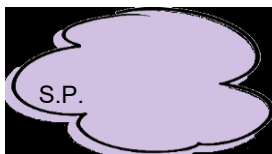

	<ul style="list-style-type: none"> Concerning safety, this service helps to prevent dangerous manoeuvres, giving drivers advanced notice and more time to prepare for the hazard and take appropriate countermeasures also for possible vulnerable road users nearby.
Use case description	
Situation	Road operators event management system forwarded to C-ITS a Stationary Vehicle(s) is expected to inform road users of stationary vehicle in front.
Logic of transmission	I2V, (with V2I combined with V2V broadcast as additional input source);
Actors and relations	<p>Road operators: (to detect within their event management systems slowly moving or broken-down vehicles) verify and forward C-ITS messages via different communication channels with one warning message ID</p> <p>Road users: as one information source and end user of SV warning message,</p> <p>Service providers: distributing positions of stationary vehicles via different networks to their users approaching the event position of the warning</p> <p>Sources of information can be:</p> <ul style="list-style-type: none"> Cameras (incident detection ones as well) Operating agents/RO equipped patrol vehicles Other C-ITS-equipped vehicles which have detected the danger.
Use Case Scenario	<p>I2V Scenario:</p> <ul style="list-style-type: none"> A conventional (non-C-ITS) vehicle or a C-ITS equipped vehicle is stopped and the road operator has determined it as such the road operator generates an appropriate warning message that is sent I2V via the C-ITS System in the relevant zone approaching vehicles receive the warning and drivers adapt their behaviour.
Display principle / Alert logic	<ul style="list-style-type: none"> The user is provided with related information, displayed on the dashboard. Layout and sequence of presentation is left to OEM-specific implementation. The display to the driver needs to be early enough to adapt their vehicle's speed but not too early that the alert is forgotten. The alert can be repeated when nearer to the position of the event. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / Dependencies	<ul style="list-style-type: none"> How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> The DENM message for HLN-SV is profiled in chapters 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. For this use case, causeCode 94 (stationary vehicle) and subCauseCode 0 (unavailable) or 2 (vehicle breakdown) shall be used. eventSpeed shall not be used eventPositionHeading is optional stationType: 15

	<ul style="list-style-type: none">• informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4].• traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].• a point based relevance zone shall be sent. It shall be represented as:<ul style="list-style-type: none">○ The eventPosition shall be set to the location of the stationary vehicle.<ul style="list-style-type: none">▪ awarenessDistance shall not be provided○ awarenessTrafficDirection shall be provided as specified C-Roads, C-ITS Message Profiles [4].○ eventZone shall not be used.• lanePosition shall be used, if the information is available and reliable.• The stationaryVehicle DE shall not be provided.• Message management shall be done by either providing short validity durations or by actively terminating messages. <p>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</p>																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 94 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><td colspan="5">SSP value per station type</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td><td>6 (bus)</td><td>9 (trailer)</td><td>10 (special vehicles)</td><td>11 (tram)</td><td>15 (road side unit)</td></tr><tr><td>stationaryVehicle(94)</td><td>3</td><td>2</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	stationaryVehicle(94)	3	2	-	-	-	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
stationaryVehicle(94)	3	2	-	-	-	-	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">• serviceType = HLN-SV• messageType = DENM <p>Geographic area (Quadtree) for DENM 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</p>																								

	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 [7].
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1 <p>List of applicable Specific Test Cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-SV_ITSG5_DENM_relevanceTrafficDirection_8_R2.0.1 ○ TC_CROADS_HLN-SV_ITSG5-DENM_CC-sCC_13_R2.0.1 ○ TC_CROADS_HLN-SV_ITSG5_DENM_stationType_16-1_R2.0.1 ○ TC_CROADS_HLN-SV_ITSG5_DENM_eventSpeed_16-2_R2.0.1 ○ TC_CROADS_HLN-SV_ITSG5_DENM_eventHistory_16-4_R2.0.1 ○ TC_CROADS_HLN-SV_ITSG5_DENM_stationaryVehicleDE_16-5_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-SV_Hybrid_DENM_relevanceTrafficDirection_8_R2.0.1 ○ TC_CROADS_HLN-SV_Hybrid_DENM_CC-sCC_13_R2.0.1 ○ TC_CROADS_HLN-SV_Hybrid_DENM_stationType_16-1_R2.0.1 ○ TC_CROADS_HLN-SV_Hybrid_DENM_eventSpeed_16-2_R2.0.1 ○ TC_CROADS_HLN-SV_Hybrid_DENM_eventHistory_16-4_R2.0.1 ○ TC_CROADS_HLN-SV_Hybrid_DENM_stationaryVehicleDE_16-5_R2.0.1

3.2.4 HLN - Weather Condition Warning (HLN-WCW)

Type of road network	All road networks
Type of vehicle	All vehicles
Use case introduction HLN-WCW	
Summary	<p>Weather Conditions Warning (WCW) use case shows both static and dynamic information of weather conditions and road status in-vehicle.</p> <p>As reported in the Study of the Deployment of C-ITS in Europe: Final Report, this service provides (...) <i>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.</i></p> <p><i>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.</i> [12]</p>
Background	<p>With reference the Commission Delegated Regulation (EU) 886/2013, weather condition is within the minimum set of road safety-related traffic information services free of charge to users on the European Roads (Article 3, category (h)). Article 2 defines exceptional weather conditions as <i>unusual, severe or unseasonal weather conditions which might affect safe driving.</i></p> <p>The Weather Conditions Warning (WCW) I2V service is intended to inform drivers via in-vehicle information systems of static and expected information of weather conditions and road status along the road. Both advisory events are in scope of WCW. WCW information is provided by means of Infrastructure-to-Vehicle (I2V) communication, referring to a sub use case of Hazardous Location Notifications, as in ETSI TR 102 638 V1.1.1 [13] and coherently in the C-ITS Platform final report [12].</p>
Objective	To improve traffic safety via additional means of C-ITS messages to inform drivers in a more accurate way about weather conditions and road status information.
Desired behaviour	<ul style="list-style-type: none"> The vehicle driver adapts their driving behaviour compliant to the applicable driving regulations and any advice or guidance provided. In the future the information may be used by Advanced Driver Assistance Systems for supported and automated driving.
Expected benefits	<ul style="list-style-type: none"> The primary expected impact is more attentive driving by providing actual and continuous (expected) information on road conditions (e.g. poor road traction conditions, visibility, wind, rainfall etc.) and, which improves traffic safety as it reduces (the numbers and the severity of) accidents. A topic of future day 2 C-ITS services can be to evaluate, the applicability of this concept to Autonomous Driving functions.
Use case description	
Situation	WCW is expected to inform drivers of current and/or expected information related to precipitation or extreme weather conditions (scenario 1), or low visibility ranges due to, for example, fog (scenario 3).
Logic of transmission	I2V broadcast
Actors and relations	The actors are: road operator, (e.g. Weather Information) service provider, end user, vehicle driver or vulnerable road users.

	<ul style="list-style-type: none"> • Road operator: validates warning, issues triggering information via different communication channels with one message ID • Service provider: collects and ensures triggering information is correct, triggers I2V warning, and/or aggregates information in cloud service. • Weather information provider: shares real-time information with the road operator, or TCC • End User: receives the warning via the on-board unit and/or receives notification that the automatic vehicle control is taking adverse weather conditions into account. • Vehicle driver: is informed about dangerous weather conditions ahead in time to adapt the driving behaviour • Vulnerable road users, or special vehicle categories (e.g. PTW) could receive adapted WCW messages <p>Additional Information sources for the use case could be as follows:</p> <ul style="list-style-type: none"> • Roadside sensors/weather forecasts provide weather data. • C-ITS vehicles
Use Case Scenario	<p>I2V</p> <p>The operator in the TCC gets informed about extreme weather conditions (and the consequences: e.g., low visibility,) on his network He puts the information together, confirms it in his TCC and the WCW message is then distributed via different communication channels and broadcasted to the road users The vehicles receive the information and display it to the driver. The driver adapts his behaviour.</p> <p>Additional scenarios can be implemented as follows:</p> <p>Scenario 1: data are sent directly but after the TCC confirmed the data and the triggering conditions</p> <div>  </div> <div>  </div> <p>Scenario 2: the vehicle gets the WCW message and asks to the Service Provider (linked to TCC) for a confirmation of the data already on-board, and displays the message in time to react.</p> <div>  </div> <div>  </div> <p>The event is cleared by the respective actors involved in each scenario by the end of lifetime with a next update.</p> <p>The sources of information for this use case are the following:</p> <ul style="list-style-type: none"> • "Study of the Deployment of C-ITS in Europe: Final Report, pp 158-160, 2016, includes references to the EU projects mentioned

	<ul style="list-style-type: none"> • Commission Delegated Regulation (EU) No 886/2013 of 15 May 2013, for definition of weather warning • ETSI TR 102 638 V1.1.1 (2009), for Hazardous location notifications • C-ITS Platform final report, includes WC within the day 1 services • ETSI TS 101 539 1, reports WC requirements • ETSI-EN-302-637-3-V1.2.2 (2014-11), specifies the data structure
Display principle / alert logic	<ul style="list-style-type: none"> • The user is provided with related information, displayed on the dashboard. Layout is left to OEM-specific implementation. • The WCW message is displayed early enough for the driver to be able to adapt the driving behaviour, and at the same time not too distant from the affected road segment. • The distribution of this warning message to end users can be wider than the single road segment or area affected. • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<p>The document ETSI TS 101 539 1 defines Adverse Weather condition specific functional requirements, as part of Road Hazard Signalling (RHS), clause 6.3.6.</p> <p>It includes:</p> <ul style="list-style-type: none"> • <i>DENM transmission conditions.</i> • <i>Event triggering condition</i> • <i>Relevance area</i> • <i>Event termination condition</i> • <i>Use case specific data element values to be provided</i> • How the information is presented to the road user is not part of the service description. • It is left to the provider of the In-Vehicle information system with HMI how information is presented. • Information might e.g. be translated to the preferred language of the driver.
Interoperability requirements	
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, C-ITS Message Profiles [4].</p> <ul style="list-style-type: none"> • For this use case, causeCode 17 (extreme weather condition), 18 (visibility), or 19 (precipitation) shall be used. All respective subcauseCodes are applicable. • stationType: 15 • informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4] • traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. • a single circular awareness area shall be sent. It shall be represented as: <ul style="list-style-type: none"> ○ eventPosition shall be set to the centre of the area subject to the event ○ awarenessDistance shall be provided using values 0 to 6 ○ awarenessTrafficDirection shall be set to allTrafficDirections (0) ○ eventZone shall not be provided • Message management shall be done by either providing short validity durations or by actively terminating messages.
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 CauseCode 17, 18 or 19 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):

CauseCodeType / Container	SSP position		SSP value per station type				
	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)
ExtremeWeatherCondition(17)	2	2	-	-	1	-	1
Visibility(18)	2	3	-	-	1	-	1
Precipitation(19)	2	4	-	-	1	-	1

SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.

Communication technology requirements: ITS-G5

For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of C-Roads, C-ITS Roadside ITS G5 System Profile [6] shall apply.

For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.

Communication technology requirements: IP-Based

For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.

For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:

- serviceType = HLN-WCW
- messageType = DENM

Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable specific test cases:

- ITS-G5 only:
 - TC_CROADS_HLN-WCW_ITSG5_DENM_CC-sCC_18_R2.0.1
 - TC_CROADS_HLN-WCW_ITSG5_DENM_stationType_18-1_R2.0.1
 - TC_CROADS_HLN-WCW_ITSG5_DENM_relevanceTrafficDirection_18-2_R2.0.1
 - TC_CROADS_HLN-WCW_ITSG5_DENM_eventHistory_18-3_R2.0.1
 - TC_CROADS_HLN-WCW_ITSG5_DENM_eventPosition_18-4_R2.0.1
 - TC_CROADS_HLN-WCW_ITSG5_DENM_relevanceDistance_18-5_R2.0.1
 - TC_CROADS_HLN-WCW_ITSG5_DENM_informationQuality_18-6_R2.0.1
- IP-based only:
 - TC_CROADS_HLN-WCW_HYBRID_DENM_CC-sCC_18_R2.0.1
 - TC_CROADS_HLN-WCW_HYBRID_DENM_stationType_18-1_R2.0.1
 - TC_CROADS_HLN-WCW_HYBRID_DENM_relevanceTrafficDirection_18-2_R2.0.1
 - TC_CROADS_HLN-WCW_HYBRID_DENM_eventHistory_18-3_R2.0.1
 - TC_CROADS_HLN-WCW_HYBRID_DENM_eventPosition_18-4_R2.0.1
 - TC_CROADS_HLN-WCW_HYBRID_DENM_relevanceDistance_18-5_R2.0.1
 - TC_CROADS_HLN-WCW_HYBRID_DENM_informationQuality_18-6_R2.0.1

3.2.5 HLN - Temporarily slippery road (HLN-TSR)

Type of road network	All
Type of vehicle	All
Use case introduction HLN-TSR	
Summary	A road operator knows that a section of a road (or a single lane or point) is temporarily slippery and sends thus information to the road user, or/and a vehicle detects that it is slipping and broadcasts an alert message to other vehicles. The combination of these two information sources within a C-ITS system makes it possible to generate much better information quality and accuracy compared to both single sources used up to now.
Background	<ul style="list-style-type: none"> • Today information about slippery road sections is very limited, and this information is provided only by VMS. • With C-ITS, the availability is better, the coverage and the information quality is much improved using a I2V and V2V C-ITS System which complement each other. • This use case could decrease the risks of accidents by broadcasting this information more largely and reach the end user in many more driving situations than today.
Objective	The objective of this use case is to increase the awareness of drivers about dangerous slippery sections to make the drivers adapt their speed and trajectory to the situation.
Desired behaviour	<ul style="list-style-type: none"> • Increased driver attention • Adaptation of the driving speed • Change of lanes (if needed) • Rerouting (e.g. for HGV or specific vehicle categories)
Expected benefits	<ul style="list-style-type: none"> • Reducing the risk of accidents • Improved traffic management
Situation	<ul style="list-style-type: none"> • Depending on the cause of the slippery section, this use case can concern both directions of roads, even for dual carriageways. • Dealing with this information can be different for HGV or passenger vehicles since HGV might even adapt their itinerary completely. • Natural causes and/or spillage of various materials on the road are possible reasons for this risky situation and the warning generation: <ul style="list-style-type: none"> - oil, chemical fluids etc. - rolling elements (e.g. bottles, golf balls, fruits,) - black ice or water • - etc.
Logic of transmission	I2V Broadcast; V2V logic Broadcast
Actors and relations	<ul style="list-style-type: none"> • Road operator generates the warning in the TCC and sends it to the C-ITS systems and various communication channels with one message ID • Service provider forwards the warning messages to their users, and contribute to the detection of slippery road segments. • End-user is the driver, for detected slippery segments by the vehicle sensors he is also the generator of the data / information.

	<ul style="list-style-type: none"> • Or sender is the vehicle detecting the slippery road • End user are all vehicles around or ahead of the slippery road segment. <p>Other sources of this information can be</p> <ul style="list-style-type: none"> • Cameras • Phone call of a witness • Operating agents • C-ITS equipped vehicles with sensors which have detected the danger
Use Case Scenario	<p>I2V</p> <ul style="list-style-type: none"> • The operator in the TCC gets informed about a section that is slippery on the road network • The TCC operator puts information into the TCC systems and the message is then broadcasted to the road users by the C-ITS system and by various communication channels with one message ID • The vehicles receive the information and display it to the driver. • The drivers adapt their behaviour
Display principle / Alert logic	<ul style="list-style-type: none"> • The user is provided with related information, displayed on the dashboard. Layout is left to OEM-specific implementation. • The alert needs to be early enough for the driver to adapt their speed without stress, but not too early so that the driver does not forget about the alert. • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / Dependencies	<ul style="list-style-type: none"> • The vehicles might have to deal with two different sources of information for this use case: e.g., from other vehicles and from the TCC. Both information could inform about a similar event but not exactly with the same warning message, therefore the vehicle will have to deal with the priority between both messages. • For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully, and to deliver high quality warning messages to the TCC. • Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators in order to generate the information about all the slippery road segment locations for this use case. Therefore, restrictions of the service-availability could apply. • The Information quality of this use case temporarily slippery road depends mainly on the detection of the event "temporarily slippery road" and the confirmation/ maturity of the information. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> • The DENM message for HLN-TSR is profiled in chapters 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. • For this use case, causeCode 6 (adhesion) and subCauseCode between 0 and 9 shall be used • eventSpeed shall not be provided. • eventPositionHeading is optional. • In case of a linear event, a single linear awareness area shall be sent. It shall be represented as: <ul style="list-style-type: none"> ◦ eventPosition shall be set to the most upstream location of the event.

	<ul style="list-style-type: none">○ awarenessDistance shall not be provided○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].○ eventZone shall be provided.• In all other cases, a single circular awareness area shall be sent encoded as:<ul style="list-style-type: none">○ eventPosition shall be set to the centre of the area subject to the event○ awarenessDistance shall be provided using values 0 to 6.○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].○ eventZone shall not be provided• The alacarte container shall not be provided• stationType: 10,15• informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4].• traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].• Message management shall be done by either providing short validity durations or by actively terminating messages.																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 6 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><td colspan="5">SSP value per station type</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td><td>6 (bus)</td><td>9 (trailer)</td><td>10 (special vehicles)</td><td>11 (tram)</td><td>15 (road side unit)</td></tr><tr><td>Adhesion(6)</td><td>1</td><td>3</td><td>-</td><td>-</td><td></td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	Adhesion(6)	1	3	-	-		-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
Adhesion(6)	1	3	-	-		-	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <p>serviceType = HLN-TSR messageType = DENM</p> <p>Geographic area (Quadtree) for DENM message:</p>																								

<p>Test and validation requirements</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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p> <p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-TSR_ITSG5-DENM_CC-sCC_17_R2.0.1 ○ IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-TSR_HYBRID-DENM_CEC-sCC_17_R2.0.1
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3.2.6 HLN - Animal or person on the road (HLN-APR)

Type of road network	All
Type of vehicle	All
Use case introduction HLN-APR	
Summary	<ul style="list-style-type: none"> A road operator knows that one or several animal(s) is(are) present on the road network and broadcasts the information to road users, or A driver detects one or several animals on the road and signals that information via his HMI, broadcasting a message to road users, or both situations or warnings are combined.
Background	<ul style="list-style-type: none"> Today, this information is typically provided only by the VMS or radio. With C-ITS, the availability is better. The update of the information can also be improved (moving animal). Wandering animals are not easily detectable. Such a use case can be an added information for the road users.
Objective	The objective of this use case is to alert a road user of a potential danger. Since there is usually no automatic detection, and the animal can be moving quite fast the accuracy of the localization is not very high. Note, the road user needs to increase his driver attention.
Desired behaviour	<ul style="list-style-type: none"> Increased driver attention Adaptation of driving speed Change of itinerary (e.g., because of a flock of animals in mountains)
Expected benefits	<ul style="list-style-type: none"> Reducing the risk of accidents Improved traffic management
Use case description	
Situation	<ul style="list-style-type: none"> The starting situation of this use case can be several situations like a vehicle breakdown, an accident or a person taking a call, for which persons or also animals are on a part of the road network, and their movements are a dangerous situation for all involved in the area. The dangerous situations like <ul style="list-style-type: none"> persons present or a flock, or group of animals need to be detected, and the warnings created and distributed to all possible road users involved. According to the type of the road (and the speed limit consequently), the danger can be more or less important. A flock of animals in the mountains can be quite frequent for example.
Logic of transmission	I2V Logic Broadcast
Actors and relations	<p>I2V</p> <p>Sender is a road operator in the TCC</p> <p>End-receiver is the road user</p> <p>Sources of information can be:</p> <ul style="list-style-type: none"> Cameras Phone call of a witness Operating agents or

