C-ITS Infrastructure Functions and Specifications

C-ROADS Platform

Working Group 2 Technical Aspects

Taskforce 3 Infrastructure Communication

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Acronyms

A	Applications layer
ABT	Arrow Board Trailer
AG	Amsterdam Group
CA	Cooperative Awareness
CAM	Cooperative Awareness Message
CITSC	C-ITS Corridor
C-ITS-S	Central ITS Station (the so-called Scoop@F platform)
CRW	Collision Risk Warning
CT	Container
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
F	Facilities Layer
GN	Geo Network Layer
GNSS	Global Navigation Satellite System
HF	Header Field
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). ITS-G5 refers to the approved amendment of the IEEE 802.11 (standard IEEE 802.11p). This technology (possibly others) uses the 5.9 GHz frequency band to support safety- and non-safety ITS applications. In this document ITS-G5 stands for IEEE802.11p/ETSI ITS-G5.
ITS	Intelligent Transport Systems
ITS-S	ITS Station
ITSS-VG	ITS-S in a road operator mode
IVI	In-Vehicle Information
IVIM	Infrastructure to Vehicle Information Message
IVI service	Infrastructure to Vehicle Information (IVI) service
IVS	In-Vehicle Signage
km	kilometre
m	metre
MAPEM	MAP (topology) Extended Message
ms	millisecond
MS	Member State
OBU	On Board Unit
OHLN	Other Hazardous Location Notifications
OSI	Open Systems Interconnection model

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P	Parameter
PDU	Protocol Data Unit
R-ITS-S	Roadside ITS Station (the so-called RSU or ITS-S R in the French terminology)
RSP	ITS-G5 Roadside System Profile (abbreviated as Roadside System Profile or Infrastructure Profile)
RWW	Roadworks Warning
s	seconds
SAP	Service Access Point
SCT	Sub-Container
SDU	Service Data Unit
SP	Service Primitive
SPATEM	Signal Phase And Timing Extended Message
SREM	Signal Request Extended Message
SSEM	Signal request Status Extended Message
T	Transport
TCC	Traffic Control Centre

N/A	*Not Applicable*

Glossary

Use case	Denotes a procedure of executing an application in a particular situation with a specific purpose [24] e.g. is RWW, IVS and CRW.
Use case scenario	Denotes a more specific way to execute a use case, e.g. the stand-alone mode of Roadworks Warning in case of safety trailers failing to connect to the centre. As another example, in the C-ITS Corridor terminology, “TCC-triggered RWW” denotes a use case scenario to implement RWW use case based on TCC data only.

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Introduction

Being a part of Intelligent Transport Systems, cooperative ITS (**C-ITS** or cooperative systems) encompass a group of technologies and applications that allow effective data exchange through wireless communication technologies between components and actors of the transport system, very often between vehicles (vehicle-to-vehicle or V2V) or between vehicles and infrastructure (vehicle-to-infrastructure or V2I).

The deployment of C-ITS is an evolutionary process that will start with the less complex use cases. These are referred to as "Day-1-services", encompassing messages about traffic jams, hazardous locations, road-works and slow or stationary vehicles, as well as weather information and speed advises to harmonise traffic. Using probe vehicle and infrastructure-related data, all C-ITS services shall be transmitted directly into the vehicles in a way that allows users to get informed but not distracted.

C-ROADS is a platform of Member States working on the deployment of harmonised and interoperable C-ITS services in Europe. The C-ROADS Platform will pursue cooperation among Member States for issues related to the deployment of C-ITS, such as sharing experiences and knowledge or user acceptance.

This document defines the common base for the ITS-G5 functional and technical specifications. The specification targets the communication between **roadside units and vehicles**. The communication directions derived from this are also known as **I2V** (Infrastructure-to-Vehicle) and **V2I** (Vehicle-to-Infrastructure) communication.

Thus, note that the interfaces between the following units are not included in the current release of this specification:

- Roadside and centres (R2C and C2R)
- Roadside and web services (R2W and W2R)
- Vehicles and vehicles (V2V)

Since this document focuses more on the technical specifications of supported C-ROADS use cases (day-1 services) according to the list of the final C-ITS Platform report [2], another document (Roadside ITS-G5 System Profile) [3] defines the requirements of the Infrastructure Roadside System Profile (RSP). The Infrastructure Roadside System profile references to this document frequently.

This document is structured into three sections:

- Section 1 defines verbal forms and provisions
- Section 2 lists the functional description of supported use cases and scenarios (from AT, DE, FR and NL)
- Section 3 provides the technical specifications of the supported use cases, including triggering conditions.

Section 3 will include also the security and management entity related specifications. Nevertheless, these will not be handled fully in this release.