	<ul style="list-style-type: none"> Other C-ITS equipped vehicles which have detected the danger with various – C-ITS messages as follows
Use case scenario	<p>I2V:</p> <ul style="list-style-type: none"> The operator in the TCC gets informed about the presence of one or several persons or animal(s) on his network. The TCC operator puts the information in the TCC systems and the message is then broadcasted by the C-ITS system on various communication channels with one message ID to the road users The vehicles receive the information and display it to the driver. The drivers adapt their behaviour.
Display principle / alert logic	<ul style="list-style-type: none"> The display to the driver needs to be early enough to adapt their speed or itinerary (in case of a flock for example). However, since the driver should not forget about the alert, it could be repeated closer to the location. The information could be displayed differently according to the type of the road. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully. Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators in order to generate the information about persons/ animals detected on road segment locations for this use case. Therefore, restrictions of the service-availability could apply. The Information quality of this use case depends mainly from the detection of the event “animals or persons on the road” and the confirmation/ maturity of the information. The localisation can be very imprecise. And the information cannot always be verified by the road operator. How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> The DENM message for HLN-APR is profiled in chapters 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. In case of a linear event, a single linear awareness area shall be sent. It shall be represented as: <ul style="list-style-type: none"> eventPosition shall be set to the beginning of the road segment where the animal or person was detected. awarenessDistance shall not be provided awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. eventZone shall be provided. In all other cases, a single circular awareness area shall be sent. It shall be represented as: <ul style="list-style-type: none"> eventPosition shall be set to the location where the animal or person was detected. awarenessDistance shall be provided using values 0 to 6. awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. eventZone shall not be provided

	<ul style="list-style-type: none">For this use case, causeCode 11 (animal on the road) or 12 (human presence on the road) shall be used. All respective subcauseCodes are applicable.stationType: 15traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4].Message management shall be done by either providing short validity durations or by actively terminating messages. <p>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</p>																																
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 11 or 12 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>AnimalOnTheRoad(11)</td><td>1</td><td>6</td><td>-</td><td>-</td><td>1</td><td>-</td><td>1</td></tr><tr><td>humanPresenceOnTheRoad(12)</td><td>1</td><td>7</td><td>-</td><td>-</td><td>1</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	AnimalOnTheRoad(11)	1	6	-	-	1	-	1	humanPresenceOnTheRoad(12)	1	7	-	-	1	-	1
	SSP position		SSP value per station type																														
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																										
AnimalOnTheRoad(11)	1	6	-	-	1	-	1																										
humanPresenceOnTheRoad(12)	1	7	-	-	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																																
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <p>serviceType = HLN-APR messageType = DENM</p> <p>Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																																

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of use case specific test cases:

- ITS-G5 only:
 - TC_CROADS_HLN-APR_ITSG5_DENM_AnimalOrPersonOnTheRoad_19_R2.0.1
 - TC_CROADS_HLN-APR_ITSG5_DENM_CC-sCC_19_R2.0.1
 - TC_CROADS_HLN-APR_ITSG5_DENM_eventHistory_19-1_R2.0.1
 - TC_CROADS_HLN-APR_ITSG5_DENM_eventPosition_19-2_R2.0.1
 - TC_CROADS_HLN-APR_ITSG5_DENM_relevanceDistance_19-3_R2.0.1
- IP-based only:
 - TC_CROADS_HLN-APR_Hybrid_DENM_AnimalOrPersonOnTheRoad_19_R2.0.1
 - TC_CROADS_HLN-APR_Hybrid_DENM_CC-sCC_19_R2.0.1
 - TC_CROADS_HLN-APR_Hybrid_DENM_eventHistory_19-1_R2.0.1
 - TC_CROADS_HLN-APR_Hybrid_DENM_eventPosition_19-2_R2.0.1
 - TC_CROADS_HLN-APR_Hybrid_DENM_relevanceDistance_19-3_R2.0.1

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

Type of road network	All
Type of vehicle	All vehicles
Use case introduction HLN-OR	
Summary	A road operator knows that there is one or several obstacles on one or several lanes of his network and broadcasts the information to road users. However, traffic can still pass the obstacles (not a blockage).
Background	Today, this information is typically provided only by the VMS or radio. With C-ITS, the availability is better.
Objective	The objective of this use case is to alert a road user of a potential danger. Since there is no automatic detection, the accuracy of the localization is not very high. Note, the road user needs to increase driver attention.
Desired behaviour	<ul style="list-style-type: none"> • Increased attention • Adaptation of the speed • Change of lanes (if needed)
Expected benefits	<ul style="list-style-type: none"> • Reducing the risk of accidents • Improved traffic management for road operators
Use case description	
Situation	The obstacles can be small and not harmful and still be dangerous since they can surprise the driver, who could brake or show unpredictable behaviour if not alerted. There can also be big obstacles, such as lost furniture for example from a HGV, etc., that could result in the closure of a lane.
Logic of transmission	I2V Broadcast
Actors and relations	<p>(I2V) Sender is a road operator in the TCC</p> <p>End-receiver is the driver</p> <p>Sources of information can be:</p> <ul style="list-style-type: none"> • Cameras • Phone call of a witness • Operating agents or • Other vehicles which have detected the danger and vehicle C-ITS messages as possible source of information
Use case scenario	<p>I2V:</p> <ul style="list-style-type: none"> • The operator in the TCC gets informed about the presence of one or several obstacle(s) on his network. • The TCC operator puts the information in the TCC system and the message is then broadcast by the C-ITS system on various communication channels with one message ID to the road users. • The vehicles receive the information and display it to the driver. • The drivers adapt their behaviour
Display principle / alert logic	<ul style="list-style-type: none"> • The displayed warning to the driver needs to be early enough to adapt their speed or even their itinerary. However, since the driver should not forget about the alert, it

	<p>could be repeated closer to the location.</p> <ul style="list-style-type: none"> • The information could be displayed differently according to the type of the road. • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> • For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully. • Various sensors/procedures and their measurements/traffic detection are needed in the backend system of the road operators in order to generate the information about persons/ animals detected on road segment locations for this use case. Therefore, restrictions of the service-availability could apply. • The Information quality of this use case depends mainly on the detection of the event "animals or persons on the road" and the confirmation/ maturity of the information. • Due to the dynamic event the localisation can be very imprecise. And the information cannot always be verified by the road operator. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> • The DENM message for HLN-OR is profiled in chapters 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. • 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"> ○ The eventPosition shall be set to the location of the obstacle ○ awarenessDistance shall not be provided ○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. ○ eventZone shall not be provided • In case the 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"> ○ The eventPosition shall be set to the location of the most upstream obstacle ○ awarenessDistance shall not be provided ○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. ○ eventZone shall be provided as specified in the Message Profiles document • For this use case, causeCode 10 (obstacle on the road) and subCauseCode between 0 and 5 shall be used. subCauseCodes 6 and 7 shall not be used. • stationType: 15 • traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. • informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4]. • Message management shall be done by either providing short validity durations or by actively terminating messages. <p>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</p>

Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 10 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>ObstacleOnTheRoad(10)</td><td>1</td><td>5</td><td>-</td><td>1</td><td>1</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	ObstacleOnTheRoad(10)	1	5	-	1	1	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
ObstacleOnTheRoad(10)	1	5	-	1	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">• serviceType = HLN-OR• messageType = DENM <p>Geographic area (Quadtree) for DENM message:</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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																								

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of use case specific test cases:

- ITS-G5 only:
 - TC_CROADS_HLN-OR_ITSG5_DENM_ObstacleOnTheRoad_20_R2.0.1
 - TC_CROADS_HLN-OR_ITSG5_DENM_CC-sCC_20_R2.0.1
 - TC_CROADS_HLN-OR_ITSG5_DENM_eventHistory_20-1_R2.0.1
 - TC_CROADS_HLN-OR_ITSG5_DENM_eventPosition_20-2_R2.0.1
 - TC_CROADS_HLN-OR_ITSG5_DENM_relevanceDistance_20-3_R2.0.1
- IP-based only:
 - TC_CROADS_HLN-OR_Hybrid_DENM_ObstacleOnTheRoad_20_R2.0.1
 - TC_CROADS_HLN-OR_Hybrid_DENM_CC-sCC_20_R2.0.1
 - TC_CROADS_HLN-OR_Hybrid_DENM_eventHistory_20-1_R2.0.1
 - TC_CROADS_HLN-OR_Hybrid_DENM_eventPosition_20-2_R2.0.1
 - TC_CROADS_HLN-OR_Hybrid_DENM_relevanceDistance_20-3_R2.0.1

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

Type of road network	All
Type of vehicle	All
Use case introduction	
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 road users 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 place of an accident, incident or another type of intervention and the involved vehicles could be located at unclear sections of the road and could surprise or confuse drivers arriving to this section of the road and could complicate passing the intervention location. This could lead to another accident and could pose a serious danger for the 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 road user(s).
Objective	<p>Ensure that road users are informed in a timely manner through C-ITS messages about the place of intervention ahead, so it is possible to adjust their speed and distance to lower the risk of other complications or incidents/accidents.</p> <p>Ensure more attentive driving while approaching and passing the area of an accident by providing in-car information and warnings about the type of rescue and recovery work.</p>
Desired behaviour	<ul style="list-style-type: none"> Increased driver attention Adaptation of the driving speed Adaptation of the driving trajectory (e.g. lane changes if needed) by leaving space to the emergency vehicle.
Expected benefits	<ul style="list-style-type: none"> Reducing the risk of an accident with stationary emergency and rescue/recovery vehicles and thus increased safety for the involved crews Avoid follow up accidents and possible additional confusion for road users Increased driving comfort Increasing safety of operation for all participants
Use case description	
Situation	<p>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 road users 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-car or mobile device about the position and distance to the intervention. Drivers can adjust their speed and position on the road for easy passing by.</p> <p>Differentiation with HLN-SV use case:</p> <p>There is a difference to the regular stationary vehicle use case (HLN-SV). Basically, standing emergency or rescue/recovery vehicle 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</p>

	of a fire engine). Thus, “in intervention” could imply that there is work going on, which requires more space and more attention of other road users than in the case of a “regular” stationary vehicle.
Logic of transmission	V _{erv2V} ¹
Actors and relations	<ul style="list-style-type: none"> • Road user receives information on the in-vehicle display about an emergency and/or rescue/recovery vehicle activity on the road, its distance and exact position. • Emergency or rescue/recovery vehicle drivers use the ERVI use case for warning 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 distance, direction and lane position of the emergency or rescue/recovery vehicle(s). • Road operator 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.
Scenario	<p>V_{erv2V}</p> <ul style="list-style-type: none"> • The equipped emergency/prioritised or rescue/recovery vehicle arrives at the incident place • 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. • Vehicles in the relevance zone receive the message and drivers adapt their behaviour.
Display / alert principle	<ul style="list-style-type: none"> • Vehicles approaching the intervention site receive the message, process it and display the information to the road user. • When the road user arrives near the intervention site, the road user receives an alert with possible instructions. • The warnings may include the type of dangers, distance to the emergency vehicle and lane position. • The alert needs to be displayed on the HMI early enough and is moderately intrusive (at the manufacturer's discretion). • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.
Functional Constraints / dependencies	<ul style="list-style-type: none"> • 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. • For road operators the detection quality of the accident and the linked traffic conditions are of high importance to be able to warn precisely and generate a correct message for this use case. • For service providers the transmission speed and targeting accuracy for the road users is a major dependency to implement this use case successfully. • The link of this use case with other C-ITS messages 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.

¹ V_{erv2V} = Emergency or Rescue/Recovery vehicle to vehicle

- Another message could be sent by the TCC providing information on the actual event protected by the operating vehicle (e.g. HLN-AZ). Two messages could then be sent. It should be advised to see if it is possible to link the events dynamically.
- In case of a big accident / incident with a lot of intervention vehicles, a problem could be that a lot of messages would be sent.

Interoperability requirements

Message profile requirements

The DENM message for ERVI is profiled in chapter 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4].

- 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: less than 5km (5)
 - awarenessTrafficDirection: In case of separated carriageways: upstreamTraffic, in case of non-separated carriageways or unknown: allTrafficDirections
Note: the GN destination area shall be set accordingly to 1000m
 - eventZone shall not be provided
- Transmission Logic: V_{erv2V} – message sent from the vehicle in intervention:
 - stationType shall be set according to [TS 102 894-2]
 - Note: the stationType of vehicle ITS stations 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.
 - A trace shall be provided based on the path history of the vehicle.
 - trace(s) shall be provided as specified in the C-ITS Mobile Roadside ITS G5 System Profile [5].
 - At least one of the following triggering conditions shall be met, and informationQuality shall be set as follows:

Type of triggering	Triggering Condition	information Quality
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

- 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

- o 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.

Note: The following cases apply to V_{erv2V} and $I2V$. The CAM requirements apply only to V_{erv2V} .

Case 1: Emergency vehicle in intervention:

- For this case, causeCode 15 (rescueAndRecoveryWorkInProgress) 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 15 (rescue and recovery work in progress) 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 15 (rescue and recovery work in progress) and subCauseCode 0 shall be used.
- CAM vehicleRole: "rescue(5)"
- CAM SpecialVehicleContainer: RescueContainer

Note: there is no IncidentIndication in the RescueContainer

Security and data protection requirements

Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].

An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 15 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):

	SSP position	SSP value per station type
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	<table><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>rescueAndRecoveryWorkInProgress(15)</td><td>2</td><td>1</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>	CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	rescueAndRecoveryWorkInProgress(15)	2	1	-	-	1	-	-
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)										
rescueAndRecoveryWorkInProgress(15)	2	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">• serviceType = HLN-ERVI• messageType = DENM <p>Geographic area (Quadtree) for DENM message, see appendix A of [7]: 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 specification are defined in chapter 3.3 of [7].</p>																
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none">• ITS-G5 only:<ul style="list-style-type: none">○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1○ TC_CROADS_GENERIC_ITSG5_DENM_Traces_02_R2.0.1○ TC_CROADS_GENERIC_ITSG5-DENM_TIMING_03_R2.0.1○ TC_CROADS_GENERIC_ITSG5-DENM_UPDATE_04_R2.0.1○ TC_CROADS_GENERIC_ITSG5-DENM_CANCEL_04_R2.0.1○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1○ TC_CROADS_GENERIC_ITS-G5_DENM_relevanceTrafficDirection_35_R2.0.1○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1• IP-based only:<ul style="list-style-type: none">○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1○ TC_CROADS_GENERIC_HYBRID_DENM_Traces_02_R2.0.1○ TC_CROADS_GENERIC_HYBRID-DENM_Timing_03_R2.0.1○ TC_CROADS_GENERIC_HYBRID-DENM_UPDATE_04_R2.0.1○ TC_CROADS_GENERIC_HYBRID-DENM_CANCEL_04_R2.0.1																

	<ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36_R2.0.1 <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-ERVI_ITSG5_DENM_CC-sCC_63_R2.0.4 ○ TC_CROADS_HLN-ERVI_ITSG5_DENM_eventHistory_63_1_R2.0.4 ○ TC_CROADS_HLN-ERVI_ITSG5_DENM_eventPositionHeading_63_6_R2.0.4 ○ TC_CROADS_HLN-ERVI_ITSG5_DENM_eventSpeed_63_4_R2.0.4 ○ TC_CROADS_HLN-ERVI_ITSG5_DENM_informationQuality_63_8_R2.0.4 ○ TC_CROADS_HLN-ERVI_ITSG5_DENM_relevanceDistance_63_7_R2.0.4 ○ TC_CROADS_HLN-ERVI_ITSG5_DENM_StationType_63_2_R2.0.4 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-ERVI_Hybrid_DENM_CC-sCC_63_R2.0.4.xlsx ○ TC_CROADS_HLN-ERVI_Hybrid_DENM_eventHistory_63_1_R2.0.4 ○ TC_CROADS_HLN-ERVI_Hybrid_DENM_eventPositionHeading_63_6_R2.0.4 ○ TC_CROADS_HLN-ERVI_Hybrid_DENM_eventSpeed_63_4_R2.0.4 ○ TC_CROADS_HLN-ERVI_Hybrid_DENM_informationQuality_63_8_R2.0.4 ○ TC_CROADS_HLN-ERVI_Hybrid_DENM_relevanceDistance_63_7_R2.0.4 ○ TC_CROADS_HLN-ERVI_Hybrid_DENM_StationType_63_2_R2.0.4
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3.2.9 HLN – Emergency or Prioritized Vehicle Approaching (HLN-EPVA)

Type of road network	All
Type of vehicle	All
Use case introduction HLN-EPVA	
Summary	<p>This use case can be used to warn road users about an approaching emergency or prioritized vehicle in order to facilitate free passage of such emergency or prioritized 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 road users 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> <ol style="list-style-type: none"> 1. 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. 2. 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 road users have to facilitate their passage or to give way to the extent necessary that they can fulfil their mission. <p>The expected behaviour of road users 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>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.</p>
Background	<p>Emergency vehicles and other prioritised special vehicles signal the urgency or importance of their journey to other road users and for the road users to 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 the other road users without knowing the upcoming presence of these vehicles increases the risk of accidents.</p>
Objective	<p>The objective is to warn road users in time about an approaching emergency or prioritized vehicle, to ensure a free passage for the specific vehicle, and to reduce dangerous situations in connection with these vehicles.</p> <p>To increase the safety of the emergency vehicle personnel and road users. In addition, to reduce the travel time for the emergency and prioritized vehicles by avoiding blockages and/or when necessary, by fostering the formation of an emergency corridor in advance.</p>
Desired behaviour	<p>In this use case two specific types of behaviour are distinguished.</p> <ul style="list-style-type: none"> • Yield the right of way to an emergency vehicle (e.g. pull over to the edge of the road or clear an intersection) • 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. <p>In all cases, it is desired that the road user drives more attentively and where necessary adapts its driving behaviour accordingly.</p>
Expected benefits	<ul style="list-style-type: none"> • More attentive driving while an emergency or prioritized vehicle is approaching. • Minimize risks to collisions and accidents. • Faster formation of the emergency corridor and therefore reduced travel time for the emergency vehicles due to a proper emergency corridor.

	<ul style="list-style-type: none"> • Avoidance of congestion • Faster arrival to the incident/accident site to improve road safety of such zones • Reduction of risks taken by road operating agents to reach those accident sites • Improvement of traffic management
Use case description	
Situation	<ul style="list-style-type: none"> • The emergency or prioritized 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. • The sending of appropriate messages to the road users nearby can be started automatically (automatically activated when the light bar/siren is activated) or manually, based on the desire of the implementer. • However, the activation of the light bar, siren or both is a precondition to trigger (manually or automatically) this use case. • As soon as the siren and/or light bar is off, the sending of HLN-EPVA messages shall stop. • If the vehicle is stationary, then the sending of HLN-EPVA messages shall stop. Instead, the use case for stationary special vehicles apply, see HLN-ERV1, as long as the light bar is still active. • The road user receives the information about the approaching vehicle. • The road user adapts their driving behaviour accordingly by either ensuring a free passage of the approaching vehicle and/or driving more attentive knowing an emergency or prioritized vehicle in mission is in the vicinity.
Logic of transmission	VEPV2V Broadcast ² , I2V
Actors and relations	<p>Emergency or prioritized vehicle: sends appropriate HLN-EPVA messages to the vehicles in the vicinity of the emergency/prioritized vehicle or HLN-EPVA information to the Emergency Control Centre.</p> <p>Emergency Control Centre: Collects the necessary information (a.o. mission status, status of light bar / usage of siren) of the approaching emergency or prioritized vehicle and sends this information to the Traffic Control Centre.</p> <p>Traffic Control Centre: Creates the HLN-EPVA message based on the information received from the ECC and sends out the HLN-EPVA message</p> <p>Road user: receives HLN-EPVA message sent by the emergency or prioritized vehicle or by the TCC. The road user is informed about the situation and can act accordingly.</p>
Scenario	<p>The below mentioned cases could have 2 types of implementation, either VEPV2V or I2V.</p> <p><u>Case 1: Emergency Vehicle with absolute right of way</u> 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>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 by 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.</p>

² VEPV2V means emergency or prioritized Vehicle to Vehicle

Case 1a: V_{EPV2V}

- 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 road user receives this HLN-EPVA message and can act accordingly given the circumstances.

Case 1b: I2V

- The emergency vehicle sends frequently the necessary information about its status to the Emergency Control Centre. With respect to information on the position, position updates shall be retrieved at least every 2 seconds. The Emergency Control Centre relays this information to the Traffic Control Centre. The TCC creates the appropriate HLN-EPVA messages and sends this to the vehicles in the vicinity of the emergency vehicle.

For both cases the exact interoperability requirements can be found in the interoperability requirements section of this use case.

Case 2: Prioritized vehicle with some kind of priority

In this scenario the vehicle assumes a task / mission where other road users have to facilitate its passage according to applicable traffic rules. The vehicle is not stationary, and the light bar and possibly siren is active.

Case 2a: V_{EPV2V}

- The prioritized vehicle sends appropriate HLN-EPVA messages which can directly be used for communication to the vehicles in the vicinity of the prioritized vehicle. The road user receives this HLN-EPVA message and can act accordingly given the circumstances.

Case 2b: I2V

- The prioritized vehicle sends frequently the necessary information about its status to the Emergency Control Centre. The Emergency Control Centre relays this information to the Traffic Control Centre. The TCC creates the appropriate HLN-EPVA messages and sends this to the vehicles in the vicinity of the prioritized vehicle.

For both cases ("a" and "b") the exact interoperability requirements can be found in the interoperability requirements.

Note:

Traffic rules regarding right of way for emergency and prioritized 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.

Display principle	<p>The road user is provided with related information, to be displayed on the dashboard. Layout and sequence of presentation is left to specific implementation.</p> <p>The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional Constraints / dependencies	This use case has been described and harmonized 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.

How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.

There are specific interoperability requirements with respect to the I2V implementation of this use case.

In I2V implementations, the location, speed and lightbar 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.

The trigger for this use case is a confirmed mission status and the vehicle is moving.

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.

Interoperability requirements

Message profile requirements

The DENM message for HLN-EPVA is profiled in chapters 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4].

All cases:

- Traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
- A trace shall be provided based on the path history of the vehicle.
- awarenessTrafficDirection: allTrafficDirections.
- the awarenessDistance should be used. If so, the awarenessDistance shall be set to lessThan1000
- Note: the GN destination area shall be set accordingly to 1000m
- eventPositionHeading and eventSpeed shall be provided
- 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.

Cases 1a (V_{EPV2V}) Emergency Vehicle with absolute right of way

- The CauseCode is “emergencyVehicleApproaching (95)” and the subCauseCode is “emergencyVehicleApproaching (1)”
- The vehicle shall send CAMs with associated vehicleRole and SpecialVehicleContainer (containing lightBarSirenInUse) as specified below
 - CAM vehicleRole: “safetyCar(7)”
 - CAM SpecialVehicleContainer: SafetyContainer
 - IncidentIndication in the SafetyContainer shall be set to the causeCode/subCauseCode of this case.

Cases 2a (VEPV2V) Prioritized vehicle with some kind of priority

- The CauseCode is “emergencyVehicleApproaching (95)” and the subCauseCode is “prioritisedVehicleApproaching (2)”
- The vehicle shall send CAMs with associated vehicleRole and SpecialVehicleContainer (containing lightBarSirenInUse) as specified below
 - CAM vehicleRole: “safetyCar(7)”
 - CAM SpecialVehicleContainer: EmergencyContainer
 - IncidentIndication in the EmergencyContainer shall be set to the causeCode/subCauseCode of this case.

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

- The CauseCode is “emergencyVehicleApproaching (95)” and the subCauseCode is “emergencyVehicleApproaching (1)”

Cases 2b (I2V) Prioritized vehicle with some kind of priority

- The CauseCode is “emergencyVehicleApproaching (95)” and the subCauseCode is “prioritisedVehicleApproaching (2)”

Case 1a and 2a (VEPV2V)

- 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
 - awarenessTrafficDirection as defined above
 - eventZone shall not be provided
- The stationType: shall be set according to [TS 102 894-2]
 Note: the stationType of vehicle ITS stations 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
 - awarenessTrafficDirection 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 2 seconds in order to match the DENM update requirements.
The eventZone shall be matched to a road topology.
- stationType: roadsideUnit(15)
- 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
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.

Note 1:

- 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)
- 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.

	<div>Note 2:<ul style="list-style-type: none">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.</div> <ul style="list-style-type: none">Message management shall be done providing short validity durations as follows:<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>The use case shall be terminated when the emergency vehicle has arrived at its destination.detectionTime shall refer to the time when the position of the vehicle has been recorded within the vehicle. <p>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.</p>	Message management	Setting	validityDuration	2 s	Termination	Not used																																		
Message management	Setting																																								
validityDuration	2 s																																								
Termination	Not used																																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 95 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>EmergencyVehicle Approaching (95)</td><td>3</td><td>3</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td></tr><tr><td>emergencyContainer</td><td>1</td><td>6</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td></tr><tr><td>safetyCarContainer</td><td>1</td><td>7</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	EmergencyVehicle Approaching (95)	3	3	-	-	1	-	-	emergencyContainer	1	6	-	-	1	-	-	safetyCarContainer	1	7	-	-	1	-	-
	SSP position		SSP value per station type																																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																																		
EmergencyVehicle Approaching (95)	3	3	-	-	1	-	-																																		
emergencyContainer	1	6	-	-	1	-	-																																		
safetyCarContainer	1	7	-	-	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7]</p>																																								

	<p>shall apply:</p> <p>serviceType = HLN-EPVA messageType = DENM</p> <p>Geographic area (Quadtree) for DENM message, see appendix A of [7]: 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 specification are defined in chapter 3.3 of [7]</p>
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_ITS-G5_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_HYBRID_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID-DENM_Timing_03_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID-DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID-DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36_R2.0.1 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_HLN-EPVA_ITSG5_DENM_CC-sCC_60_R2.0.5.xlsx

- TC_CROADS_HLN-EPVA_ITSG5_DENM_StationType_60_2_R2.0.5.xlsx
- TC_CROADS_HLN-EPVA_ITSG5_DENM_detectionTime_60_10_R2.0.5.xlsx
- TC_CROADS_HLN-EPVA_ITSG5_DENM_eventHistory_60_1_R2.0.5.XLSX
- TC_CROADS_HLN-EPVA_ITSG5_DENM_eventPositionHeading_60_6_R2.0.5.xlsx
- TC_CROADS_HLN-EPVA_ITSG5_DENM_eventSpeed_60_4_R2.0.5.xlsx
- TC_CROADS_HLN-EPVA_ITSG5_DENM_informationQuality_60_8_R2.0.5.xlsx
- TC_CROADS_HLN-EPVA_ITSG5_DENM_relevanceDistance_60_7_R2.0.5.xlsx
- Hybrid (IP-based only):
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_CC_sCC_60_R2.0.5.xlsx
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_StationType_60_2_R2.0.5.xlsx
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_detectionTime_60_10_R2.0.5.xlsx
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_eventHistory_60_1_R2.0.5.xlsx
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_eventPositionHeading_60_6_R2.0.5.xlsx
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_eventSpeed_60_4_R2.0.5.xlsx
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_informationQuality_60_8_R2.0.5.xlsx
 - TC_CROADS_HLN-EPVA_HYBRID_DENM_relevanceDistance_60_7_R2.0.5.xlsx

3.2.11 HLN - Railway Level Crossing (HLN-RLX)

Use case introduction HLN-RLX	
Summary	The railway infrastructure manager or a service provider informs the driver about the presence of a railway level crossing and its type/parameters/status. This use case covers both protected level crossings along with unprotected ones. The messaging to drivers and the information provided is addressed, too.
Background	<p>Very serious accidents, sometimes with a high number of fatalities, occur at railway level crossings. These accidents are often caused by a road vehicle driver overlooking the warning lights of the signalling system and failing to stop in front of the crossing. Even at level crossings with barriers, serious accidents occur due to reluctance of drivers to stop before the barriers are down and, in addition, tendencies of drivers to bypass half barriers during active warning (waiting) phase at a crossing (so called S-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>
Objective	<p>The driver gets warned about the presence of a railway level crossing to raise his/her attention when approaching it. Special warning is also shown to the driver when the signalling system (when available) detects approaching train.</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"> • Increased driver attention • Adaptation of the driving speed in the vicinity of railway crossing and when passing the crossing according to national speed limits • Stopping the vehicle in front of the crossing if the crossing is in a warning state • Waiting for the train to pass the level crossing
Expected benefits	<ul style="list-style-type: none"> • Reducing the risk of accident between road and railway vehicles • Reducing the risk of road vehicle accidents in the vicinity of railway level crossings • Increased driving comfort
Use case description	
Situation	A vehicle is approaching a railway level crossing which may be equipped with a signalling system with warning lights and barriers, without barriers, or with a warning cross only. In due time and location, the driver is informed about the presence of the railway crossing, and, if warning is active, about the current status of the crossing.
Logic of transmission	<p>I2V broadcast</p> <ul style="list-style-type: none"> • locally to both sides of the level crossing, covering all roads leading to the level crossing and denoting the boundaries, or stopping points, of the crossing • over the network to various communication channels
Actors and relations	<ul style="list-style-type: none"> • Railway infrastructure manager is responsible that the signalling system generates warnings locally at the railway crossing and distributes respective warnings directly (with low latency) as C-ITS messages to all drivers approaching the crossing or via alternate communication channels. <i>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.</i> • Service provider receives the warning messages from the railway infrastructure

Scenario	<p>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).</p> <ul style="list-style-type: none"> End-user receives the warnings in the vicinity of the railway crossing. <p>I2V</p> <p>1. Basic warning:</p> <ul style="list-style-type: none"> Information about the location of the level crossing including the national ID, the type of the level crossing, the number of rail tracks, its length, width, height and other optional information like recommended/maximum passing speed for road vehicles, is available in the railway system. The information is periodically sent out by the C-ITS system at the crossing directly on various communication channels with one message ID to the road users. Inclusion of optional information is dependent on the rules of the respective railway infrastructure manager The vehicle receives the information and displays it to the driver. The drivers adapt their behaviour <p>2. Approaching train:</p> <ul style="list-style-type: none"> If the approaching train is detected (by the signalling system), C-ITS system will automatically and continuously broadcast/distribute C-ITS message with a special warning about the warning state active at the crossing, including optional information like estimated time to the end of the warning state, direction of the approaching train(s), etc. directly or on alternate communication channels with one message ID to the road users. Inclusion of optional information is dependent on the rules of the respective railway infrastructure manager The vehicle receives the information and displays it to the driver. The drivers adapt their behaviour <p>3. Railway crossing out of order:</p> <ul style="list-style-type: none"> If the railway crossing signalling system is malfunctioning or out of order and such event is detected by the signalling system itself or remotely by the Railway infrastructure manager's means, or if fully closed for traffic, respective warning information is continuously sent out by the C-ITS system on various channels with one message ID to the road users. In case of malfunctioning, which can be demonstrated to the driver in several different ways, it is recommended to send only "long-term warning state" information as the driver may not comprehend precisely the meaning and react in a wrong way. The vehicle receives the information and displays it to the driver. The drivers adapt their behaviour
Display / alert principle	<ul style="list-style-type: none"> The warning to the driver needs to be displayed early enough and with adequate priority for the driver to adapt his driving. However, since the driver should not forget about the alert, it could be repeated closer to the location. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility The user is provided with related information. Layout and sequence of presentation is left to OEM-specific implementation.
Functional constraints / dependencies	<p>Due to strict safety requirements on railway and the danger that the C-ITS system, which is not fail-safe, might, by its failure, send an information valid for another time instant, no 'positive' information should be sent to the driver and also should not be implemented in the OBU, i.e., informing that the railway crossing is open (no train approaching). Only neutral (railway crossing is ahead) and 'negative' (signalling system is broken down or railway crossing closed/train is approaching) information should be given.</p>

	How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<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, currently only the scenario of a risk of collision can be handled by the DENM standard.</p> <ul style="list-style-type: none"> • The DENM message for HLN-RLX is profiled in the chapter 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. • CauseCode: 97 • SubCauseCode: 2 • a single linear relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> ○ eventPosition shall be at the light/barrier of the level crossing for the direction concerned ○ awarenessDistance shall not be provided ○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. ○ 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 by direction) • informationQuality shall be set to 4 or 6 for this UC, 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 • traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. • Message management shall be done by either providing short validity durations or by actively terminating messages. <p>It will be used on the following situations: Train is approaching or the signalling system is broken down.</p> <p><u>The current cC/sCC combinations in the standard do not suffice for the purposes of this use case. The therefore favoured and implemented but not yet standardised solution is:</u></p> <ul style="list-style-type: none"> • CauseCodeType : railwayLevelCrossing (100) • RailwayLevelCrossingSubCauseCode: <ul style="list-style-type: none"> ○ unavailable (0): for non-available information on status. ○ doNotCross-AbnormalSituation (1): when something wrong is detected by equation or sensors of the railway level crossing, including level crossing is closed for too long (e.g. more than 10 minutes long; default value). Behaviour expected from road user: do not cross. ○ closed (2): when it is closed (barriers down). Behaviour expected from road user: stop before the level crossing and wait.

	<ul style="list-style-type: none">o unguarded (3): unguarded Level Crossing (i.e. a Saint Andrew cross level crossing without detection of train). Behaviour expected from road user: cross but with extreme caution.o nominal (4) : when barriers are up and lights are off. Behaviour expected: to cross, but be careful still, a risk can always occur and situation can always change.																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 97 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><td colspan="5">SSP value per station type</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td><td>6 (bus)</td><td>9 (trailer)</td><td>10 (special vehicles)</td><td>11 (tram)</td><td>15 (road side unit)</td></tr><tr><td>collisionRisk(97)</td><td>3</td><td>5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	collisionRisk(97)	3	5	-	-	-	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
collisionRisk(97)	3	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">• serviceType = HLN-RLX• messageType = DENM <p>Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																								

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable Specific Test Cases:

- ITS-G5 only:
 - TC_CROADS_HLN-RLX_ITSG5_DENM_CC-sCC_40_R2.0.1
 - TC_CROADS_HLN-RLX_ITSG5_DENM_stationType_40-1_R2.0.1
 - TC_CROADS_HLN-RLX_ITSG5_DENM_eventHistory_40-3_R2.0.1
 - TC_CROADS_HLN-RLX_ITSG5_DENM_eventPosition_40-4_R2.0.1
 - TC_CROADS_HLN-RLX_ITSG5_DENM_informationQuality_40-5_R2.0.1
- IP-based only:
 - TC_CROADS_HLN-RLX_HYBRID_DENM_CC-sCC_40_R2.0.1
 - TC_CROADS_HLN-RLX_HYBRID_DENM_stationType_40-1_R2.0.1
 - TC_CROADS_HLN-RLX_HYBRID_DENM_eventHistory_40-3_R2.0.1
 - TC_CROADS_HLN-RLX_HYBRID_DENM_eventPosition_40-4_R2.0.1
 - TC_CROADS_HLN-RLX_HYBRID_DENM_informationQuality_40-5_R2.0.1

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

Type of road network	All
Type of vehicle	All
Use case introduction HLN-UBR	
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 road users. A blockage means that there is no traffic going through the road segment and passing it by on a single or several lanes., The complete road is blocked (not an obstacle on one or more lanes).
Background	Today, this information is provided only by the VMS or the radio. With C-ITS, the availability of information is better. In mountainous regions for example, where there are a lot of kilometres be driven before road operators reach a site, providing such warning information to drivers before the road operator arrives to the site can be essential.
Objective	The objective of this use-case is two-fold: <ul style="list-style-type: none"> • For vehicles that are very close to the blockage: to alert them about a danger ahead • For vehicles much more upstream, to allow them to reroute early enough This use case concerns one whole road, or one direction of a dual carriage way.
Desired behaviour	<ul style="list-style-type: none"> • Increased vigilance of the approaching drivers • Adaptation of the speed • Rerouting if blocked road is far away and rerouting possible for the targeted destination
Expected benefits	<ul style="list-style-type: none"> • Reducing the risk of accidents • Improved traffic management • Reduce the number of drivers impacted by the road blockage
Use case description	
Situation	<ul style="list-style-type: none"> • a vehicle close to the blockage is warned of the dangerous situation ahead • a more upstream vehicle is informed to adapt the driving route <p>Causes of blockage:</p> <ul style="list-style-type: none"> • rocks falling • accidents of HGV • water flood • etc. <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>
Logic of transmission	I2V Broadcast
Actors and relations	<ul style="list-style-type: none"> • Sender is an operator in the TCC • End-receiver is the driver in the vehicle • Sources of information can be: <ul style="list-style-type: none"> ○ Other vehicles which have detected the danger ○ Cameras ○ Phone call of a witness ○ etc.

Scenario	<ol style="list-style-type: none"> 1. The operator in the TCC gets informed about a section of road that is blocked 2. The operator puts the information in his TCC and the message is then broadcasted to the road users 3. The vehicles receive the information and display it to the driver. 4. The driver adapts his behaviour, depending on the distance and driving situation compared to the accident location 5. When the operating agents arrive on site, the blockage becomes managed, and additional use cases activated. 6. This C-ITS message will be terminated and enhanced with more accurate information and use cases.
Display / alert principle	<ul style="list-style-type: none"> • The information to the driver needs to be send in time and the display to the driver needs to be early enough to adapt his speed or even his itinerary. However, since the driver should not forget about the alert, it could be repeated closer to the location. • The HMI display 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.
Functional Constraints / dependencies	<ul style="list-style-type: none"> • 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. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> • The DENM message for HLN-UBR is profiled in chapter 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. • For this use case, for now, causeCode 5 (impassability) and subCauseCode 0 (unavailable) shall be used. • a point based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> ○ The eventPosition shall be set to the location of the blockage. ○ awarenessDistance shall not be provided ○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. ○ eventZone shall not be used. • stationType: 15 • traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. • informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4]. • Message management shall be done by either providing short validity durations or by actively terminating messages. <p>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</p> <p><u>Note, a C-Roads follow up action with ETSI is planned to provide a more adequate solution on the CC and sCC.</u></p>

Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 5 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>Impassability(5)</td><td>To be defined</td><td>To be defined</td><td>-</td><td>-</td><td>1</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	Impassability(5)	To be defined	To be defined	-	-	1	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
Impassability(5)	To be defined	To be defined	-	-	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">• serviceType = HLN-UBR• messageType = DENM <p>Geographic area (Quadtree) for DENM message:</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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																								

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable specific test cases:

- ITS-G5 only
 - TC_CROADS_HLN-UBR_ITSG5_DENM_CC-sCC_48_R2.0.1
 - TC_CROADS_HLN-UBR_ITSG5_DENM_stationType_48-1_R2.0.1
 - TC_CROADS_HLN-UBR_ITSG5_DENM_eventHistory_48-3_R2.0.1
 - TC_CROADS_HLN-UBR_ITSG5_DENM_informationQuality_48-4_R2.0.1
- Hybrid (IP-based only):
 - TC_CROADS_HLN-UBR_HYBRID_DENM_CC-sCC_48_R2.0.1
 - TC_CROADS_HLN-UBR_HYBRID_DENM_stationType_48-1_R2.0.1
 - TC_CROADS_HLN-UBR_HYBRID_DENM_eventHistory_48-3_R2.0.1
 - TC_CROADS_HLN-UBR_HYBRID_DENM_informationQuality_48-4_R2.0.1