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1 Provisions

1.1 Verbal forms for the expression of provisions

In this document, the following verbal forms are used to indicate requirements:

Shall / Shall not

Recommendations shall be indicated by the verbal forms:

Should / Should not

Permissions shall be indicated by the verbal forms:

May / May not

Possibility and capability shall be indicated by the verbal forms:

Can / Cannot

Inevitability used to describe behavior of systems beyond of the scope of this deliverable shall be indicated by:

Will / Will not

Facts shall be indicated by the verbal forms:

Is / Is not

1.2 Provisions from referenced documents

Normative requirements included in the referenced documents supporting the required functionality of the ITS system shall apply. The verbal forms for the definition of provisions of referenced documents are defined either inside the particular document or generally by the respective SDO (= standards developing organization) or the organization providing them.

When the requirements defined in the standards - also in the standard profiles - and published by various organizations stand in conflict or contradict the requirements specified inside this document, the ones in the referenced documents shall always outweigh the requirements specified inside this document.

1.3 Multiplicity and Usage

The multiplicity of elements is denoted 0 (not used), 0..1 (for optional), 1 (for mandatory).

In case the multiplicity in this profile is stricter than in the original standard, the original multiplicity is written in brackets in the line below. Example for an optional element, which became mandatory in this profile:

1

[0..1]

The usage contains information on the particular use of the DE/DF in the scope of the ITS-G5 Roadside System profile. This may contain restrictions regarding value / lexical space in case of DEs (e.g. if only a subset of possible values in used). The usage may contain definitions of DE/DF in accordance with corresponding standards. Table 3 and Table 9 provide general usage information of message sets, while Table 1, Table 6, Table 8 and Table 10 provide details of use case specific's usage information.

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2 System Services

2.1 5.8 GHz DSRC / 5.9 GHz C-ITS Coexistence System Service

2.1.1 Functional description

The Coexistence use case is a system use case. In contrast to e.g. RWW or IVI, this use case is used to ensure that the system functions properly.

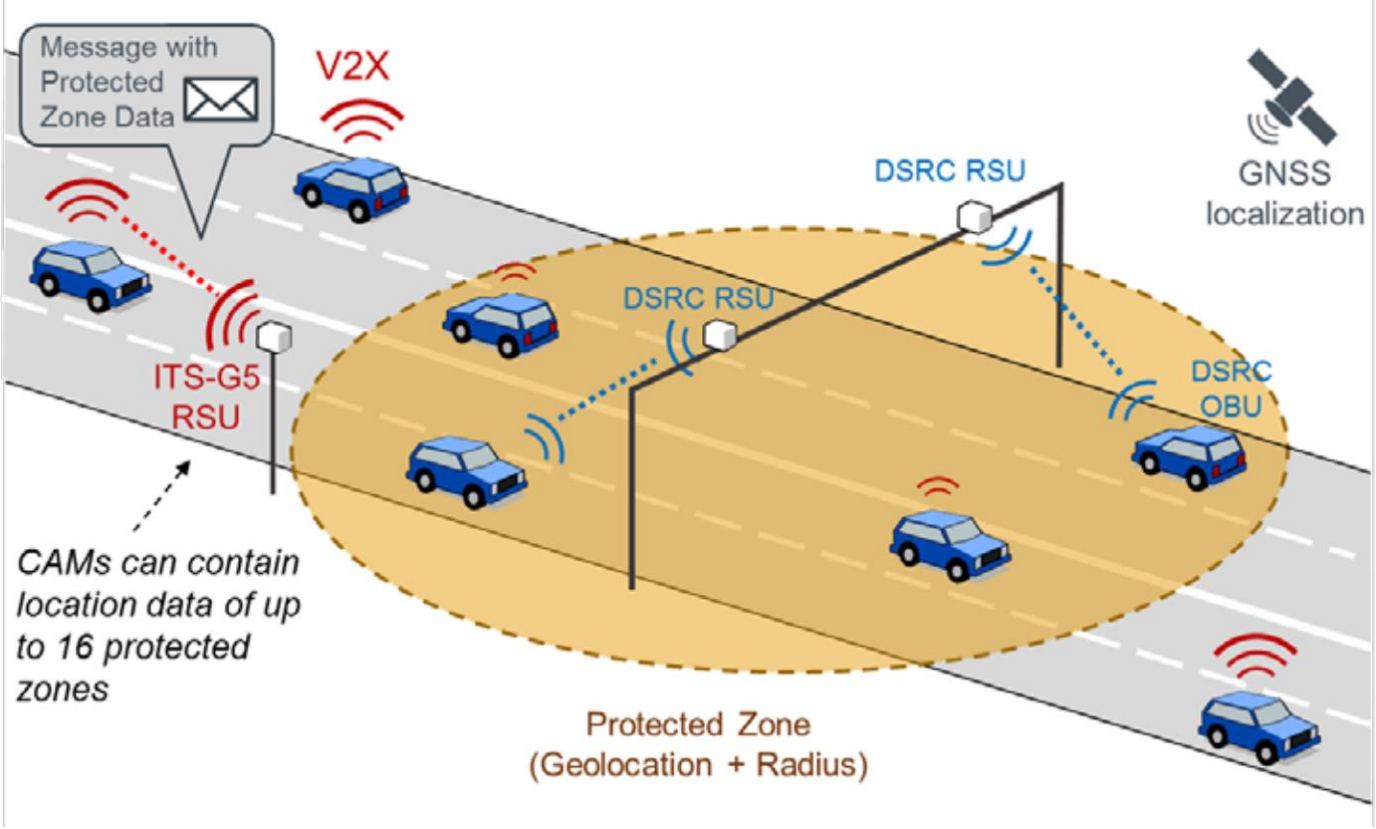

Figure 1 Example of coexistence between ITS-G5 and CEN-DSRC

The new cooperative ITS-G5 systems (V2V and V2I communication) use a dedicated frequency band around 5.9 GHz. The installed CEN-DSRC road toll systems operate within the 5.8 GHz frequency band. Due to the neighbourhood of the two frequency bands potential interference may occur.