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

Type of road network	Road with separate carriageways (non-urban) including entrance and exit segments.
Type of vehicle	All
Use case introduction HLN - AWWD	
Summary	<p>This use case is to warn a driver that he could encounter a vehicle that is driving in the wrong way. It is not the primary aim of this use case to alert the wrong-way driver that he is on the wrong way. This V2V use case could be added in the future to the warning sequence if detection quality and confirmed status of information is improved.</p> <p>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 similarly high.</p>
Background	<p>Today, the information about a wrong-way driver exists, but is only broadcasted by radio and/or VMS. The detection rate, time and accuracy of information is initially low, even if the wrong way driver alert is activated. Because of the high relative vehicle speeds involved between the approaching vehicles on the same lane, this generates always a highly risky situation on the road motorway network.</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 driver to adapt his driving lane, speed and his behaviour, in case of a wrong-way driver to minimise his risk.</p> <p>The aim is <u>not to alert the wrong-way driver</u> that he is on the wrong way. This can be an optional V2V message and possibly even an in-vehicle detection application in the future.</p> <p>This would lead to enhanced road safety through the prevention of high speed, and therefore very risky, road accidents on motorways by faster detection and more precise location of the wrong way driver and activate a detailed warning sequence to all nearby and approaching drivers.</p>
Desired behaviour	<p>Vehicle drivers receiving this information:</p> <ul style="list-style-type: none"> • can adapt their speed and / or trajectory by driving at the most right (and mostly slowly travelling vehicles compared to left lanes on motorways, which are used to overtake or higher speed cruises) • and can put themselves in a safe place (rest area, motorway interchange, etc) • Pay more attention to their direct traffic surroundings
Expected benefits	<p>The added value of this use case is that potential directly involved drivers are informed faster and more accurately. Moreover, the service aims to inform more drivers than currently (not all drivers listen to the radio). This leads to:</p> <ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none"> Reduce the number of follow up accidents by detecting high risk situations linked to wrong way drivers fast and efficiently and distribute the correct and precise warning sequence of messages to all drivers approaching the risky area of driving.
Use case description	
Situation	<p>The wrong way driving alert could be triggered by several situations:</p> <ul style="list-style-type: none"> On a motorway, a vehicle takes a slip road (entrance or exit segment) in the wrong way or turns back in the toll station / rest area and drives the motorway in the wrong driving direction. On a ring road with separate carriageways, the situation can be the same, but with slip roads / exits more regular. <p>Because the wrong way driver is entering the motorway* segment he mostly uses the most left lane*, which is for the correct drivers the one with the highest travelling speed*.</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> <p>For the wrong way driving alert the following phases of the use case should be defined depending on the confirmed status of information of the road operator, possibly the warning sequence in a single case can also consist of more than two, but linked use case phases as follows. Phase 1 and 3 always apply. The WWD alert could be extended with Phase 2 if more specific information becomes available.</p> <p>Phase 1 - Warning all approaching drivers to the risky area or segment of the transport network at early indications of a wrong way driver present. The WWD - alert informs drivers to drive carefully and slowly and only on the right lane and not to overtake (and therefore use the most left lane of the motorway) on both directions of the motorway.</p> <p>Phase 2 - If the wrong way driver position, heading and lane is confirmed, alert all drivers approaching this respective road segment to drive carefully and switch lanes to drive on the right lanes. And at the same time alert drivers on the opposite driving direction of the motorway that the WWD alert has been clarified and regular traffic conditions have been resumed.</p> <p>Phase 3 - After clearance of the complete warning case, inform all drivers involved that regular traffic conditions have been resumed.</p>
Logic of transmission	I2V Broadcast
Actors and relations	<p>Vehicle driver: the end-users of this service are drivers in their vehicle, exposed to the wrong way driving vehicle in their direction and in the opposite direction of driving at the beginning of the WWD-alert.</p> <p>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.</p> <p>Road operator: the sender of the message is an operator in the TCC, using various detection sources of the wrong way driving vehicle e.g.:</p> <ul style="list-style-type: none"> Automated wrong-way detector Camera's

	<ul style="list-style-type: none"> • Phone call (field operator, police, drivers, radio). • Other C-ITS equipped vehicles <p>Service providers: providing the message to the involved drivers and contributing the fast and precise detection of WWD cases by sending their WWD cases from vehicles to the involved road operators / public.</p>
Scenario	<ol style="list-style-type: none"> 1. An operator in the TCC is alerted of the presence of a wrong way driving vehicle on a motorway segment. 2. Phase 1: The TCC broadcast the information for the relevant road segments for both directions. The subject of the message is "wrong-way driver on your way". No detailed recommendations will be given initially. It informs drivers only to drive slowly and not to overtake. 3. Vehicles receive the information. 4. If the information is relevant for a vehicle (driver), the information is displayed to the driver with a high priority. 5. Phase 2: Wrong way driver details (driving position, speed, heading, driving lane) are confirmed by a second source of information to the road operator in the TMC. 6. Vehicles involved receive the driving direction dependent updated information. 7. Updated information (for same traffic event and message) is displayed to the driver with a high priority. 8. A message cancellation is transmitted after clearance of the WWD alert. <p>Note, if the detailed information does not become available, steps 5-7 will not be applicable.</p> <p>The use case could in the future also be extended in urban road networks, where drivers are driving against the allowed driving direction of a single direction road, which is also mainly a V2V use case.</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 to try to turn, deviate or perform other driving actions).</p>
Display / alert principle	<p>There are two main display possibilities:</p> <ul style="list-style-type: none"> • A moderately intrusive alert to encourage the driver to adapt his behaviour (change lane to right as precaution) without risk of an overreaction. (this can be related to phase 1) • An intrusive alert to encourage the driver to adapt his behaviour in case of urgency. (this can be related to phase 2). <p>In both cases, the alert should be done enough in advance to give the drivers the time to adapt their driving behaviour, possibly vehicle speed and lane advice.</p> <p>The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional Constraints / dependencies	<ul style="list-style-type: none"> • For this particular use-case, the validity duration and the dissemination area of the information will need to be determined and ascertained for every phase of the use case and the respective status and quality of the available information about the wrong way driver in the TMC. • The information will not be precise enough to manage an imminent emergency. <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 have a robust WWD-Detection logic on board for the EGO vehicle and for other vehicles in the surrounding traffic environment.</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 and to the correct drivers group (approaching the risky situation with the WWD.)

How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.

Interoperability requirements

Message profile requirements

- The DENM message for HLN use-cases is profiled in chapter 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4].
- For this use-case, causeCode 14 (wrongWayDriving) and subCauseCode 2 (wrongDirection) shall be used.
- stationType: 15
- traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
- informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4].
- Message management shall be done by either providing short validity durations or by actively terminating messages.
- a single linear awareness area shall be sent. It shall be represented as:
 - eventPosition shall be set to a position upstream of the position where the wrong way driver was last detected.
 - awarenessDistance shall not be provided
 - awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
 - eventZone shall be provided.

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.

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.

NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.

Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 14 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><td colspan="5">SSP value per station type</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td><td>6 (bus)</td><td>9 (trailer)</td><td>10 (special vehicles)</td><td>11 (tram)</td><td>15 (road side unit)</td></tr><tr><td>wrongWayDriving(14)</td><td>2</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	wrongWayDriving(14)	2	0	-	-	-	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
wrongWayDriving(14)	2	0	-	-	-	-	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">• serviceType = HLN-AWWD• messageType = DENM <p>Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																								

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.



List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable specific test cases:

- ITS-G5 only
 - TC_CROADS_HLN-AWWD_ITSG5-DENM_CC_sCC_49_R2.0.1
 - TC_CROADS_HLN-AWWD_ITSG5-DENM_StationType_49_1_R2.0.1
 - TC_CROADS_HLN-AWWD_ITSG5-DENM_RelevanceZone_50_R2.0.1
 - TC_CROADS_HLN-AWWD_ITSG5-DENM_informationQuality_50_1_R2.0.1
- IP-based only:
 - TC_CROADS_HLN-AWWD_Hybrid-DENM_CC_sCC_49_R2.0.1
 - TC_CROADS_HLN-AWWD_Hybrid-DENM_StationType_49_1_R2.0.1
 - TC_CROADS_HLN-AWWD_Hybrid-DENM_RelevanceZone_50_R2.0.1
 - TC_CROADS_HLN-AWWD_Hybrid-DENM_InformationQuality_50_1_R2.0.1

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

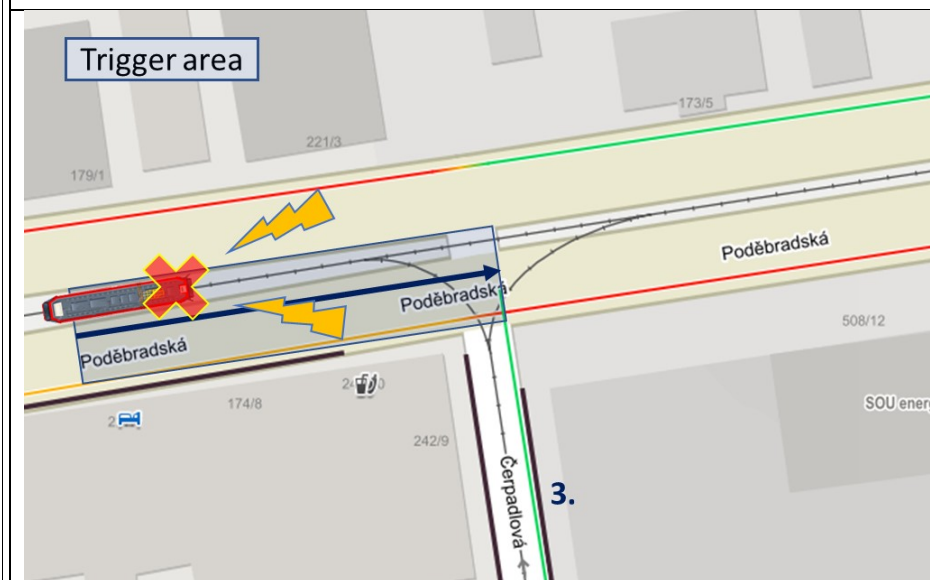
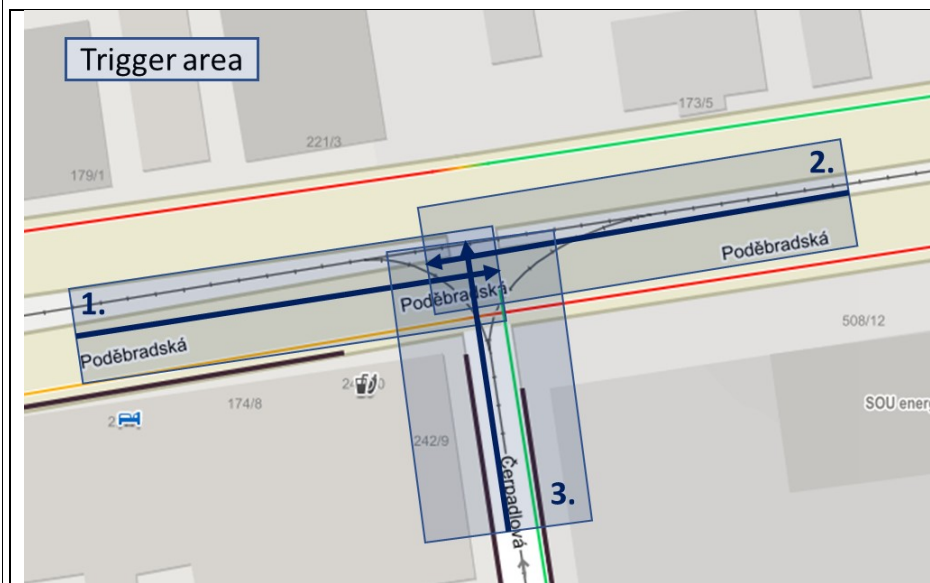
Type of road network	Road, urban road
Type of vehicle	All vehicles
Use case introduction HLN – PTVC	
Summary	Vehicle is approaching a location of a high risk of collision with PT vehicles. The driver is informed about this situation via in-car information and warning.
Background	<p>Mainly in the cities, there are many places where tram tracks cross a road for other vehicles and these places are not equipped with traffic lights. Mainly during the turning manoeuvre, the driver doesn't expect to cross with tram tracks which often leads to the accident with trams.</p>  <p>Other dangerous situations include where buses merge from a bus priority lane into the mixed traffic lane. Most drivers are unaware that they have to give priority to buses, as a consequence this leads to conflict and accidents.</p> 
Objective	The driver gets warned about the presence of locations with a risk of collision with PT vehicle, i.e. where tram tracks cross a road (or in the connection from reserved lane). The aim of the service is raising the driver's attention and reminding him/her to "Give priority!" when approaching the location.
Desired behaviour	<ul style="list-style-type: none"> • Increased driver attention • Adaptation of the driving speed
Expected benefits	<ul style="list-style-type: none"> • Reducing the risk of accident with PT vehicles • Increased driving comfort

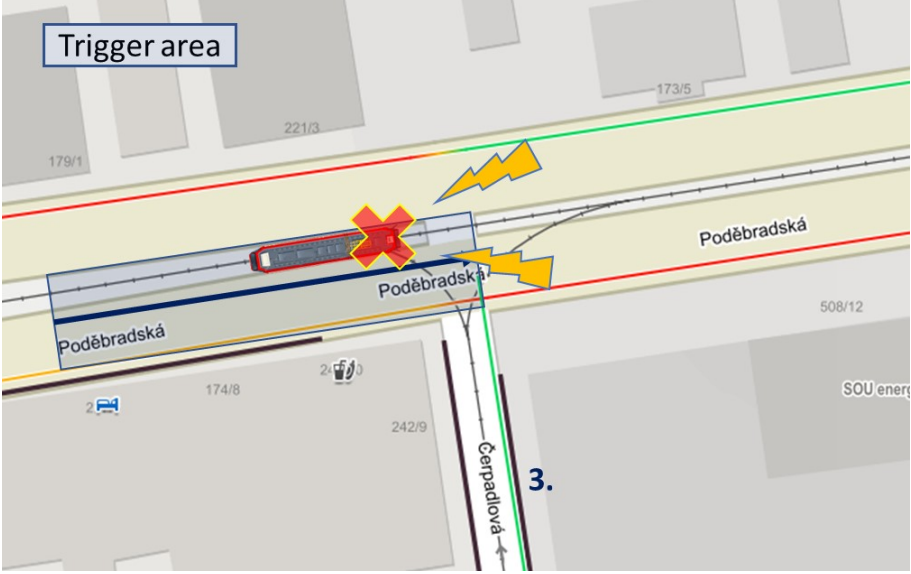
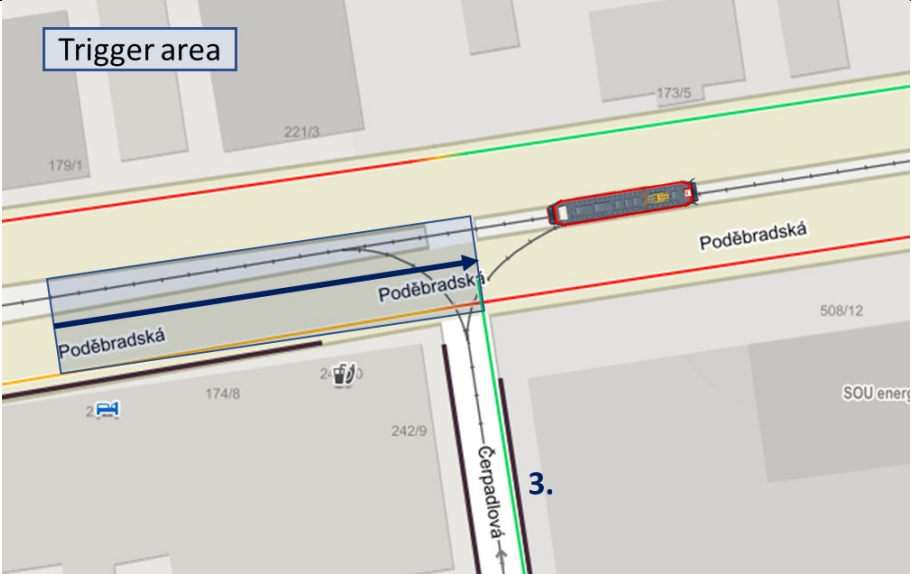
Use case description

Situation

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

The dangerous locations (and its trigger areas) are usually chosen by the road operators or public transport companies who know where the spots of the 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>Logic of transmission</p> <p>Actors and relations</p>	<p>V_{PT}2V</p> <ul style="list-style-type: none"> Public transport operator is the origin of the information of the message. The direct source are OBUs in their vehicles. End-user receives the warnings in the vicinity PT vehicle crossing.
<p>Scenario</p>	<ul style="list-style-type: none"> 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 and it contains its actual position (within eventPosition DE). Transfer of information into vehicles equipped with an OBU. The vehicle receives the information and displays it to the driver. The driver adapts his/her behaviour.

Display / alert principle	<ul style="list-style-type: none"> The warning to the driver needs to be displayed early enough for him/her to adapt his driving. However, since he/she should not forget about the alert, it could be repeated closer to the location. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> This UC should be in place 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 even though the PT vehicle just left the dangerous location. 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. The approaching PT vehicle should transmit its position with certain accuracy and in a timely manner. How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.

Interoperability requirements

Message profile requirements	<ul style="list-style-type: none"> The DENM message for HLN-PTVC is profiled in chapter 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. For this use-case, causeCode 97 (collision risk) and subCauseCode 2 (crossing collision risk) shall be used a point based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> The eventPosition shall be set to the location of the PT vehicle. awarenessDistance shall not be provided awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. eventZone shall not be provided stationType shall be set to 6 (bus) or 11 (tram) → indicator of PT vehicles traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4]. Message management shall be done by either providing short validity durations or by actively terminating messages. <p>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.</p> <p>In addition to the DENM a CAM shall be sent.</p> <ul style="list-style-type: none"> CAM vehicleRole: "publicTransport (1)" CAM SpecialVehicleContainer: publicTransportContainer
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Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 97 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><td colspan="5">SSP value per station type</td></tr><tr><td>CauseCodeType / Container</td><td>Octet position</td><td>Bit position</td><td>6 (bus)</td><td>9 (trailer)</td><td>10 (special vehicles)</td><td>11 (tram)</td><td>15 (road side unit)</td></tr><tr><td>collisionRisk(97)</td><td>3</td><td>5</td><td>1</td><td>-</td><td>-</td><td>1</td><td>-</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	collisionRisk(97)	3	5	1	-	-	1	-
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
collisionRisk(97)	3	5	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <p>serviceType = HLN-PTVC messageType = DENM</p> <p>Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																								

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.


List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable specific test cases:

- ITS-G5 only
 - TC_CROADS_HLN-PTVC_ITSG5_DENM_CC-sCC_51_R2.0.1
 - TC_CROADS_HLN-PTVC_ITSG5_DENM_stationType_52_1_R2.0.1
 - TC_CROADS_HLN-PTVC_ITSG5_DENM_eventHistory_52_2_R2.0.1
- IP-based only:
 - TC_CROADS_HLN-PTVC_HYBRID_DENM_CC-sCC_51_R2.0.1
 - TC_CROADS_HLN-PTVC_HYBRID_DENM_stationType_52_1_R2.0.1
 - TC_CROADS_HLN-PTVC_HYBRID_DENM_eventHistory_52-2_R2.0.1

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

Type of road network	Road, urban road
Type of vehicle	All vehicles
Use case introduction HLN-PTVS	
Summary	Providing in-car information and warning about public transport vehicle at a stop.
Background	<p>The public transport vehicles stopping in some types of stops create an obstacle on the road. These situations happen mainly in the stops on the road lane or stops where passengers get off directly on the road. In these locations, approaching vehicle could collide with the stationary public transport vehicle or even the passengers. These locations can be very dangerous mainly in combination with bad weather conditions.</p> 
Objective	<p>The driver gets warned about the presence of a public transport vehicle at the stop to raise his/her attention when approaching it by providing in-car information and warnings about this situation.</p> <p>During the getting on/off to public transport, the passengers often don't pay much attention. Due to the warning, the driver can be prepared for unexpected pedestrian behaviour.</p>
Desired behaviour	<ul style="list-style-type: none"> • Increased driver attention • Adaptation of the driving speed in the vicinity of the stop (stopping the vehicle behind the stationary PT vehicle) • Readiness for unexpected pedestrian behaviour
Expected benefits	<ul style="list-style-type: none"> • Reducing the risk of accident with PT vehicles • Reducing the risk of road vehicle accidents in the vicinity of PT stops • Increased driving comfort
Use case description	
Situation	Vehicle is approaching a PT stop (e.g., stop on the road lane) where the PT vehicle is standing and passengers are getting on/off the vehicle in a hurry. The driver is informed about this situation.
Logic of transmission	V _{PT} 2V
Actors and relations	<ul style="list-style-type: none"> • Public transport operator is the origin of the information of the message. The direct source are OBUs in their vehicles. • End-user receives the warnings in the vicinity PT vehicle at a stop.
Scenario	<ul style="list-style-type: none"> • The PT vehicle stops at a stop. • Warning messages begin to be generated by the PT vehicle's OBU. • Transfer of information into vehicles equipped with OBU. • The vehicle receives the information and displays it to the driver. • The driver adapts his/her behaviour.