In the last years experts from several countries conducted several studies and set up specialist task forces at ETSI and defined new mitigation techniques to prevent radio interference from future ITS-G5 stations towards installed CEN-DSRC tolling systems. CEN-DSRC Systems are already installed in many countries (e.g. Austria, France, Czech Republic, Poland as main technology, e.g. in Germany for enforcement). Since the ITS-G5 technology will be introduced into the market in the next years, the goal is to protect the operation of the existing tolling systems and at the same time allow communication via ITS-G5. The implementation of mitigation techniques in an ITS-S is mandatory as defined in the harmonized standard for ITS-G5 communication, see Ref. [25].

Two main techniques have been identified to mitigate interference:

- Limiting the ITS-G5 transmit power level
  - In band transmit power level
  - Out of band unwanted emission power density
- Restricting the ITS-G5 transmission duty cycle

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- Transmission time (Ton) – an ITS-S is allowed to transmit for at most this time span
- Idle time (Toff) – an ITS-S is not transmitting within at least this time span

In the vicinity of a tolling station an ITS-S operates in a “coexistence mode” and applies one or both of the above techniques. Four coexistence modes (Table 5.3 in Ref. [15]) describe the allowed combination of transmit power limit and duty cycle restriction.

An ITS-S operating with the default transmit power of 23dBm has to apply a duty cycle restriction if it is not lowering its transmit power within a protected zone (coexistence modes C+D). In this case the ITS-S has to wait at least for a certain idle time (Toff) between transmissions, where the idle time depends on the transmission time (Ton) and the number of other ITS stations in the vicinity.

For the default ITS-G5 transmit power level of 23 dBm the default protection radius is 55 m to each CENDSRC RSU. This protection radius and the geographic position of the CEN-DSRC RSU define the protected zone around a CEN-DSRC RSU. Outside this protected zone no mitigation methods are necessary. The actual protection radius applied by an ITS station is the result of the radius specification and the radius adaption:

1. Radius specification: In a first step, for each CEN-DSRC station the protection radius is specified. The default is 55 m for a single CEN-DSRC RSU. Higher protection radii are used, if multiple CEN-DSRC RSU locations (e.g. toll plazas) are covered by a single protected zone definition, see Ref. [15] , Clause 5.3.2.
2. Radius adaption: ITS-G5 stations apply the radius, if they use the default 23 dBm transmit power and their unwanted emissions in the CEN-DSRC frequency range is at most -33 dBm/MHz EIRP. Higher and lower transmit powers result in an increased or decreased radius applicable by the respective ITS station, according to Table 5 in Ref. [15].

Protected zone detection: Vehicle ITS stations have to detect whether they are within a protected zone and activate a coexistence mode if necessary. A protected zone in the case of a toll station consists basically of the following parameters:

- Center of protected zone (GNSS position of CEN-DSRC RSU or toll station)
- Radius of protected zone for the default ITS-G5 transmit power level of 23 dBm (distance from center of tolling station, where the coexistence mode shall apply)

There are three basic strategies for protected zone detection, which apply to vehicle ITS stations:

1. Vehicles are equipped with a protected zone detector and detect protected zones cooperatively:

   A hardware detector installed in the front of the vehicle or using the ITS-G5 antenna is continuously monitoring the 5.8 GHz frequency band to detect a CEN-DSRC tolling signal. When a tolling signal is detected, the vehicle ITS station switches to coexistence mode. Furthermore, it broadcasts a protected zone information via ITS-G5 to the surrounding vehicles using the CAM protocol. The CAM includes a protected zone center position given by the geographic location of the vehicle at detection time. Approaching vehicles (without a hardware detector) that receive such CAM trigger the coexistence mode based on the contained information (cf. strategy c below).

2. Vehicles use an on-board protected zone database:

   A protected zone database with GNSS information (WGS841 coordinates) containing the locations of the protected zones and their protection radii for the default ITS-G5 transmit power level is stored in the V-ITS-S. This concept requires provision of a protected zone database by the motorway operator(s) and the installation of a local copy in the V-ITS-S by the manufacturer.