Display / alert principle	<ul style="list-style-type: none"> The warning to the driver needs to be displayed early enough for him/her to adapt his driving. The user is provided with related information. Layout and sequence of presentation are left to OEM-specific implementation. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> The broadcasted position of the PT vehicle and the exact lane it is located should be sufficiently accurate. The broadcasted info that the PT vehicle is coming to a stop should be communicated timely enough to leave time for surrounding vehicles to be aware and react. – How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> The DENM message for HLN-PTVS is profiled in chapter 4.2.1.1 and 4.2.1.3 of C-Roads, C-ITS Message Profiles [4]. For this use-case, causeCode 94 (stationary vehicle) and subCauseCode 4 (publicTransportStop) shall be used. a point based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> The eventPosition shall be set to the location of the PT vehicle. awarenessDistance shall not be provided awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. eventZone shall not be provided stationType shall be set to 6 (bus) or 11 (tram) to clearly indicate public transport vehicles. traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. informationQuality shall be set according to the definition in C-Roads, C-ITS Message Profiles [4]. 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 <p>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.</p> <p>In addition to the DENM a CAM shall be sent.</p> <ul style="list-style-type: none"> CAM vehicleRole: “publicTransport (1)” CAM SpecialVehicleContainer: publicTransportContainer
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 CauseCode 94 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):

	SSP position		SSP value per station type				
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)
stationaryVehicle(94)	3	2	1	-	-	1	-

SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.

Communication technology requirements: ITS-G5

For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of C-Roads, C-ITS Roadside ITS G5 System Profile [6] shall apply.

For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.

Communication technology requirements: IP-Based

For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.

For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:

- serviceType = HLN-PTVS
- messageType = DENM

Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].

Test and validation requirements

The document "C-ITS Cross-Border Testing and Validation Concept" [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1

- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable specific test cases:

- ITS-G5 only
 - TC_CROADS_HLN-PTVS_ITSG5_DENM_CC-sCC_53_R2.0.1
 - TC_CROADS_HLN-PTVS_ITSG5_DENM_stationType_54_1_R2.0.1
 - TC_CROADS_HLN-PTVS_ITSG5_DENM_eventHistory_54-2_R2.0.1
- IP-based only:
 - TC_CROADS_HLN-PTVS_HYBRID_DENM_CC-sCC_53_R2.0.1
 - TC_CROADS_HLN-PTVS_HYBRID_DENM_stationType_54_1_R2.0.1
 - TC_CROADS_HLN-PTVS_HYBRID_DENM_eventHistory_54-2_R2.0.1

4 Road Works Warning (RWW)

4.1 RWW: Service introduction

Service introduction – RWW	
Summary	With this service, warnings will be provided to road users about road works, which can be mobile or static, short-term or long-term. Road works is seen as all type of road operations by the road operator including operations involving road operator vehicles.
Background	<p>Road works usually affect the road layout and often the driving regulations. Despite dedicated signage prior to road work zones, such changed conditions frequently come as a surprise to road users. This may lead to unsafe situations and sometimes even accidents, which involve both road users and workers (i.e., changes to the road layout and applicable driving regulations). Moreover, the attention of the driver can fade with regular or longer road works.</p> <p>Road operators' vehicles are not always recognized and are not as equipped as police vehicles or fire engines for example. Use cases involving road operator vehicles (e.g., salting, ploughing, bypassing towards incident, protecting accident zone, vehicle recovery by road operator) support the safety of the involved road operators and road users.</p>
Objective	More attentive and adjusted driving while approaching and passing a work zone or road operator vehicles in operation by providing in-car information and warnings about road works, changes to the road layout and applicable driving regulations.
Expected benefits	<ul style="list-style-type: none"> • The primary expected impact is more attentive driving while approaching and passing a work zone or road operator vehicles in operation, helping to avoid sudden braking or steering / swerving manoeuvres, thereby improving traffic safety as it reduces (the severity of) accidents. • RWW aims at reducing the number of collisions with road vehicle safety-objects and road operator vehicles near road works. RWW will inform the road user when approaching a work zone and will simultaneously provide information on the changes in the road layout. • Better flow • Less accidents
Use cases	<ol style="list-style-type: none"> 1. Lane closure (and other restrictions) (RWW – LC) 2. Road Closure (RWW – PC) 3. Road Works – Mobile (RWW-RM) 4. Winter Maintenance (RWW-WM) <p>Other RWW use cases are under review and may be added in future releases.</p>

4.2 RWW: Use Cases

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

Use case introduction RWW-LC	
Type of road network	All
Type of vehicle	All
Use case introduction RWW-LC	
Summary	<ul style="list-style-type: none"> The road user receives information about the closure of part of a lane, whole lane or several lanes (including hard shoulder), but without the road closure. The closure is due to a static road works site. In this use case, alternate mode and road closure are excluded.
Background / added values	Currently, many road users enter the road works sites or strike the protection equipment of the site, sometimes causing victims. Information sufficiently in advance would prevent this type of situation by adapting the behaviour of the road user.
Objective	<ul style="list-style-type: none"> The objective is to allow road users to anticipate the closure of lanes due to a road works site on the road ahead and to adapt their speed and lane on the road. The objective is not to signal a road closure and therefore no alternative route will be transmitted, even if a warning message could be sent. It is also not the objective to signal to the user that he/she is likely to have to stop, as in the case of an alternate mode.
Desired behaviour	<ul style="list-style-type: none"> Increased vigilance Adaptation of the speed Change of lanes (if needed)
Expected benefits	<ul style="list-style-type: none"> Reduce the risk and number of accidents and dangerous situations for road users and workers. Informing the road user about a risk of discomfort on the road (slowing down, manoeuvring) Improved traffic management due to less traffic relevant events on the road
Use case description	
Situation	<ul style="list-style-type: none"> Road works equipped with warning beacons / temporary road signs / illuminated lights arrows, on a road with separate carriageways or on a dual carriageway. Carriageway crossover (in a divided highway. situation where vehicles need to use the contraflow carriageway because their own carriageway is closed) Lane closure by sign gantries (line control system) Lane closure by warning trailer equipped with RSU (short term road works)
Logic of transmission	I2V Broadcast
Actors and relations	<ul style="list-style-type: none"> The Road operator is the origin of the information of the message. It can be the Traffic Operations Centre, or a road operator vehicle if no connection to the central station ("stand alone mode"). The road user approaching the area is the end-user of this service (receives the information/message). Service provider: the road works planner of the road operator, a management system or the RSU on the trailer (in case of the "stand – alone mode").

Use case scenarios	<ol style="list-style-type: none"> Static planned road works (TOC Triggered): <ol style="list-style-type: none"> The road operator programs static and planned (or ad hoc) road works in its Traffic Management System (TMS). The information contains all the elements that could be used to describe the work site (start / end position of the work site, duration) precisely. Additional information could be added, such as the speed limit of each affected section. Some data could be provided to the TOC by the trailers or road operator (vehicle) of the road work. The message is then broadcasted to the road users The road user receives the information and processes it. Stand-Alone Mode <ol style="list-style-type: none"> A trailer is used for a short-term or long-term road work, but without a connection to the TOC (no connection available). The message is then broadcasted to the road users without additional information from the TOC. The road user receives the information and processes it. Augmented (Stand-alone then TOC Triggered): <ol style="list-style-type: none"> A trailer is used for a short-term or long-term road work (e.g. broken road surface after an accident). Firstly, the message is then broadcasted to the road users without additional information from the TOC. Then, the TCC can send messages from the TOC. The message can be sent with additional information from the TOC. The road user receives the information and processes it.
Display / alert logic	<ul style="list-style-type: none"> When the road user arrives near the work zone site, he receives information to allow him to adjust his speed and position on the road to prevent dangerous situations. The information needs to be displayed on the HMI early enough and is moderately intrusive (at the manufacturer's decision). The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> Trailers being used to indicate lane closures or other restrictions in Stand-Alone or Augmented mode need to provide a proper trace to their current position at the beginning of the road works zone where the lane closure starts. It must be assured that information generated via different messages/ information networks can be linked by the receiver to the same road works event. The validation process of transmitted information (quality) against the physical layout of an RWW site needs to be taken care of. How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> The DENM message for RWW-LC is profiled in chapters 4.2.1.1 and 4.2.1.2 of C-Roads, C-ITS Message Profiles [4]. For this use case, causeCode 3 (road works) and subCauseCode either 0 or 4 shall be used. For TOC triggered and augmented: <ul style="list-style-type: none"> informationQuality shall be set to 6 if start and end time can be confirmed on site. For standalone: <ul style="list-style-type: none"> informationQuality shall be set to 6. closedLanes and/or trafficFlowRule shall be used if available.

	<ul style="list-style-type: none">For augmented and TOC triggered scenarios:<ul style="list-style-type: none">If multiple DENMs are sent out for the same work zone, the referenceDenms DE shall be used.a single linear relevance zone shall be sent. It shall be represented as<ul style="list-style-type: none">The eventPosition shall be set to the location where the trailer or first cone is located.awarenessDistance shall not be providedawarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].eventZone shall be provided for the entire extension of the road works.stationType: 9,15traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].Message management shall be done by either providing short validity durations or by actively terminating messages. <p>NOTE: The position confidence depends on the detection system. If no precise value can be given, the value 4095 (unavailable) shall be used.</p>																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 3 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>roadworks(3)</td><td>1</td><td>2</td><td>-</td><td>1</td><td>1</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	roadworks(3)	1	2	-	1	1	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
roadworks(3)	1	2	-	1	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <p>serviceType = RWW-LC messageType = DENM</p> <p>Geographic area (Quadtree) for DENM message:</p>																								

<p>Test and validation requirements</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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p> <p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure_26_R2.0.1 ○ TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure_26_1_R2.0.1 ○ TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure_26_2_R2.0.1 ○ TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure_26_3_R2.0.1 ○ TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure_26_4_R2.0.1 ○ TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure_26_5_R2.0.1 ○ TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure_26_6_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_RWW-LC_Hybrid_DENM_LaneClosure_26_R2.0.1 ○ TC_CROADS_RWW-LC_Hybrid_DENM_LaneClosure_26_1_R2.0.1 ○ TC_CROADS_RWW-LC_Hybrid_DENM_LaneClosure_26_2_R2.0.1 ○ TC_CROADS_RWW-LC_Hybrid_DENM_LaneClosure_26_3_R2.0.1 ○ TC_CROADS_RWW-LC_Hybrid_DENM_LaneClosure_26_4_R2.0.1 ○ TC_CROADS_RWW-LC_Hybrid_DENM_LaneClosure_26_5_R2.0.1 ○ TC_CROADS_RWW-LC_Hybrid_DENM_LaneClosure_26_6_R2.0.1
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4.2.2 RWW - Road Closure (RWW – RC)

Type of road network	All
Type of vehicle	All
Use case introduction RWW-RC	
Summary	The road user receives information about a road closure due to a set of static road works. The closure is temporary.
Background	<ul style="list-style-type: none"> When road users are stuck without being informed on the situation, they can become anxious, and they may do dangerous U-turns or use an inappropriate lane (e.g. hard shoulder). Providing that kind of information can prevent these situations, bringing more safety and comfort to road users. There is an added value in this use case if the information is accurately linked with re-routing information.
Objective	<ul style="list-style-type: none"> To allow the driver to anticipate the closure of a road so he can choose an alternate route. This anticipation can be geographical or temporal.
Desired behaviour	<ul style="list-style-type: none"> The drivers adapt their route.
Expected benefits	<ul style="list-style-type: none"> Safety (avoid dangerous behaviour, e.g., U-turns) Improved traffic management Improved comfort for road users
Use case description	
Situation	<ul style="list-style-type: none"> On a dual carriageway: one direction is closed, without carriageway crossover. On a two-way carriageway: the whole road is closed (therefore without alternate). In both case: a deviation is indicated near the closure.
Logic of transmission	I2V Logic Broadcast
Actors and relations	<ul style="list-style-type: none"> The Road operator is the sender of the message. Can be in contact with the other road operators in order to implement a smart deviation itinerary. The Road user is the end-user of the service (receiver of the closure information). The service provider can be the road operator.
Use case scenario	<p>TOC triggered only.</p> <ul style="list-style-type: none"> The road operator programs static and planned road works in its Traffic Management System (TMS). This information contains all the elements that can be used to precisely describe the work site (start / end position of the closure, duration) and potential alternative routes (may be different by type of road user or destination). The message is then broadcasted to the road users approaching the road closure, so that users can adapt their itinerary. The information is received in the vehicle and displayed to the driver.
Display principle / alert logic	<ul style="list-style-type: none"> Little intrusive alert in the case of a significant temporal anticipation; a little more intrusive in case of a shorter anticipation time. The display of alternate routes is to be considered. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> Management of planned events to be sent to road users. Prior the standards decision, some checks would be necessary: <ul style="list-style-type: none"> Update of the Message Set and Triggering Conditions for Road Works Warning Service which also includes LT-RWW Work plan proposal, including IVI, MAP and several stakeholder perspectives

- How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.

Interoperability requirements

Message profile requirements

- The DENM message for RWW-RC is profiled in chapters 4.2.1.1 and 4.2.1.2 of C-Roads, C-ITS Message Profiles [4].
- For this use case, causeCode 3 (road works) and subCauseCode 1 (majorRoadworks) shall be used. Major Roadworks are characterised by having at least one driving direction completely blocked.
- informationQuality shall be set to 6, if start and end time can be confirmed on site
- closedLanes should be used with all lanes set to closed
- stationType: 9,10,15
- traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
- a single linear relevance zone shall be sent. It shall be represented as
 - The eventPosition shall be set to the location, where the road is blocked (trailer, first cone or any other method of blocking).
 - awarenessDistance shall not be provided
 - awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].
 - eventZone shall be provided for the closed part of the road.
- Message management shall be done by either providing short validity durations or by actively terminating messages.

NOTE: The position confidence depends on the localisation method. If no precise value can be given, the value 4095 (unavailable) shall be used.

Security and data protection requirements

Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].

An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 3 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):

	SSP position		SSP value per station type				
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)
roadworks(3)	1	2	-	1	1	-	1

SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.

Communication technology requirements: ITS-G5

For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of C-Roads, C-ITS Roadside ITS G5 System Profile [6] shall apply.

For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.

<p>Communication technology requirements: IP-Based</p>	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> • serviceType = RWW-RC • messageType = DENM <p>Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>
<p>Test and validation requirements</p>	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1 ○ TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1 ○ TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1 ○ TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_RWW_RC_ITSG5_DENM_RoadClosure_34_R2.0.1 ○ TC_CROADS_RWW_RC_ITSG5_DENM_RoadClosure_34_1_R2.0.1 ○ TC_CROADS_RWW_RC_ITSG5_DENM_RoadClosure_34_2_R2.0.1 ○ TC_CROADS_RWW_RC_ITSG5_DENM_RoadClosure_34_3_R2.0.1 ○ TC_CROADS_RWW_RC_ITSG5_DENM_RoadClosure_34_4_R2.0.1 ○ TC_CROADS_RWW_RC_ITSG5_DENM_RoadClosure_34_5_R2.0.1 • Hybrid (IP-based only): <ul style="list-style-type: none"> ○ TC_CROADS_RWW_RC_Hybrid_DENM_RoadClosure_34_R2.0.1 ○ TC_CROADS_RWW_RC_Hybrid_DENM_RoadClosure_34_1_R2.0.1 ○ TC_CROADS_RWW_RC_Hybrid_DENM_RoadClosure_34_2_R2.0.1

- TC_CROADS_RWW_RC_Hybrid_DENM_RoadClosure_34_3_R2.0.1
- TC_CROADS_RWW_RC_Hybrid_DENM_RoadClosure_34_4_R2.0.1
- TC_CROADS_RWW_RC_Hybrid_DENM_RoadClosure_34_5_R2.0.1

4.2.3 RWW – Road Works Mobile (RWW-RM)

Type of road network	All
Type of vehicle	All
Use case introduction RWW – RM	
Summary	The road user receives information about a zone on the road that contains, at some point, the neutralization of part of a lane or a lane closure (but without road closure) due to a planned mobile work site.
Background	Currently, many road users enter the road works sites or strike the protection equipment of the site, sometimes causing victims. An alert sufficiently in advance would prevent this type of situation by adapting the behaviour of the driver. The risk is even more important with mobile work site that are “lighter” in terms of protection and signalling, since moving.
Objective	The objective of this use case is to inform a road user of a mobile work zone where he will encounter operating agents in the zone. However, road work equipment / workers might not be present / visible on the whole section.
Desired behaviour	<ul style="list-style-type: none"> • Increased vigilance • Adaptation of the speed • Change of lanes (if needed)
Expected benefits	<ul style="list-style-type: none"> • Reduce the risk of accidents (for users, road agents) • Informing the road user about a risk of discomfort on the road (slowing down, manoeuvring) • Improved traffic management
Use case description	
Situation	<ul style="list-style-type: none"> • Mowing • road markings • fixing restraint systems • phyto-sanitary treatments • sweeping, road cleaning, • etc....
Logic of transmission	I2V Broadcast
Actors and relations	<ul style="list-style-type: none"> • The Road operator is the sender of the message. It can be the TCC (TCC triggered mode) or the operator vehicle (standalone mode) • The Road user approaching the area is the end-user of this service (receives the message). • Information service provider: the road works planner of the road operator.
Use case scenario	<ol style="list-style-type: none"> 1. TOC triggered: <ol style="list-style-type: none"> a. The road operator programs mobile and planned road works in its Traffic Management System (TMS). The information contains all the elements that can be used to precisely describe the work zone (start / end position of the work zone, duration). This zone will not be entirely used by the operating agents; they will set markings around the actual work site within this zone. b. Additional information can be added, such as the speed limit of each neutralized portion. c. The message is then broadcasted to the road users. d. The vehicle receives the information, processes it, and displays it to the driver. 2. Stand-alone Mode <ol style="list-style-type: none"> a. The message is sent by a mobile RSU mounted on a road operator vehicle (e.g. trailer) without a connection to a central station

	<ul style="list-style-type: none"> b. The message contains a basic set of information (event speed, position, arrow position) c. There is no additional information from a management system d. The message is then broadcasted to the road users. e. The vehicle receives the information, processes it, and displays it to the driver <p>3. Augmented (Stand-alone then TOC Triggered):</p> <ul style="list-style-type: none"> a. The message is broadcasted to the road users by a mobile RSU mounted on a road operator vehicle (e.g., trailer), firstly without additional information from the TOC b. The message contains a basic set of information (event speed, position, arrow position) c. Then, the TOC can send messages with additional information. d. The vehicle receives the information, processes it, and displays it to the driver
Display principle / alert logic	<ul style="list-style-type: none"> • When the road user arrives near the planned work zone, the road user receives an alert to allow him to adjust his speed and position on the pavement. • The alert needs to be displayed on the HMI early enough and is moderately intrusive (at the manufacturer's discretion). • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> • Prior the standards decision, some checks would be necessary: <ul style="list-style-type: none"> ○ Update of the Message Set and Triggering Conditions for Road Works Warning Service which now also includes LT-RWW (all based on DENM only) ○ Work plan proposal, including IVI, MAP and several stakeholder perspectives • The road operator vehicle on site, if equipped, might broadcast a message signalling a mobile work site as well. The HMI might need to handle those two messages. The priority shall be given to the information given by the vehicle on site. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> • The DENM message for RWW-RM is profiled in chapters 4.2.1.1 and 4.2.1.2 of C-Roads, C-ITS Message Profiles [4]. • For this use case, causeCode 3 (road works) and either subCauseCode 0 or 3 shall be used. subCauseCode 0 shall be used in stop-and-go situations. • awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. • informationQuality shall be set to 6, if the message is being sent out from the vehicle doing the road works, else set to 4 • eventPositionHeading shall be provided. • For each affected driving direction, a separate DENM shall be sent. • stationType: 9,10,15 • traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. • For the TOC-triggered scenario: <ul style="list-style-type: none"> ○ a single linear relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> ▪ the eventPosition shall be set at the location of the trailer if known; if not, it shall be set at the beginning of the zone, where the mobile roadworks is planned. ▪ awarenessDistance shall not be provided ▪ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. ▪ eventZone shall be provided. <p>If the RM is planned, the eventZone shall be provided to indicate the zone, where the mobile roadworks is planned.</p>

	<ul style="list-style-type: none">For the standalone and TOC-augmented scenarios:<ul style="list-style-type: none">a point based relevance zone shall be sent encoded as:<ul style="list-style-type: none">The eventPosition shall be set to the location of the towed trailer or the road operator vehicle conducting or securing the mobile road works in scenarios without a trailerawarenessDistance shall not be providedawarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4].eventZone shall not be providedMessage management shall be done by either providing short validity durations or by actively terminating messages. <p>NOTE: The position confidence depends on the localisation method. If no precise value can be given, the value 4095 (unavailable) shall be used.</p>																								
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 3 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>roadworks(3)</td><td>1</td><td>2</td><td>-</td><td>1</td><td>1</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	roadworks(3)	1	2	-	1	1	-	1
	SSP position		SSP value per station type																						
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																		
roadworks(3)	1	2	-	1	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																								
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">serviceType = RWW-RMmessageType = DENM <p>Geographic area (Quadtree) for DENM 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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																								

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5_DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid_DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable specific test cases:

- ITS-G5 only:
 - TC_CROADS_RWW-RM_ITSG5_DENM_RWW-Mobile_23_R2.0.1
- IP-based only:
 - TC_CROADS_RWW-RM_Hybrid_DENM_RWW-Mobile_23_R2.0.1

4.2.4 RWW - Winter Maintenance (RWW-WM)

Type of road network	All
Type of vehicle	All
Use case introduction RWW-WM	
Summary	The winter maintenance vehicle, equipped with the necessary technology for a road operator vehicle-to-vehicle (Vro2V) communication, sends a message signalling their activity (salting and/or snow/ice removal). The alerted road user can adapt its driving behaviour accordingly.
Background	Winter maintenance vehicles are much slower and, in some countries, it is forbidden to overtake them when in operation. Even if most of the drivers are driving slowly because of the potential slippery road conditions, bad visibility can lead to not seeing exactly where the winter maintenance vehicles are on the road. Then this use case can support the prevention of collisions between winter maintenance vehicles and road users. It can also help sending information about a possible spill of salt for road users driving in the opposite direction of the road (bi-directional roads) or passing by the winter maintenance vehicle (where allowed).
Objective	<p>The objective of this use case is to alert road users that will encounter an operating winter maintenance vehicle so that they can adapt their driving behaviour accordingly.</p> <p>This use case is also relevant for road users in the opposite direction because the salting and/or snow removal operations could have an impact for them as well, especially in the case of bidirectional roads.</p>
Desired behaviour	<ul style="list-style-type: none"> Increased vigilance Adaptation of speed
Expected benefits	<ul style="list-style-type: none"> Reducing the risk of accidents for road users and winter maintenance crews Improved winter maintenance interventions efficiency
Use case description	
Situation	<p>In case of winter maintenance vehicle in operation (salting and/or ploughing):</p> <p>A road user is arriving behind one (or several) winter maintenance vehicle(s) in intervention. The road users can adapt their driving behaviour accordingly on the basis of the information received in advance. In some countries, the road user knows then (or is warned) that he cannot overtake the winter maintenance vehicle(s).</p> <p>In case of circulating winter maintenance vehicle (not in operation):</p> <p>A road user is arriving behind this larger than usual vehicle (because of the snowplough). The road user can adapt their driving and their overtaking taking the information of a large vehicle into account</p>
Logic of transmission	Vro2V Logic Broadcast ³
Actors and relations	<ul style="list-style-type: none"> The winter maintenance vehicle (through the on-board unit) is the sender of the information/warning The road user approaching the relevant area is the end user of this service (receives the message).

³Vro2V = Road operator vehicle to vehicle

Scenario	<p>Scenario (1) A winter maintenance vehicle is on the road and the salting process is activated. If connected directly to the salting equipment, the In-Vehicle System sends a message to inform road users of the salting process; otherwise, the activation can be done manually.</p> <p>Scenario (2) A winter maintenance vehicle is on the road and the snow removal process is activated. Additionally, the salting process can be activated. If connected directly to the snow plough equipment, the In-Vehicle System sends a message to inform road users of the snow removal process; otherwise, the activation can be done manually.</p> <p>Scenario (3) A winter maintenance vehicle with large dimensions is on the road and the light bar is switched on. If connected directly to the light bar or the beacon, the In-Vehicle System sends a message to inform road users of the winter maintenance vehicle; otherwise, the activation can be done manually.</p> <p>The road users nearby the winter maintenance vehicle receive the message(s) and the messages are displayed to the road user when appropriate.</p>
Display / alert principle	<p>The display logic might be different if the message is received by a road user behind the winter maintenance vehicle or next to it (or on the other side of the road). For the reason that in some countries the road users are not allowed to overtake a winter maintenance vehicle, a reminder of not overtaking the winter maintenance vehicle as displayed in the road user's vehicle could be interesting. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints / dependencies	<p>This message could be also accompanied by a message sent by the TCC signalling a zone of winter maintenance (using VMS for example). The receiving systems will have to deal with the priority or redundancy of both messages.</p> <p>How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.</p>
Interoperability requirements	
Message profile requirements	<ul style="list-style-type: none"> • The DENM message for RWW-WM is profiled in chapters 4.2.1.1 and 4.2.1.2 of C-Roads, C-ITS Message Profiles [4]. • For this use case, either causeCode 26 (slow vehicle) or causeCode 3 (road works) shall be used. • Appropriate subCauseCodes for causeCode 26 (slow vehicle) shall be subCauseCode 8 (salting vehicle), 3 (snow plough) or 0 (unavailable), with subCauseCode 0 (unavailable) being used in case of an approaching winter maintenance vehicle. • The matching subCauseCode for causeCode 3 (road works) shall be 6 (winter service). • a point based relevance zone shall be sent. It shall be represented as: <ul style="list-style-type: none"> ○ The eventPosition shall be set to the location of the winter maintenance vehicle. Message management shall be done by either providing short validity durations or by actively terminating messages. ○ awarenessDistance shall not be provided ○ awarenessTrafficDirection shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. ○ eventZone shall not be provided • informationQuality shall be set to 6 if the message is being sent out by the vehicle on the road, otherwise set to 4. • eventPositionHeading shall be provided

	<ul style="list-style-type: none">For each affected driving direction, a separate DENM shall be send.stationType: 10traces shall be provided as specified in C-Roads, C-ITS Message Profiles [4]. <p>If multiple events happen in parallel, e. g. salting and snow ploughing, the major incident should be alerted, in the example the snow plough.</p>																																
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 3 and 26 and therefore requires appropriate DENM permission (SSP) in the certificate to be used (AT):</p> <table><tr><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>Roadworks (3)</td><td>1</td><td>2</td><td>-</td><td>1</td><td>1</td><td>-</td><td>1</td></tr><tr><td>Slow vehicle (26)</td><td>2</td><td>5</td><td>-</td><td>1</td><td>1</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	Roadworks (3)	1	2	-	1	1	-	1	Slow vehicle (26)	2	5	-	1	1	-	1
	SSP position		SSP value per station type																														
CauseCodeType / Container	Octet position	Bit position	6 (bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																										
Roadworks (3)	1	2	-	1	1	-	1																										
Slow vehicle (26)	2	5	-	1	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																																
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on DENM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">serviceType = RWW-WMmessageType = DENM <p>Geographic area (Quadtree) for DENM message:</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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																																

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_GENERIC_ITSG5-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_Generic_ITSG5-DENM_Traces_02_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36_R2.0.1
- IP-based only:
 - TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01_R2.0.1
 - TC_CROADS_Generic_Hybrid-DENM_positionConfidenceEllipse_01_1_R2.0.1
 - TC_CROADS_GENERIC_HYBRID-DENM_TIMING_03_R2.0.1
 - TC_CROADS_GENERIC_HYBRID-DENM_UPDATE_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID-DENM_CANCEL_04_R2.0.1
 - TC_CROADS_GENERIC_HYBRID-DENM_relevanceTrafficDirection_35_R2.0.1
 - TC_CROADS_GENERIC_Hybrid-DENM_referenceDenms_36_R2.0.1

List of applicable specific test cases:

- ITS-G5 only:
 - TC_CROADS_RWW-WM_ITSG5-DENM_WinterMaintenance_55_R2.0.1
- Hybrid (IP-based only):
 - TC_CROADS_RWW-WM_Hybrid-DENM_WinterMaintenance_55_R2.0.1

5 Signalized Intersections (SI)

5.1 SI: service introduction

Service introduction	
Summary	This service will provide information to road users, and vehicle data to traffic light controllers, for a safe and efficient approach and crossing of a signalised intersection(s). The implementation of the infrastructure-based intersection use cases will increase the safety and traffic flow efficiency and minimize environmental pollution at a signalised intersection.
Background	Traffic intersections can be complex traffic environments, where traffic flows can be affected negatively by various traffic aspects. Additionally, intersections are also areas with higher risks for accidents, because of conflicting traffic streams. Also emissions are higher due to stops and acceleration. For these reasons C-ITS services that allow a smooth passing of one or more intersections with a constant speed for a large number of road users decrease negative effects of urban traffic.
Objective	More attentive driving while approaching and passing an intersection by providing in-car information, speed advice and priority to designated vehicles (e.g. public transport, emergency vehicles, heavy goods vehicles, etc.) for better energy efficiency and improved road safety.
Expected benefits	Enhanced safety for emergency vehicles as conflicting traffic streams can be stopped and drivers can cross with less risk.
Use Cases	<p>The following use cases are included in this release:</p> <ol style="list-style-type: none"> 1. Signal Phase and Timing Information 2. Green Light Optimal Speed Advisory 3. Imminent Signal Violation Warning 4. Traffic Light Prioritisation 5. Emergency Vehicle Priority

5.2 SI: Use Cases

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

Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	This service will provide information to road users approaching and passing traffic light controlled intersections, on the current phase as well as upcoming phase(s) and the moment these are expected to start and end.
Background	Intersections cause delay and stops thereby negatively affecting environmental pollution and traffic safety. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights can be given to road users to optimize their driving and to overcome the inefficiencies.
Objective	Enable road users to adapt their behaviour due to left time until the next phase of the upcoming traffic light to minimise sudden stops, deceleration and acceleration (delay), resulting in better safety, throughput and sustainability.
Desired behaviour	Road users can adapt their speed while approaching a signalised intersection, or when stopped at a red phase, they can turn off their engine.
Expected benefits	The expected benefit is increased awareness of traffic lights and their phase changes and more efficient and effective driving behaviour while approaching or waiting at traffic light controlled intersections with reduced stops, thus reduces emissions, anger and aggressiveness, and increases safety.
Use case description	
Situation	A V2X equipped vehicle approaches an I2V enabled signalised intersection, which transmits periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> • Road authority: defines policy and traffic light infrastructure (i.e. traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology). • Road operator: ensures coordination of traffic light controlled intersections and provides access to signal phase and timing data. • Data provider: processes the signal phase and timing data. • Service provider: disseminates phase and timing information to traffic participants. • Road user: receives phase and timing information and adapts his or her behaviour according to this information.
Scenario	<p><u>Scenario 1: Vehicle approaches a green traffic light</u> The I2V enabled signalized intersection transmits periodically and in real time the current green phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle approaching the intersection, aware of its own location, velocity, and speed limit receives the messages and extracts the relevant time to red information and uses that information to determine its trajectory towards the intersection.</p> <p><u>Scenario 2: Vehicle approaches a red traffic light</u> The I2V enabled signalized intersection transmits periodically and in real time the current red phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped</p>

	<p>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 information to determine its trajectory towards the intersection.</p> <p><u>Scenario 3: Vehicle is stopped at red traffic light</u></p> <p>The I2V enabled signalized intersection transmits periodically and in real time the current red phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle extracts the relevant time to green information.</p>
Display / alert principle	<p>The phase and timing information needs to be provided to the road user on an HMI early enough, and be moderately intrusive. The notification could be, for example, a traffic light symbol, countdown timer, sand glass, alert to turn off the engine or an alert to prepare for green. The presentation of signal phase and timing on the HMI should be done in a way that discourages drivers from increasing their speed beyond the speed limit or to depart before the start of the green phase. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional Constraints / dependencies	<ul style="list-style-type: none"> • Current phase state and timing of upcoming phase changes from the signalized intersection shall be sufficiently accurate and reliable to ensure high quality information. • The signal state as indicated by the physical signal heads shall always outweigh the information provided in the vehicle. • Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.

Interoperability Requirements

Message profile requirements	<ul style="list-style-type: none"> • The SPATEM and MAPEM messages for SI-SPTI are profiled in chapter 4.2.3 of C-Roads, C-ITS Message Profiles [4]. • The data frame 'speeds' is not used in this use case.
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> • serviceType = SI-SPTI • messageType = SPATEM or MAPEM <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [7]: 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</p>

<p>Test and validation requirements</p>	<p>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 [7].</p> <p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ 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): <ul style="list-style-type: none"> ○ 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 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ 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): <ul style="list-style-type: none"> ○ TC_CROADS_SI-SPTI_HYBRID_SPATEM_SignalPhaseAndTimingInformation_08_R2.0.4 ○ TC_CROADS_SI-SPTI_HYBRID_SPATEM_speeds_08_1_R2.0.4
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5.2.2 SI - Green Light Optimal Speed Advisory (SI-GLOSA)

Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	This service will provide speed advice information to road users for a safe and efficient approach and crossing of a signalised intersection(s)
Background	Intersections cause delay and stops thereby negatively affecting environmental pollution and traffic safety. At signalised intersections actual and/or predicted information on the phases and timing of traffic lights as well as speed advisory can be given to road users to optimize their driving speed and to overcome the inefficiencies.
Objective	To calculate a speed advice for one or multiple intersections which enables road users to adapt their approach speed and to pass one or more signal-controlled intersections in an energy efficient manner (e.g. by minimizing stops, acceleration and deceleration), safely and sustainably.
Desired behaviour	Road users comply with the speed advice and adapt their speed while approaching, stopping and/or passing a signalised intersection or driving through a sequence of traffic light controlled intersections.
Expected benefits	The expected benefit is a smoother driving behaviour while approaching and driving through a sequence of traffic light controlled intersections, which reduces stops, reduces emissions and increases safety.
Use case description	
Situation	<p><u>Situation 1 (single intersection):</u> A V2X equipped vehicle approaches a <i>single</i> I2V enabled signalized intersection, which transmits periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead.</p> <p><u>Situation 2 (sequence of intersections):</u> A V2X equipped vehicle approaches a <i>sequence</i> of I2V enabled traffic light controlled intersections, which transmit periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection(s) ahead.</p>
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> • Road user: receives speed advisory information and adapts his or her behaviour according to this information. • Road operator: ensures coordination of traffic light controlled intersections, and provides access to signal phase and timing data. • Road authority: defines policy and traffic light infrastructure (i.e. traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology). • Data provider: processes the signal phase and timing data. • Service provider: calculates speed advisory and disseminates the speed advisory information to traffic participants.
Scenario	<p><u>Scenario 1a (vehicle calculates speed advice):</u> The I2V enabled signalized intersection transmits periodically and in real time the current phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and calculates the optimal speed advice for approaching the intersection.</p>

Display / alert principle	<p><u>Scenario 1b (infrastructure calculates speed advice):</u> The I2V enabled signalized intersection calculates and transmits periodically and in real time advisory speed information for multiple road segments of the approach of the intersection. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and extracts the optimal speed advice for approaching the intersection.</p> <p><u>Scenario 2 (green wave speed advice):</u> A sequence of I2V enabled traffic light controlled, synchronized intersections transmit a pre-defined/planned green wave speed advice. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and extracts the green wave speed for passing the intersections.</p> <p>The speed advisory information needs to be provided to the road user on an HMI early enough, is moderately intrusive, and could be anything from a speed value, a speed range, a driving indication like slow down, or something else. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional Constraints / dependencies	<ul style="list-style-type: none"> • Current phase state and timing of upcoming phase changes from the signalized intersection shall be sufficiently accurate and reliable to ensure high quality speed advisory. • The signal state as indicated by the physical signal heads always outweigh the information provided in the vehicle. • Traffic conditions, e.g. queues or traffic jams, affect the validity of speed advisory information and therefore shall be considered. • Speed advisory shall never exceed the legal speed limit. • Public Transport Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver. • ETSI TS 103 301, Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services, V1.2.1
Interoperability Requirements	
Message profile requirements	<ul style="list-style-type: none"> • The SPATEM and MAPEM messages for SI-SPTI are profiled in chapter 4.2.3 of C-Roads, C-ITS Message Profiles [4]. • For this use case: <ul style="list-style-type: none"> ◦ 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. • For scenarios 1b and 2, 'speeds' is mandatory, as are the AdvisorySpeed data elements type, speed, confidence, distance. • The data frame 'speeds' is not used in scenario 1a. • The data element type of AdvisorySpeed must be set to greenwave (1) for scenario 2 and set to ecoDrive (2) for scenarios 1b.
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> • serviceType = SI-GLOSA • messageType = SPATEM or MAPEM <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [7]: 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 specification are defined in chapter 3.3 of [7].</p>
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ 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): <ul style="list-style-type: none"> ○ 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 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ 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
 - TC_CROADS_SI-GLOSA_HYBRID_SPaTEM-
MAPEM_speedLimit_13_5_R2.0.4
 - TC_CROADS_SI-GLOSA_HYBRID_SPaTEM-
MAPEM_speedLimit_13_6_R2.0.4
 - TC_CROADS_SI-GLOSA_HYBRID_SPaTEM-
MAPEM_speedLimit_13_R2.0.4

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

Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	This service will provide imminent signal violation warnings to road users approaching traffic light controlled intersections.
Background	Signalised intersections can be complex traffic environments, and occasionally road users do not stop for a red traffic light, intentionally or unintentionally. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights, as well as imminent signal violation warnings, can be given to road users to increase their awareness of red traffic lights and avoid red light violation.
Objective	To reduce the likelihood and severity of collisions and injuries at signalized intersections by warning the driver that he is potentially violating a red intersection signal.
Desired behaviour	Road users react to the imminent red light violation warning, stopping their vehicle in time to avoid red light violation or reducing their speed to minimise the impact of the red light violation.
Expected benefits	The primary expected benefits are increased awareness of signal phases and their timing, less red light violations and thereby less collisions at signalised intersections
Use case description	
Situation	A V2X equipped vehicle approaches an I2V enabled signalised intersection, which transmits periodically and in real time the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> • Road user: receives imminent red light violation warning and adapts his or her behaviour according to this information. • Road operator: provides access to signal phase and timing data. • Road authority: defines policy and traffic light infrastructure (i.e. traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology). • Data provider: processes the signal phase and timing data. • Service provider: disseminates imminent red light violation warnings to traffic participants.
Scenario	The I2V enabled signalised intersection transmits periodically and in real time the current phase state and timing of upcoming phase changes of the traffic lights. The V2X equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and calculates if red light violation is imminent.
Display / alert principle	The imminent red light violation warning needs to be provided to the road user on an HMI early enough and is intrusive (e.g. supported acoustically). The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility
Functional Constraints / dependencies	<ul style="list-style-type: none"> • Current phase state and timing of upcoming phase changes from the signalized intersection shall be sufficiently accurate and reliable to ensure high quality red light violation warnings. • The time critical nature of this use case requires for a sufficiently low latency system implementation. • The signal state as indicated by the physical signal heads always outweigh the information provided in the vehicle.