3. Vehicle gets information about protected zones via ITS-G5:

   Protected zone information of new or temporary toll stations as well as CEN-DSRC enforcement vehicles, which are not contained in the protected zone database, can be disseminated via ITS-G5 using the CAM protocol (see Ref. [12]). Such CAMs are broadcasted by an ITS-S installed at the roadside or in the enforcement vehicle. CAMs can contain up to 16 protected zone records. Since the protected zone information is geo-referenced, the sender (R-ITS-S) does not need to be co-located with the CEN DSRC toll station. As an example, it is possible to broadcast protected zone information from the roadside several hundred meters ahead of the next CEN-DSRC toll gantry.

This document describes only option 3.

Fixed ITS stations do not need to use the same detection method as mobile ITS stations. For fixed stations located within a protected zone, the coexistence mode can be configured at installation time in the following way: If the fixed ITS station can be synchronized with CEN-DSRC system it never transmits within a CENDSRC uplink or downlink window, then the ITS station can operate in normal mode. Otherwise, it has to apply a coexistence model.

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2.1.2 Scenarios

For the ECo-AT and Scoop@F projects, basic coexistence scenarios with focus on the motorway are investigated. The goal is to enable successful coexistence between the installed CEN-DSRC road side units with ITS-G5 communication stations integrated in fixed R-ITS-Ss (mounted on a gantry), mobile stations (mounted on a trailer) and vehicles and trucks. ITS-G5 stations integrated in personal phones are not considered within Eco-AT and Scoop@F wave 1.

Using the default ITS-G5 transmit power level, a coexistence scenario occurs in the vicinity of a CEN-DSRC tolling zone (usually within 55 m radius to the CEN-DSRC RSU – see Figure 2). There are three basic scenarios which may cause interference problems to CEN-DSRC tolling systems: V-ITS-S vehicles in tolling zone, R-ITS-S installed on a CEN-DSRC gantry and R-ITS-S installed in the area of a CEN-DSRC gantry. More information about these scenarios can be obtained in [11].

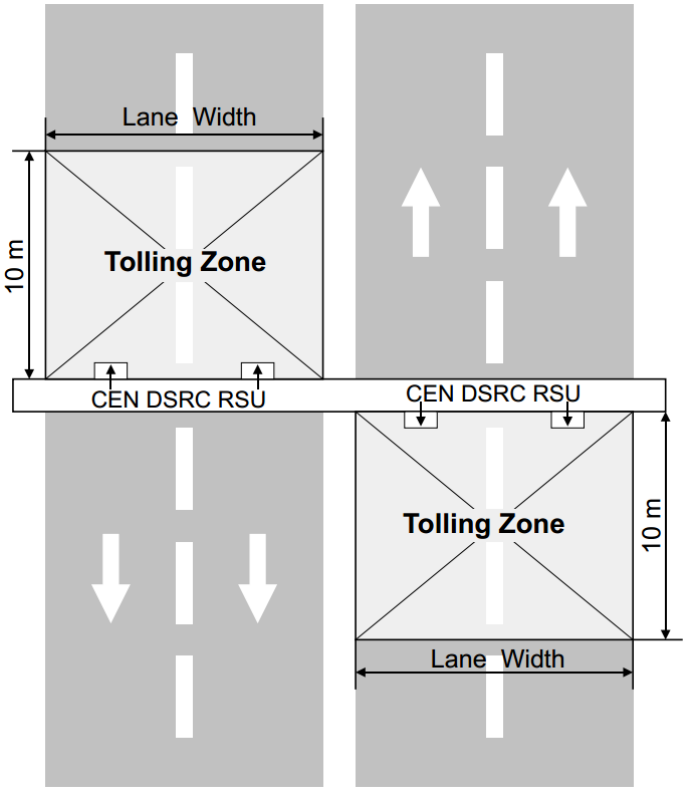

Figure 2 CEN-DSRC tolling zone

2.2 Technical specifications / triggering conditions

2.2.1 Service definition and message content of CA basic service

The CA basic service is a Facilities layer entity that operates the CAM protocol [12]. It provides two services: sending and receiving CAMs. CAM is a Message Set which creates and maintains awareness among ITS-Ss within its vicinity area (direct communication range).

The CA basic service uses the services provided by the protocol entities of the ITS networking & transport layer to disseminate the CAM.

Due to the specificity of this use case, the data elements in the HighFrequencyContainer and the DF rsuContainerHighFrequency, which are used, are considered.

It is mandated to implement mitigation techniques in every ITS-S as defined in ETSI 302 571. The Coexistence specific usage of CAM data elements is defined in Table 1. Note that the CAM message set in this I2V document is used only in the "coexistence" system use case and only for stationary R-ITS-S, and only CAM elements that are actually used for this use case are denoted there.

The ITS PDU header shall be as specified in ETSI TS 102 894-2 [12]. Detailed data presentation rules of the ITS PDU header in the context of CAM shall be as specified in annex B of [12].

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ECo-AT specified this use case, while Scoop@F stated that the implementation of the CAM protocol should make use of the data frame ProtectedCommunicationZonesRSU. This DF is part of a French tailored solution for service advertisement based on the use of a “CAM Infrastructure (CAM-I) message”[20].

Table 1 CAM elements specific to Coexistence use case

Name	Type	Multi.	Common Usage	Specific Usage
HighFrequency-Container	**CT**	**1**		
ProtectedCommunicationZonesRSU	DF	0..1	Optional	
zoneType	DE	1	This DE is sent by TCC regardless of use cases scenarios. In Ref. (ETSI 102 894-2) [16] only the value "0" for cenDsrcTolling is defined	
expiryTime	DE	0..1	This DE is sent by TCC regardless of use cases scenarios. Example: The value for timestampIts for 2007-01-01T00:00:00.000Z is 94 694 401 000 milliseconds, which includes one leap second insertion since 2004-01-01T00:00:00.000Z.	
Latitude	DE	1	This DE is sent by TCC regardless of use cases scenarios.	
Longitude	DE	1	This DE is sent by TCC regardless of use cases scenarios.	
Radius	DE	1	This DE is sent by TCC.	*AT* The default value of radius is set to 55m. Note: The “radius” data element is optional in the ETSI ITS Common Data Dictionary, Ref. (ETSI 102 894-2) [16], but mandatory in ECo-AT.
Id	DE	0..1	optional	
Interval	DE	0..1	This DE is sent by C-ITS-S.	

For the values of the service parameters see C-ROADS, Roadside ITS G5 System Profile, Release 1 [3].

2.2.2 Operational specifications / triggering conditions

2.2.2.1 The principles of CAM transmission conditions

AT

The information about protected zone around a CEN-DSRC is provided by the TCC, distributed by the C-ITS-S to selected R-ITS-S and broadcasted to V-ITS-S using the CAM protocol.

ECo-AT has identified a set of use case scenarios and associated mitigation techniques, see ECo-AT SWP3.5 Coexistence [11]. The following use case scenarios (among others) identified by ECo-AT are relevant:

1. R-ITS-S installed on a CEN-DSRC gantry (not applicable if synchronized with the tolling station)

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2. R-ITS-S installed in the area of a CEN-DSRC gantry (not applicable, if it is not possible to use a directional antenna that meet the requirement in clause 4.2 in (see Ref. [15]))
3. Enforcement vehicles, temporary tolling stations and new tolling stations

Type of messages: CAM activation “new” and CAM termination, with information about CAM generation frequency.

FR

The triggering conditions are not specified in the reference documents, it is left to the road operator to do so.

Table 2 CAM service primitives for Coexistence

Name	AT	FR
CAM Trigger	Triggered centrally by TCC via C-ITS-S	Not specified
CAM Termination	not used	
CAM generation frequency (default if not specified: 1s)	-	

2.3 Other system services

There are currently no other system services.

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3 Technical specifications / triggering conditions

This chapter defines technical and operational specifications of the infrastructure use cases, in line with their functional description in C_ROADS_WG2_TF2_Service Descriptions v1.1 [35]. For the current release, those definitions and rules have been considered that have been specified and tested in the context of the C-ITS Corridor (NL, DE, AT), the French Scoop@F project or the InterCor project (BE(Fla), FR, NL, UK). This selection has been taken based on maturity consideration, i.e. only specifications that have been implemented and tested in the field can be considered for this document.
This chapter is structured into four subsections:

- Subsection 3.1 is based on following facilities layer service definitions based on the ETSI ITS station reference architecture / ITS-S host [14] and the facilities layer protocols and communication requirements for infrastructure services [17]:
    - Decentralized Environmental Notification basic service (DEN) [13],
    - Infrastructure to Vehicle Information (IVI) service [17].

  This section provides the content profiles of the corresponding message sets (DENM and IVIM). If necessary, the description is divided into a general part and variations received from different countries. Besides the profiles of data elements and data frames used from the respective message sets, the tables in this section also include relevant service parameters from the respective Facilities layer services.
- Subsection 3.2 provides operational specifications of the supported use cases, including their triggering conditions. Service parameters of the respective Facilities layer services not mentioned in this document have default values regardless of use case, scenario or national implementation (such general parameters are defined in chapter 3 of the Roadside ITS-G5 System Profile [3]). This section also contains choices and parameters of lower layer services (in particular the transport and network layer services and parameters), as far as they are relevant for the use cases addressed.
- Subsection 3.3 and subsection 3.4 are reserved for specifications regarding the security and management entities in later revisions.

In the context of a layered communication stack, the message sets handled in this document are Facilities layer PDUs that are exchanged between ITS-Ss. The payload is generated by ITS applications in the transmitting ITS-S or other connected ITS-S (e.g. a C-ITS-S) and passed to the Facilities layer via service access points. Beyond the payload, these service access points may include further parameters to control the handling and transmission of the payload (service parameters). At the receiving ITS-S, the messages are forwarded to applications or connected ITS-S by forwarding mechanisms.
Once message transmission is triggered, the Facilities layer services may be configured to repeat the transmission, until the applications request its termination or trigger another request to generate an updated message.

3.1 Service definition and message content

3.1.1 DEN Basic Service

“The DEN basic service uses the services provided by the protocol entities of the ITS networking & transport layer to disseminate DENM” (ETSI 302 637-3) [13].