	<ul style="list-style-type: none"> Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance. If red light violation is inevitable, another use case comes in play which ensures that other road users are warned for the presence of a red light violator at the signalised intersection. How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.
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Interoperability Requirements

Message profile requirements	<ul style="list-style-type: none"> SPATEM and MAPEM messages for SI-ISVW are profiled in chapter 4.2.3 of C-Roads, C-ITS Message Profiles [4]. The data frame 'speeds' is not used in this use case. One consistent SPATEM/MAPEM message per intersection has to be distributed for this use case
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> serviceType = SI-ISVW messageType = SPATEM or MAPEM <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [7]: 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 specification are defined in chapter 3.3 of [7].</p>
Test and validation requirements	<p>The document "C-ITS Cross-Border Testing and Validation Concept" [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> ITS-G5 only: <ul style="list-style-type: none"> 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

List of applicable specific test cases:

- ITS-G5 only:
 - TC_CROADS_SI-ISVW_ITSG5_SPATEM_Latency_15_R2.0.4
 - TC_CROADS_SI-ISVW_ITSG5_SPATEM_SignalPhaseAndTimingInformation_14_R2.0.4
 - TC_CROADS_SI-ISVW_ITSG5_SPATEM_speeds_18_2_R2.0.4
 - TC_CROADS_SI-ISVW_ITSG5_SPATEM-MAPEM_oneMessageAvailable_18_3_R2.0.4
- Hybrid (IP-based only):
 - 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 - Traffic Light Prioritisation (SI-TLP)

Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	This service will give priority to designated vehicles (e.g. public transport, heavy goods vehicles, etc.) over individual vehicles at signalized intersections for assuring on time transportation schedule (e.g. bus, tram) and/or minimise emissions.
Background	To assure punctual transportation and minimise emissions, a prioritization system for designated vehicles at signalized traffic intersections is necessary. The prioritization system will also make the use of public transport more comfortable and attractive to the public.
Objective	Interaction between designated vehicle and traffic light controller (either local or central) to reduce the delay of designated vehicles at signalized intersections, thereby improve the efficiency of vehicle operations.
Desired behaviour	Designated vehicles (e.g. buses, trams, trucks) drive through an intersection without stopping on "red light" or waiting for "green light" and cross the intersection without any delays.
Expected benefits	<p>The following benefits are expected:</p> <ul style="list-style-type: none"> • Minimum delay for designated vehicles at signalised intersections • Less emissions from designated vehicles • Improved punctuality due to reduced disturbance on branch lines • Increased attractiveness of public transport due to improved comfort • Improved efficiency of vehicle operations (e.g. same service quality with less vehicles or higher frequency with equivalent fleet) • Improved choice of suppliers for fleet operators or public authorities due to standardized V2X solution for designated vehicle prioritization systems.
Use case description	
Situation	A V2X equipped priority eligible vehicle approaches a signalized intersection which is serviced with a prioritization system.
Logic of transmission	I2V and V2I
Actors and relations	<ul style="list-style-type: none"> • Priority eligible vehicle: transmits the priority request, receives priority status information and benefits from the priority • Road authority: sets the priority policy • Road operator: processes the priority request and implements the priority policy • Fleet operator: determines if the designated vehicle is in time or delayed
Scenario	The designated vehicle transmits a prioritisation request. The prioritization system processes the request and either accepts (e.g. the vehicle is behind schedule and/or eligible to get priority) or rejects (e.g. other priorities are granted) the request, then gives feedback to the designated vehicle. If the request is accepted, e.g. "red phases" may be shortened and "green phases" extended, thus the vehicle gets "green light" with minimum delay at the stop line. After the vehicle has successfully driven through the intersection, the traffic light controller switches back to normal operation.
Display / alert principle	The driver of the designated vehicle receives on an in-vehicle display information about the prioritisation status, early enough and in a moderately intrusive manner (at the vehicle manufacturer's and/or service provider's decision). For example, if the request is accepted or rejected. In addition, time to green information may be presented to the driver. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.

Functional Constraints / dependencies	<ul style="list-style-type: none"> The stationID of the vehicle shall not change during processing of a prioritization request. Authentication and authorization of designated priority vehicles shall be ensured. Policy on vehicle prioritization shall be defined, e.g. the level of priority, which vehicles and/or lines the priority applies to, the locations in which priority is available, etc. The priority request shall be provided in time to allow the prioritization system to react on the request. Traffic Light Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance. How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver. ETSI TS 103 301, Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services, V1.2.1
Interoperability Requirements	
Message profile requirements	<ul style="list-style-type: none"> The SSEM and SREM messages for SI-TLP are profiled in chapter 4.2.4 of C-Roads, C-ITS Message Profiles [4]. As inBoundLane the data element 'connection' must be provided. As part of RequestorType the 'role' emergency (6) is reserved for Emergency vehicle Priority (SI-EVP)
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on SSEM/SREM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> serviceType = SI-TLP messageType = SSEM or SREM <p>Geographic area (Quadtree) for SSEM/SREM message, see appendix A of [7]: 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 specification are defined in chapter 3.3 of [7].</p>

Test and validation requirements

The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_SI-GENERIC_ITSG5_SREM-SSEM_REQUEST-ID_23_R2.0.4
- IP-based only:
 - TC_CROADS_SI-GENERIC_HYBRID_SREM-SSEM_REQUEST-ID_23_R2.0.4

List of applicable specific test cases:

- ITS-G5 only:
 - TC_CROADS_SI-TLP_ITSG5_SREM_INBOUNDLANE_34_2_R2.0.4
 - TC_CROADS_SI-TLP_ITSG5_SREM_REQUESTORTYPE_34_1_R2.0.4
- IP-based only:
 - TC_CROADS_SI-TLP_HYBRID_SREM_INBOUNDLANE_34_2_R2.0.4
 - TC_CROADS_SI-TLP_HYBRID_SREM_REQUESTORTYPE_34_1_R2.0.4

5.2.5 SI - Emergency Vehicle Priority (SI-EVP)

Type of road network	All
Type of vehicle	All
Use case introduction	
Summary	This service will actively contribute to the phase control of an equipped intersection to aid the passage of an emergency vehicle (EV). It will also provide the prioritisation status to other users approaching and passing traffic light controlled intersections.
Background	Traffic light prioritisation for EVs can be distinctly different from normal traffic light prioritisation. Depending on intersection geometry, lanes other than those that the EV intends to use may be cleared, offering the EV an easier approach to and passage through the intersection. Moreover, drivers of other vehicles are often not aware that they can pass through a red light if an emergency vehicle (with sirens and light bar enabled) is approaching and there is no other way to clear a path. This results in drivers blocking the path of the emergency vehicle until the light turns green.
Objective	Interaction between emergency(s) vehicle and traffic light controller(s) (either local or central) to reduce the time taken for emergency vehicles to cross signalised intersections and increase the safety of these crossings.
Desired behaviour	The traffic light control adapts its signal phases to give priority to the emergency vehicle, allowing the EV to pass the signalised intersection safely and with minimum delay. The EV driver responds to the information on the prioritisation status (e.g. active and accepted) and if needed adjusts the EV path to the lane which will be cleared by the traffic light controller.
Expected benefits	Primarily expected benefits are a shorter travel time for emergency vehicles and less collision risk. Additional benefit is the increased flexibility to alter the priority lane/signal and use different routes.
Use case description	
Situation	A V2X equipped EV approaches an I2V enabled signalised intersection that is serviced by an EV prioritisation system. The EV transmits periodically and in real time the current position and the certified right of a prioritised passing at the intersection ahead.
Logic of transmission	I2V and V2I
Actors and relations	<ul style="list-style-type: none"> • Emergency vehicle: transmits the priority request, receives priority status information and gets prioritised passing at the intersection. • Road operator: processes the priority request and implements the priority policy at the traffic light controlled intersection. • Road authority: defines policy and traffic light infrastructure (i.e. assigns authorisation and acceptance of certification for EV prioritisation).
Scenario	The V2X equipped vehicle approaching the intersection, sends periodically and in real time the current position and the operational state. The I2V enabled signalised intersection receives the prioritisation request and checks its validity. Dependent on the position, the heading and the distance to the intersection the traffic light phases are controlled in a way that, at first, conflicting traffic streams are stopped, then under regard of minimum inter green times, all or selected lanes of the ingress approach of the EV get a green light and are cleared. Based on the prioritisation status information, the EV passes the intersection using the cleared lane(s). After detecting that the EV has successfully passed the intersection, the intersection control switches back to normal operation (i.e. starting with green for conflicting lanes with high traffic).
Display / alert principle	The driver of the emergency vehicle receives on an in-vehicle display information about the prioritization status, early enough and in a moderately intrusive manner (at the vehicle manufacturer's and/or service provider's decision). For example, if the request is accepted or rejected and what lane(s) will be cleared. A combination with the signal phase and timing

	<p>service can give additional comfort. The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional Constraints / dependencies	<ul style="list-style-type: none"> • The stationID of the emergency vehicle shall not change during processing of a prioritization request. • Authentication and authorization of emergency vehicles shall be ensured. • Policy on emergency prioritization shall be defined, e.g. the level of priority, what locations, which lanes to clear, etc. • The priority request shall be provided in time to allow the prioritization system to react on the request. • Traffic Light Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g. be translated to the preferred language of the driver.
Interoperability Requirements	
Message profile requirements	<ul style="list-style-type: none"> • The SREM and SSEM message for SI-EVP are profiled in chapter 4.2.4 of C-Roads, C-ITS Message Profiles [4]. • As inBoundLane the data element 'approach' must be provided. • As part of RequestorType the 'role' must be set to emergency (6). • As part of RequestorDescription, the data elements routeName, transitStatus and transitSchedule are not used in this use case.
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on SREM/SSEM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> • serviceType = SI-TLP • messageType = SREM or SSEM <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [7]: 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 specification are defined in chapter 3.3 of [7].</p>
Test and validation requirements	<p>The document "C-ITS Cross-Border Testing and Validation Concept" [8] contains the generic applicable framework and process for interoperability testing.</p>

List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:

- ITS-G5 only:
 - TC_CROADS_SI-GENERIC_ITSG5_SREM-SSEM_REQUEST-ID_23_R2.0.4
- Hybrid (IP-based only):
 - TC_CROADS_SI-GENERIC_HYBRID_SREM-SSEM_REQUEST-ID_23_R2.0.4

List of applicable specific test cases:

- ITS-G5 only:
 - TC_CROADS_SI-EVP_ITSG5_SREM_INBOUNDLANE_47_3_R2.0.4
 - TC_CROADS_SI-EVP_ITSG5_SREM_REQUESTORDESCRIPTION_47_2_R2.0.4
 - TC_CROADS_SI-EVP_ITSG5_SREM_REQUESTORTYPE_47_1_R2.0.4
- IP-based only:
 - TC_CROADS_SI-EVP_HYBRID_SREM_INBOUNDLANE_47_3_R2.0.4
 - TC_CROADS_SI-EVP_HYBRID_SREM_REQUESTORDESCRIPTION_47_2_R2.0.4
 - TC_CROADS_SI-EVP_HYBRID_SREM_REQUESTORTYPE_47_1_R2.0.4

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 segment 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"> It is the road operators 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. 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. 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 their on the road network to enhance safety and efficiency.
Objective	<ul style="list-style-type: none"> To enhance 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. 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. Provide additional information and guidance for automated vehicles operating in regular traffic conditions, where most of traffic is not yet automated.
Expected benefits	<ul style="list-style-type: none"> Provide more detailed and specifically tailored information in order to generate more uniform and dynamically adapted transport flows on the road networks. Overall higher energy efficiency and reduced energy consumption, as well as reduced numbers of accidents and delays in transport operations. 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

Use Cases	<ul style="list-style-type: none">• SAE Level Guidance• Platoon support for automated vehicles <p>Additional Use cases will be defined and added later.</p>
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6.2 SAE Level Guidance (AVG-SAELG)

Type of road network	Interurban Roadways
Type of vehicle	Partly Automated Vehicles (at SAE levels 2,3,4) which are C-ITS connected
Use case introduction AVG-SAELG	
Summary	<p>The purpose of the 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 decrease / increase 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 flows 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 supported by standards and thus are utilized 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"> • Guide and inform vehicles about the road operators assessment of currently unsuitable SAE automation levels in a specific area • Provide detailed geographical information about the area affected as well as information about vehicles affected by this guidance information <ul style="list-style-type: none"> ○ specific road segment ○ specific lane ○ specific vehicle type • Inform vehicles about the start position of the guidance area • Inform vehicles about the end position of the guidance area • Provide additional speed recommendations for the affected road segments and lanes (optionally, if available)
Desired behaviour	<ul style="list-style-type: none"> • Vehicles consider the information in their driving plans (e.g. lane selection) or trajectories • Automated vehicles consider the information in the selection of the level of automation used • Automated vehicle driver/operator is informed about a change in the automation level recommendation from the infrastructure, especially when switching from higher

	<p>to lower levels of automation (reasoning)</p> <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 automated levels in that case, guiding the vehicle to a safe place, ...)</p>
Expected benefits	<p><u>Drivers of conventional vehicles</u></p> <p>Drivers of conventional vehicles experience safer overall traffic conditions if automated vehicles select their level of automation based on the best possible inputs from all sources, including infrastructure.</p> <p><u>Automated vehicles</u></p> <p>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.</p> <p><u>Road operator</u></p> <ul style="list-style-type: none"> • Supports a safer and more gradual introduction of automated driving on specific, C-ITS equipped road segments and/or lanes. • Brings the road operators view on automation into the decision-making process of automated vehicles • Ensures traffic safety and traffic flow efficiency in the transitional phase towards fully automated driving • Reduces costs and congestion related to accidents
Use case description	
Situation	<ul style="list-style-type: none"> • 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 under current traffic conditions • Following changes in traffic and / or driving conditions (as a result of accidents, congestion, weather, etc.), a reassessment of the given advice can occur • If the assessment leads to a change of the guidance information, vehicles and the road users need to be informed • Therefore, the road infrastructure operator distributes an updated and appropriate follow-up message.
Logic of transmission	I2V
Actors and relations	<p>Actors:</p> <ul style="list-style-type: none"> • Road operator – generating the use case information at the TCC, considering all available information for the specific road segment and the overall traffic conditions. • Road users 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)
Scenario	<ul style="list-style-type: none"> • Road operators monitor their road network, derive triggering conditions for the use case and apply them to specific parts of the road network • Scenario 1: 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 of 3 or 4 on lane 2 of the network within a

	<p>certain area, designated by a zone (with start, end and intermediate points)</p> <ul style="list-style-type: none"> • Scenario 2: 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. • 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.
Display / alert principle	<ul style="list-style-type: none"> • 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. • Display 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 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 a change in automation level. • The HMI display sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional Constraints / dependencies	<ul style="list-style-type: none"> • There is a need to display 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. • How the information is presented to the road user is not part of the service description. It is left to the provider of the In-Vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Interoperability Requirements	
Message profile requirements	<ul style="list-style-type: none"> • The IVI message for AVG-SAELG is profiled in chapter 4.2.2.4 of C-Roads, C-ITS Message Profiles [4]. • IVI messages for AVG-SAELG 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. • 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 informs about SAE levels road operators find unsuitable for automated driving on a selected segment, the respective 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.
 - 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
- 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.

Security and data protection requirements

Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].

An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.

This use case is based on "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		SSP value per station type				
	Octet position	Bit position	6 (Bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)
Road Configuration Container	5	1	-	1	-	-	1
Automated Vehicle Container	5	5	-	1	-	-	1

SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type

Communication technology requirements: ITS-G5	<p>is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p> <p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of C-Roads, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on IVIM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none"> • serviceType= AVG-SAELG • messageType = IVIM <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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_GENERIC_ITSG5-IVIM_reference position_01_R2.0.1 ○ TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02_R2.0.1 ○ 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_AVG- GENERIC_ITSG5_IVIM_AutomatedVehicleContainer_55_R2.0.1 • IP-based only: <ul style="list-style-type: none"> ○ 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_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 ○ TC_CROADS_AVG- GENERIC_HYBRID_IVIM_AutomatedVehicleContainer_55_R2.0.1 <p>List of applicable specific test cases:</p> <ul style="list-style-type: none"> • ITS-G5 only: <ul style="list-style-type: none"> ○ TC_CROADS_AVG-SAELG_ITSG5_IVIM_automatedVehicleRules_59_R2.0.1 ○ TC_CROADS_AVG-SAELG_ITSG5_IVIM_allowedSAEAutomationLevels_60_R2.0.1

- Hybrid (IP-based only):
 - TC_CROADS_AVG-SAELG_HYBRID_IVIM_automatedVehicleRules_59_R2.0.1
 - TC_CROADS_AVG-SAELG_HYBRID_IVIM_allowedSAEAutomationLevels_60_R2.0.1

6.3 Platoon Support Information (AVG-PSI)

Type of road network	Interurban roadways with more than one lane
Type of vehicle	Automated Vehicles which are C-ITS connected and want to engage in platooning situations
Use case introduction	
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 their 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 vehicles 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 flows 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 flows 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 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> <p>Further work on 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"> Guide and inform vehicles about the road operators assessment of unsuitability of

	<p>platooning in a specific area</p> <ul style="list-style-type: none"> • Provide detailed geographical information about the area affected as well as information about vehicles affected by this guidance information <ul style="list-style-type: none"> ○ specific road segment ○ specific lanes ○ specific vehicle type • Inform vehicles about the start position of the guidance area • Inform vehicles about the end position of the guidance area • Provide additional guidance in regard to 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) • Provide learning possibilities on automated vehicle guidance using cross sector collaboration
Desired behaviour	<ul style="list-style-type: none"> • Vehicles consider the information in their overall driving plans (e.g., lane selection) or trajectories • Automated vehicles consider the information in their decision to enter, leave or change a platooning situation • The vehicles forming or leaving a platoon perform the desired actions without major disruptions for the other traffic participants. • Platoons are operated on selected lanes only as indicated by the road operators guidance on unsuitability • Automated vehicle drivers/operators are informed about changes in the platooning situation, especially when starting or stopping a platoon or changing its core parameters (reasoning), especially when it requires additional attention from the driver <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	<p><u>Drivers of conventional vehicles</u></p> <p>Drivers of conventional vehicles experience safer overall traffic conditions if automated vehicles base their platooning decisions on the best possible inputs from all sources, including infrastructure.</p> <p><u>Automated vehicles</u></p> <p>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.</p> <p><u>Road operator</u></p> <ul style="list-style-type: none"> • Supports a safer and more gradual introduction of automated driving on specific, C-ITS equipped road segments and/or lanes • Brings the road operators view on platooning into the decision-making process of automated vehicles • Ensures traffic safety and traffic flow efficiency in the transitional phase towards fully automated driving • Reduces costs and congestion related to accidents

Use case description

Situation	<ul style="list-style-type: none"> • 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 • 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 • If the assessment leads to a change of the guidance information, vehicles and the road users need to be informed • Therefore, the road infrastructure operator distributes an updated and appropriate follow-up message.
Logic of transmission	I2V
Actors and relations	<p>Actors:</p> <ul style="list-style-type: none"> • Road operator – generating the use case information at the TCC, considering all available information for the specific road segment and the overall traffic conditions. • Road users 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 of 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)
Scenario	<ul style="list-style-type: none"> • Road operators monitor their road network, derive triggering conditions for the use case and apply them to specific parts of the road network • Scenario 1: The road operator wants to give guidance information that new platooning situations should not be created or existing platooning situations should be dissolved, no matter the SAE Level, due to overall difficult traffic or environmental situations, e.g. in an area with multiple ramps and intersections given high traffic • Scenario 2: Due to road conditions and current traffic on a stretch of the road, guidance information is sent out that certain vehicles 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, designated by a zone (with start, end and intermediate points) • Scenario 3: 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 has to be updated in certain parameters (e.g., length of guidance zone, type of vehicles, affected lanes, level of automation (SAE), ...) • 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.

Display / alert principle	<ul style="list-style-type: none"> 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. Display 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.
Functional Constraints / dependencies	There is a need to display information to the driver if the guidance given leads to a change of the platooning situation or its parameters requiring his reaction within a specific time or position on the network.