“A DENM contains information related to an event that has a potential impact on road safety or traffic condition. An event is characterised by an event type, an event position, a detection time and a time duration. These attributes may change over space and over time” (ETSI 302 637-3) [13]. The DENM transmission may be independent from the originating ITS-S in some situations.

Four types of DENMs are generated by the DEN basic services:

- **new** DENM,
- **update** DENM,
- **cancellation** DENM and

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- **negation** DENM.

New and **update** DENM are being used by all national specifications; the **cancellation** DENM is not always used. **Negation** DENM is never used. A common mechanism of terminating an event is sending a **cancellation** DENM by the originating ITS-S. The type of the DENM to be generated depends on the type of the application request.

The header of DENM shall be as specified in the data dictionary ETSI TS 102 894-2 [16]. Detailed data presentation rules of the ITS PDU header in the context of DENM shall be as specified in clause B.1 of [16].

3.1.1.1 DENM general elements

DENM data elements, DENM data frames and service parameters shall be used according to the definitions in Table 3.

Table 3 DENM elements in general

Name	Type	Mult.	Common Usage	Specific Usage
Management Container	CT	1		
actionId	DF	1	Mandatory **Content**: The actionID is the unique identifier of a DENM and consists of the data elements originatingStationID and sequenceNumber. originatingStationID is the unique identifier of the ITS-S whose facility layer created the message, which may be either the C-ITS-S or the R-ITS-S. If not set by the C-ITS-S, messages whose content is generated centrally but who are broadcasted from different R-ITS-Ss will have different originatingStationIDs, resulting in different actionIDs. If the originatingstationID and sequenceNumber is given by the C-ITSs in case of centrally generated content that is (potentially) sent out via multiple R-ITS-S, then the system provides the same actionID for all messages relating to the same event, regardless which R-ITS-S is sending out the message. Once the actionID is set, it will not change for messages relating to the same event, even if they are frequently updated. **Value**: not pre-defined, set by system (consistent with standard)	*AT* The sequenceNumber itself is derived out of the source DATEX II from the TCC, thus making an event traceable from the Source DATEX II to the destination DENM.
detectionTime	DE	1	Initially this DE shall be set to the time the event was detected. The time shall come from a local time source in the R-ITS-S in case of stand-alone use cases. In case of use cases with connection to the C-ITS-S, the detectionTime shall initially be set to the time that the application, that creates the DENM, receives the relevant information, i.e. the moment a roadwork or a hazardous location starts / is detected at a functional level.	*BE(Fla), FR, NL, UK* repetitionDuration equal to validityDuration. repetitionInterval between 0.25 and 1 sec *AT* **Moving and Stationary Standalone RWW**: detectionTime will come from local time source of R-ITS-S, set upon system activation.

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Table 3 DENM elements in general

Name	Type	Mult.	Common Usage	Specific Usage
			Two event update policies can be used by the road operator. The road operator can choose: - Either a short period of validity of events (e.g. 10 seconds) and updates until the end of the event. Note: Risk during a communication break between the ITS station and the TCC, the event may no longer be sent. - Either a validity period over the entire duration of the event (e.g. 24 hour) and a termination in the event of an end of the event. Note: Risk in case of communication failure with the TCC to send information on an event if it is completed earlier than expected. **Value:** detectionTime is initially set at the start time of the event (new DENM) then reset for each DENM update. For the DENM termination, this DE shall be the time at which the termination of the event is detected	**Augmented and TCC Triggered RWW, OHLN:** detectionTime will be set based on C-ITS-S system time when it receives the event information from the TCC. Will be updated using the DENM update mechanism whenever the event changes according to the TCC or after half of validityDuration for this use case (720s / 2 = 360s) has passed, for as long as the event is indicated valid from the TCC, after which it will time out.
referenceTime	DE	1	**Content:** Following the DENM standard, the referenceTime shall be set to the time the DENM message is generated or updated. referenceTime is set by the C-ITS-S or R-ITS-S depending on the scenario, for example by the R-ITS-S for Standalone RWW and by the C-ITS for other RWW and OHLN scenarios **Value:** Set automatically	
termination	DE	0..1	See 3.2.1.1 (RWW) and 3.2.1.2 (OHLN)	
eventPosition	DF	1	In the I2V use cases, the DF eventPosition is used to locate lane or carriageway blockings or hazardous locations. It represents the position where the physical blockage on the lane (including hard shoulder) or the carriageway or the hazardous location starts. In case of blockages by trailers, it depends on the Member State (MS) whether the blockage is the trailer or a cone.	See use case specific parts in the following subsections.
relevanceDistance	DE	0..1	Optional	See use case specific parts in the following subsections.

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Table 3 DENM elements in general

Name	Type	Mult.	Common Usage	Specific Usage
relevanceTrafficDirection	DE	1 [0..1]	**Content:** Fixed value. For highways this value is set to upstream traffic. This DF indicates for which traffic direction the message is relevant (from the perspective of the eventPosition). **Value:** Set to upStreamTraffic (1).	
validityDuration	DE	1	**Status:** Mandatory Events are represented by DEN messages. The duration of a singular DENM is based on the (configurable) value of “validityDuration”. As long as an event is valid for the road operator, it will be continuously sent out (using DENM repetition) and updated (using DENM update, renewing "validityDuration", "detectionTime" and "referenceTime" in the process). Message update will be triggered by "validityDuration" falling below a certain (also configurable) threshold. If the event is no longer valid, it is either timing out or being actively cancelled (DENM cancellation). **Content:** The DE validityDuration is set to a fixed value. **Value:** Set by application.	*AT, DE* AT is only using DENM repetition and DENM update. DENM update is triggered after half of "validityDuration" has passed. Events no longer valid are no longer updated and therefore timing out. DENM cancellation or negation are not used. Default values for "validityDuration" are 20s for Standalone RWW and 720s for all other RWW scenarios and OHLN. Details in 3.2.1.1 (RWW) and 3.2.1.2 (OHLN). *BE(Fla), FR, NL, UK* See section 3.2.1.1 (RWW) and 3.2.1.2 (OHLN)
TransmissionInterval	DE	0 [0..1]	Not used	
stationType	DE	1	**Content:** Fixed value, set to 15 (roadSideUnit). This is true for both fixed R-ITS-S and portable R-ITS-S. Can be 9 (trailer) or 10 (specialVehicles) in case of road operator vehicles. **Value:** Set to 9 or 10 or 15.	
Situation Container	CT	1 [0..1]		
informationQuality	DE	1	There are two visions to fulfill in this data element in accordance with the standard. There should be a harmonization with C2C-CC.	*Scoop@F* Based on the three-level quality scale of DATEX II:

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Table 3 DENM elements in general

Name	Type	Mult.	Common Usage	Specific Usage
				Q1 = risk, Q2 = probable or Q3 = certain With a table of correspondence between the 3 DATEX levels and the 8 InformationQuality levels. See also use case specific part in the following subsections. *Defined by Amsterdam Group* Minimum combinations that needs to be fulfilled: planned (1) in case traces AND event position are planned by a road operator simple GNSS (2) in case simple GNSS is used for traces AND event position differential GNSS (3) in case differential GNSS is sued for traces AND event position validated positions (4) in case of map matched traces AND map matched event position system approved (5) in case of (4) in addition with event automatically approved by traffic / road works management system operator approved (6) in case of (4) in addition with event manually approved by a traffic / road works management system (0) and (7) are not defined For further details, see [1] chapter 6.2
eventType	DF	1	Combination of DE causeCode and DE subCauseCode. See use case specific parts in the following subsections.	See use case specific parts in the following subsections
linkedCause	DF	0..1	Possibility to link the current message to a set of causeCode / subCauseCode (similar to eventType) to provide further information	*AT* linkedCause is used for OHLN. linkedCause is not used for the RWW use case because messages belonging together are linked with the more detailed "referenceDenm" data frame from the roadworks container. *DE, BE(Fla), NL, UK* Not used *FR* Used for RWW
eventHistory	DF	0..1	**Content:** This profile optionally uses this DE when the endpoint of the physical blockage can be determined. If so, it describes the start of a blockage to the end of the blockage, or to the start of a new blockage (another DENM).	*AT* eventHistory in AT is a full history of the event (using equidistant points) from the eventPosition to the end of event. Default point distance is 50m but can increase if events are longer than 1150m due to the restriction of maximum 23 points in the eventHistory. Points are placed in the middle of the carriageway"

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Table 3 DENM elements in general

Name	Type	Mult.	Common Usage	Specific Usage
				Standalone & Augmented RWW, OHLN (point events) Not used. **TCC Triggered RWW, OHLN (events with extension)** Used. *DE* Not used for Day 1 *BE(Fla), FR, NL, UK* see InterCor M03 Upgraded Specifications ITS G5 v1.1 [36]
Location Container	CT	0..1		
eventSpeed	DF	0..1	This DF will not be provided in case of a static event and be provided, when the event is moving.	
eventPosition Heading	DF	0..1	Optional data element with different usage within C-ROADS, details can be found in the "specific usage" column	*AT* AT considers the trace the only element for determining message relevance and will only provide eventPositionHeading in case of a moving event position. If a different approach towards an event is possible, either an additional trace or a separate message altogether will be provided. *FR* FR will always provide this element for determining message relevance in case the trace is not matching: as long as the approach angle is only deviating +/- 30 degrees maximum from the message heading, the message should be considered valid for the vehicle. FR should provide the heading of the carriageway at the eventPosition.
traces	DF	1	The first trace point in the message is the point closest to the event position. This point is positioned in the middle of the lane or carriageway upstream from the event position, taking into account the curvature of the road. This point is coded as an offset delta position with regard to the event position. Additional trace points are defined as offsets or delta positions with respect to their previous trace points. The trace points will be listed in upstream order, thus also defining the event heading. Up to seven traces can be present	*DE* RWW: Always set by the R-ITS-S on the roadworks trailer. *AT* Mandatory in AT profile. **TCC Triggered RWW, OHLN:** Generated in the TCC via precise map matching of event location information (potentially originating from a trailer) and provided to the C-ITS-S. The data frame shall consist of at least 10 data elements of