Interoperability Requirements

Message profile requirements	<ul style="list-style-type: none"> The IVI message for AVG-PSI is profiled in chapter 4.2.2.4 of C-Roads, C-ITS Message Profiles [4]. 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. 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: <ul style="list-style-type: none"> 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. 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"> Shifting of relevance zone(s) according to subpanel information
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| | <ul style="list-style-type: none"> ▪ 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 <ul style="list-style-type: none"> • 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"> • 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. |
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Security and data protection requirements	<p>Security requirements and specifications of certificates are described in C-Roads, C-ITS Security Requirements and Specifications [2].</p> <p>An overall introduction to the common European trust model is described in C-Roads, C-ITS Security and Governance [3] 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 “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><th></th><th colspan="2">SSP position</th><th colspan="5">SSP value per station type</th></tr><tr><th>CauseCodeType / Container</th><th>Octet position</th><th>Bit position</th><th>6 (Bus)</th><th>9 (trailer)</th><th>10 (special vehicles)</th><th>11 (tram)</th><th>15 (road side unit)</th></tr><tr><td>Road Configuration Container</td><td>5</td><td>1</td><td>-</td><td>1</td><td>-</td><td>-</td><td>1</td></tr><tr><td>Automated Vehicle Container</td><td>5</td><td>5</td><td>-</td><td>1</td><td>-</td><td>-</td><td>1</td></tr></table> <p>SSP value 1 means that an SSP for the specific causeCodeType/container is necessary for implementation of the use case when using a given stationType. SSP value '-' means that the SSP is not necessary, it does not mean that the SSP is forbidden. SSP value per station type is given only as guidance. There is no relation of SSP value and station type in the C-ITS message.</p>		SSP position		SSP value per station type					CauseCodeType / Container	Octet position	Bit position	6 (Bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)	Road Configuration Container	5	1	-	1	-	-	1	Automated Vehicle Container	5	5	-	1	-	-	1
	SSP position		SSP value per station type																														
CauseCodeType / Container	Octet position	Bit position	6 (Bus)	9 (trailer)	10 (special vehicles)	11 (tram)	15 (road side unit)																										
Road Configuration Container	5	1	-	1	-	-	1																										
Automated Vehicle Container	5	5	-	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, C-ITS Roadside ITS G5 System Profile [6] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are allowed and used, the requirements C-Roads, C-ITS Mobile Roadside ITS G5 System Profile [5] shall apply.</p>																																
Communication technology requirements: IP-Based	<p>For IP based implementations of use cases shared using backend communication, the requirements of C-Roads, C-ITS IP Based Interface Profile [7] shall apply.</p> <p>For use cases based on IVIM messages the AMQP filtering tables in chapter 3.3 of [7] shall apply:</p> <ul style="list-style-type: none">serviceType= AVG-PLATSImessageType = IVIM <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. Please be aware that the exact details of specification are defined in chapter 3.3 of [7].</p>																																
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [8] contains the generic applicable framework and process for interoperability testing.</p> <p>List of applicable generic test cases from C-Roads, C-ITS Test Plan [9]:</p> <ul style="list-style-type: none">ITS-G5 only:<ul style="list-style-type: none">TC_CROADS_GENERIC_ITSG5-IVIM_reference position_01_R2.0.1TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02_R2.0.1																																

- 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_AVG-
GENERIC_ITSG5_IVIM_AutomatedVehicleContainer_55_R2.0.1
- 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_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
 - TC_CROADS_AVG-
GENERIC_HYBRID_IVIM_AutomatedVehicleContainer_55_R2.0.1

List of applicable specific test cases:

- ITS-G5 only:
 - TC_CROADS_AVG-PSI_ITSG5_IVIM_platooningRules_61_R2.0.1
 - TC_CROADS_AVG-
PSI_ITSG5_IVIM_allowedSAEAutomationLevels_62_R2.0.1
- Hybrid (IP-based only):
 - TC_CROADS_AVG-PSI_HYBRID_IVIM_platooningRules_61_R2.0.1
 - TC_CROADS_AVG-
PSI_HYBRID_IVIM_allowedSAEAutomationLevels_62_R2.0.1

7 Probe Vehicle Data (PVD)

7.1 Probe Vehicle Data service introduction

Service introduction PVD	
Summary	<p>The 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 road user via the in-vehicle system.</p> <p>This service description specifies the requirements of V2I PVD service from the perspective of the road operators and the service providers active in C-Roads. V2V service requirements are out of the scope of this description.</p> <p>Since the PVD service provides data that can be related to the vehicle/road user (e.g., location data), it creates concerns about the traceability of the vehicle/road user 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 road user using the service and the other road users concerned by the data in compliance with the GDPR. This specification adopts the current view of C-Roads as detailed in the 'Data Protection in C-ITS' memo [14] prepared by C-Roads WG1.</p>
Background	<ul style="list-style-type: none"> • Today's vehicles know at any time their own position, speed and 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. • These data can be used by the road operator to get a more comprehensive knowledge of the road network (especially in areas not equipped with road sensors, such as loop detectors, CCTV etc.). • These data can also be used to enhance the road operator's knowledge of events, complementing road sensors, patrol and other existing sources.
Objective	<p>The objective of this service is to collect data from vehicles and/or road users 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"> • to improve knowledge of traffic conditions, traffic flow and incidents, • to improve knowledge of road and weather conditions, • to improve existing traffic management operations, • to enable innovations in traffic management and safety operations, • to improve or enable I2V use cases, • to improve traffic management strategies and policies (e. g., through exploitation of new information), and • for statistical and modelling purposes (e.g., digital twin).
Expected benefits	<p>Expected benefits of the PVD service include, but are not limited to:</p> <ul style="list-style-type: none"> • faster, more accurate and more efficient event detection on the road network, • improved network operations and event management, • improved safety of public road users, • improved air quality and environmental performance, • enhanced road network and event impact knowledge, • a possible cost reduction of the installation and maintenance of event detection infrastructure, and • new or enhanced C-ITS services:

	<ul style="list-style-type: none"> • Location-based provisioning of C-ITS messages/services by service providers • (Centralised) collision risk warning or signal violation warning • Optimisation of signalized intersections • (Dangerous) End of queue warning • Extreme weather warning • Travel time estimation and information • Hazardous Location Notification
Use cases	<p>The PVD V2I use cases are:</p> <ol style="list-style-type: none"> 1. PVD - Vehicle Data Collection (PVD-VDC) 2. PVD - Event Data Collection (PVD-EDC) <p><i>Note the current description reflects the view and requirements of C-Roads members and probably will be updated/enhanced following the discussion other stakeholders e.g., C2C-CC.</i></p>

7.2 PVD Use Cases

7.2.1 PVD - Vehicle Data Collection (PVD-VDC)

Type of road network	All
Type of vehicle	All C-ITS equipped vehicles
Use case introduction PVD – VDC	
Summary	<p>Vehicle data are sent out automatically 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.</p> <p>Editor's note: The following provides C-Roads expectations (requirements) for vehicle data that need to be collected from vehicles on public road networks by road operators and service providers for traffic management operations applications. The intention here is to identify such requirements from C-Roads members and discuss & agree on them with the relevant stakeholders, e.g., C2C-CC to make sure those data will be made available by vehicles/data providers and understood by road operators in an interoperable and harmonised way.</p>
Background / added values	Vehicle data is a first-hand or original source of traffic information for road operators and service providers. The 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 can be used to improve traffic management and safety operations, generate traffic information and enable new services for road users by the road operators and service providers.
Objective	The objective of this use case is to collect data from the vehicles on the public road network to improve traffic management and safety operations for road users.
Expected vehicle data for traffic management operations	<p>The following vehicle data are expected by the road operators from the vehicles on their road network in (near) real time for improving traffic management and safety operations:</p> <ul style="list-style-type: none"> • Timestamp • (Temporary) Station ID • Vehicle location (geo location coordinates with confidence level) • Station type • Vehicle role • Speed • Heading • Vehicle length • Vehicle width <p>The following vehicle data may also be useful for traffic management applications if the vehicle C-ITS stations can provide them (e.g., by connecting to the vehicle CAN bus):</p> <ul style="list-style-type: none"> • Longitudinal acceleration • Drive direction • Yaw rate • Light/siren bar status (TBD e.g., for emergency vehicles) • Exterior light status (TBD e.g., for detecting visibility conditions)
Expected benefits	See PVD service introduction

Situation	The V-ITS-S equipped 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"> The vehicle driver may need to give consent for automatic sharing of vehicle data with the road operator or the service provider. The V-ITS-S sends out vehicle data as a C-ITS message regularly. The road operator collects and processes vehicle data and may share processed data with other road operators and service providers for improving traffic management and safety operations. The service provider collects and processes vehicle data and may share processed data with the road operators and other service providers for improving traffic management and safety operations. The Traffic Management Centre (TMC) uses the (processed) data/information of the vehicles on the road network for improving traffic management and safety operations for road users.
Scenario	<ol style="list-style-type: none"> The driver may provide consent via an activation switch of the vehicle's C-ITS station to share vehicle data with the road operator or the service provider for improving traffic management and safety operations on the public road network. The V-ITS-S automatically generates and sends out vehicle data as C-ITS messages. 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 or aggregated or anonymised by the R-ITS-S before forwarding them to the Central C-ITS Station (C-ITS-S). The R-ITS-S or service provider may forward vehicle data/information to the C-ITS-S. The C-ITS-S may process the vehicle data. The C-ITS-S may forward (processed) vehicle data/information to the TMC (or to other service providers). 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.
Display principle / Alert logic	An indication of vehicle data transmission or consent status may be presented on the HMI. No other alert or information needs to be presented on the HMI.
Key issues, dependencies and assumptions	<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> <ol style="list-style-type: none"> Compliance to GDPR and national regulations: <ul style="list-style-type: none"> anonymisation of personal information for private vehicles anonymisation of personal information for operator/special purpose vehicles -when and how to track road operator vehicles and other special vehicles Dependencies: <ul style="list-style-type: none"> sufficient penetration of vehicles equipped with C-ITS

	<ul style="list-style-type: none"> • willingness of road users to share vehicle data (i.e., sending out CAM to the road operators and/or service providers) • trust level of road operators and service providers <p>(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</p> <p>(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)</p> <p><u>Note this document does not specify how to be compliant with the GDPR and national regulations. Please refer to WG1 work on this issue.</u></p>
Expected usage of collected vehicle data by the road operator / service provider	
Introduction	Among the C-Roads road operators the following common usages of vehicle data have been identified for improving traffic management operations.
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"> - number of vehicles - average speed - average speed per vehicle type/class - (average) length of the vehicles on the road - classification (data per vehicle type) of vehicles on the road - minimum and maximum speeds <p>during a specified interval e.g., 1 min, 5 min, 30 min, 1 hour.</p>
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 optimize 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"> - acceleration/deceleration - speed and direction - number of vehicles with headlights on - number of vehicles with daytime running lights on - number of vehicles with fog lights on - specific vehicle roles (for e.g., emergency vehicle warning) - positions of start and/or end of congested areas or queues - positions of stationary vehicles

Travel time 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>
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>
Measures taken currently by the C-Roads pilots towards GDPR compliance	
Introduction	<p>The following measures are implemented by the C-Roads pilots for complying with the GDPR and their local legislation. The measures listed below only reflect the position of the individual member states that implemented these measures.</p> <p>Note - there is no certainty or consensus in C-Roads at the moment that the approach taken in individual member states is the exact formula that needs to be adopted in all member states to guarantee compliance with GDPR. The measures listed below are only examples of practical experience so far, obtained in individual pilots through proactive interaction with the corresponding national privacy authorities before the start of the actual deployments.</p>
User consent	<p>User consent is obtained to collect and process vehicle data for specific purposes.</p> <p>For example, in the long-range C-ITS deployments in The Netherlands (Talking Traffic), and Flanders (Mobilidata), the following approach has been adopted in terms of making sure that the user consent is formally enforced on every actor in the deployment that receives the raw PVD data (e.g. CAM message): for communicating PVD-VDC data using public IP-based network/s, the road authority/operator needs to have an agreement with the respective OEM, or Service Provider (SP) in terms of interoperability, security and privacy requirements.</p> <p>To avoid that the road authority/operator needs to arrange user consent with individual clients (vehicles, smartphones) on the road to handle their personal data (i.e., GDPR relevant data), anonymisation of PVD-VDC use case data shall be performed before sharing it with the road authority/operator by the respective OEM's/SP's backend system that already has the user's consent in place.</p> <p>If a road authority/operator wants to share/republish the received PVD to other parties, the road authority/operator also needs to have an agreement with the other parties to make sure that the original agreement between the road authority/operator and the respective OEM or SP is also respected by the other parties (i.e., receivers).</p>
Changing the frequency of authorisation tickets change	<p>For calculating travel times a lower frequency of changing authorisation tickets in vehicles would be desirable. The exact range needs to be confirmed by pilot implementations but will be in the dimension between 4 to 8 minutes travel time, or between 5 and 10 km travelled distance on motorways.</p>
Anonymisation of personal data before processing	<p>Generally, it supports the minimum availability of personal data in C-ITS stations, if the principle is applied that for every C-IST 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.</p> <p>Secondly for calculating average values for traffic related analysis of parameters out of C-IST messages a minimum number of valid values per selected time period shall be applied, (in some cases this minimum number is 8 values) in order to prevent that from the average calculated value it is possible to estimate or argue about single traffic participants.</p>

C-Roads expectations with regards to interoperability requirements	
Introduction	The following provides interoperability and harmonisation requirements of C-Roads for implementation of 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 requirements	<p>Sender should comply to L1 or L2 specifications in the CPOC protocol.</p> <p>Receiver 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 in [2].</p>
Message profile requirements	<p>Case 1: Ordinary vehicles that are equipped with C-ITS stations covered by C2C-CC Basic System Profile (BSP)</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 Appendix A.</p> <p>Editor's note:</p> <p>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.</p> <p>Case 2: Special purpose vehicles that are equipped with C-ITS stations covered by C-Roads Specifications</p> <p>The CAM profile for special purpose vehicles that are covered by C-Roads spec. is provided in chapter 4.2.5 of C-Roads C-ITS Message Profiles.</p>
Communication technology requirements: short-range (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 shall comply with the C2C-CC Basic System Profile (BSP).</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 the C-Roads C-ITS Infrastructure Mobile ITS-G5 System Profile (MSP).</p>
Communication technology requirements: Long-range	<p>Back end (IP based):</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 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 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 in Chapter 3.3 of C-ITS IP Based Interface Profile shall apply: serviceType = PVD-VDC messageType = CAM</p>

7.2.2 PVD - Event Data Collection (PVD-EDC)

Type of road network	All
Type of vehicle	All C-ITS equipped vehicles
Use case introduction PVD – EDC	
Summary	<p>The driver may provide consent to share event data from the vehicle. The in-vehicle system (i.e., V-ITS-S) sends out event data that was detected by the vehicle itself or manually by the road user. Road users 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 road users to improve traffic management and safety operations on the public road network.</p> <p>Editor's note:</p> <p>The following provides C-Roads expectations (requirements) for event data that need to be collected from vehicles and road users on public road networks by road operators and service providers for traffic management operations applications. The intention here is to identify such requirements from C-Roads members and discuss & agree on them with the relevant stakeholders, e.g., C2C-CC to make sure those data will be made available by vehicles/data providers and understood by road operators in an interoperable and harmonised way.</p>
Background	<ul style="list-style-type: none"> • 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.). • Some events may not be detected automatically by the vehicle itself (e.g., animal on the road, unmanaged blockage of road, etc.). • The road user may also visually detect some events (e.g., animal on road) and report them to the road operator or service provider via in-vehicle system. • A maintenance worker or road operator personnel can be seen as specific type of road users, 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 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 road users, that 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 road users on their road network in (near) real time for improving traffic management and safety operations</p> <ul style="list-style-type: none"> ○ Temporary slippery road ○ Stationary vehicle ○ Vehicle breakdown ○ Vehicle in accident ○ Reduced visibility ○ Emergency brake ○ End of queue ○ Extreme weather conditions ○ etc.
Desired behaviour	<ul style="list-style-type: none"> • In the automatic event detection and reporting case, no specific behaviour is expected from the road users (i.e., the driver) for whom the operation of the service is totally invisible unless the HMI is programmed to display the events declared by the in-vehicle system (choice of the OEM). • In the manual event reporting case, the road user needs to be able to detect and report the event safely and quickly if allowed by the national regulation/law. • 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 & 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.
Expected benefits	See the PVD service introduction
Situation	A vehicle is driving along the road. A vehicle or a road user 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"> • The V-ITS-S gathers event data automatically from the vehicle's sensors and sends out event data. • The road user may also manually declare specific events or feedback via the HMI of the V-ITS-S. • The road user is the owner of the information and might need to give consent for automatic sharing of event data by the V-ITS-S. • The road operator collects and processes the event data from vehicles and may share processed data/information regarding the event with other service providers for improving traffic management and safety operations. • 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. • The TMC uses the (processed) data/information regarding the event for traffic management and safety operations as well as to communicate with public road users.
Scenario	<ol style="list-style-type: none"> 1. Either the V-ITS-S automatically gathers event data from vehicle sensors/embedded technologies or the road user visually detects an event (or the absence of an event) and reports it via the HMI of the V-ITS-S. 2. The V-ITS-S automatically generates and sends out event data as a C-ITS message. 3. The R-ITS-S or the service provider collects the event data sent out by the vehicles. 4. The collected data from the vehicles may be anonymised or aggregated by the R-ITS-S before forwarding them to the Central ITS Station (C-ITS-S). 5. The R-ITS-S or service provider may forward event data/information to the C-ITS-S. 6. The C-ITS-S may process the event data. 7. The C-ITS-S may forward (processed) event data/information to the TOC (or to other service providers). 8. The TMC (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 road users 9. 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.
Display principle / alert logic	<p>When a road user manually reports 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 road user. No alert or information will be displayed on the vehicle's HMI unless the HMI is programmed to display the events declared by the vehicle automatically (choice of the OEM).</p>
Key issues, Constraints / dependencies	See PVD-VDC

	<p>Additionally:</p> <p>In the manual reporting case: the road user should be able to safely report the event on the HMI (manual reporting is not permitted while driving in some member states).</p>
C-Roads expectations with regards to interoperability requirements	
Introduction	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.
Security requirements	All incoming C-ITS messages should be verified according to Annex B in [2].
Message profile requirements	TBD
Communication Requirements – short-range (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 shall comply with the C2C-CC Basic System Profile (BSP).</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 the C-Roads C-ITS Infrastructure Mobile ITS-G5 System Profile (MSP).</p>
Communication technology requirements: Long-range	TBD

8 References

#	Reference
[1]	C-Roads, Introduction to the C-Roads WG2 Deployment Documentation and Requirements, latest release
[2]	C-Roads, C-ITS Security Requirements and Specifications, latest release
[3]	C-Roads, C-ITS Security and Governance, latest release
[4]	C-Roads, C-ITS Message Profiles, latest release
[5]	C-Roads, C-ITS Infrastructure Mobile ITS G5 System Profile, latest release
[6]	C-Roads, C-ITS Roadside ITS G5 System Profile, latest release
[7]	C-Roads, C-ITS IP Based Interface Profile, latest release
[8]	C-Roads, C-ITS Cross-Border Testing and Validation Concept, latest release
[9]	C-Roads, C-ITS Test Plan, latest release
[10]	C-Roads, C-ITS Cross-Border Testing: PCAP Exchange Specification, latest release
[11]	ETSI TS 103 301 V2.1.1 (2021-03) - Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services
[12]	ETSI TR 102 638 V1.1.1 (2009-06) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions
[13]	C-ITS Platform Final report, (2016-1)
[14]	C-Roads, C-ITS Privacy – Concluding Memo V1.0 (2021)

9 Annex PVD

9.1 Annex PVD-VDC

The following table provides CAM DFs and DEs that are expected from ordinary vehicles (i.e., the vehicles covered by the C2C-CC BSP) on the road network by C-Roads members for traffic management operations applications. The CAM DFs and DEs are based on the ETSI standard EN 302 637-2 V1.4.1 (2019-04).

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	curvatureCalculationMode	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	rsuContainerHighFrequency	DF (container)	N/A	N/A	
4.0	lowFrequencyContainer	DF (container)	Optional	YES	
4.1	basicVehicleContainerLowFrequency	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	specialVehicleContainer	DF (container)	Optional	N/A	
5.1	publicTransportContainer	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	

9.2 Annex PVD-EDC

TBD