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Table 3 DENM elements in general

Name	Type	Mult.	Common Usage	Specific Usage
				type pathPoint with a steady distance of 50m. **Augmented RWW** Based on uplink information from R-ITS-S **Standalone RWW** Generated in R-ITS-S or trailer (without any manual interaction; GNSS required). *BE(Fla), FR, NL, UK* **Content:** The first trace point is the point closest to the event position. This point is positioned in the middle of the lane or the carriageway if possible as far as possible upstream from the event position, taking into account the curved road. This point is coded as an offset delta position with regard to the event position. Additional trace points are defined as offsets or delta positions with respect to their previous trace points. The trace points will be listed in upstream order, thus also defining the event heading. The last trace point is preferably at least 1.5 km upstream of the event position. Additional trace points are also positioned in the middle of the lane or the carriageway. **Value:** Set by application
roadType	DE	0..1	Optional	
Alacarte Container	CT	0..1		
lanePosition	DE	0..1	Optional	See use case specific parts in the following subsections.
impactReduction	DF	0 [0..1]	Not used	
externalTemperature	DE	0 [0..1]	Not used	
lightBarSirenInUse	DE	0 [0..1]	Not used	

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roadWorks	closedLanes	DF	0..1	Optional	See use case specific parts in the following subsections.
	restriction	DF	0 [0..1]	Not used.	
	speedLimit	DE	0..1	Optional	See use case specific parts in the following subsections.
	incidentIndication	DF	0 [0..1]	Not used.	
	recommendedPath	DF	0..1	Optional	See use case specific part in the following subsections.
	startingPointSpeedLimit	DF	0..1	Optional	See use case specific part in the following subsections.
	trafficFlowRule	DE	0..1	Optional	See use case specific part in the following subsections.
	referenceDenms	DF	0..1	Optional	See use case specific part in the following subsections.
positioningSolution		DE	0..1	Not used for I2V, but may be used for V2V by road operator vehicles.	
stationaryVehicle		DFSCT	0 [0..1]	Not used in Day 1. (Might be used for equipped pre-warners in future)	

Table 4 Service Parameters associated with DEN Basic Service

Service Parameters			
Name	**Type**	**Layer**	**Value**
repetitionDuration	P	F	Equal to the value of data element ValidityDuration. Note: Shall be discussed with other stakeholders.
repetitionInterval	P	F	See use case specific part in the following subsections. Note: Shall be discussed with other stakeholders.
itGnLocalAddrConMethod	P	GN	Use case and country specific.
LifeTime	HF	GN	Use case and country specific.
Flags	HF	GN	Use case and country specific.
Country Code	HF	GN	Use case and country specific.
Other parameters	-	All	See the Roadside ITS-G5 System Profile [3].

3.1.1.2 Roadworks Warning (RWW)

This section provides an overview of short-term Roadworks Warning use cases supported by C-ROADS countries. Use cases, which require the application of multiple message types, e.g. IVIM, MAPEM and DENM for long-term RWW, are currently not covered.

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Table 5 RWW use case scenarios

Use Case	Scenarios	Austria [AT]	Germany [DE]	France [FR]	Netherlands [NL]	Spain [ESP]
Closure of part of a lane, whole lane or several lanes	TCC Triggered	Yes	No	Yes	Yes	Yes
	Standalone	Yes	Yes	Yes	No	No
	Augmented	Yes	Yes	No	No	No
Alert planned closure of road or a carriageway	TCC Triggered	Yes	No	Yes	Yes	Yes
	Standalone	Yes	Yes	No	No	No
	Augmented	Yes	Yes	No	No	No
Alert planned road works – mobile	TCC triggered	No	No	Yes	Yes	Yes
	Standalone	Yes	Yes	Yes	No	No
	Augmented	No	Yes	No	No	No

The RWW specific usage of DENM data elements and DENM data frames is defined in Table 6.

Table 6 DENM elements specific to RWW

Name	Type	Mult.	Common usage	Specific Usage
	CT	1	**Management Container**	
eventPosition	DF	1	**Content:** DENM messages focus on the safety related aspects. DENMs thus primarily communicate the position of obstacles. Within this RWW profile it has therefore been decided to define the event position as the point where a lane (including the hard shoulder) is physically blocked (e.g. by a sign, trailer, cone, etc.). The accuracy should be on the level of a lane, but shall at least be on the accuracy level of the carriageway. Altitude and confidence DEs are currently not used and thus set to the values corresponding with 'unavailable'. **Value:** Set by application.	*AT* **Standalone and Augmented RWW:** The position of the trailer. The position of the trailer. **TCC Triggered RWW** The position of the cone. *DE:* The position of the trailer.
relevanceDistance	DE	0..1		*AT* A default value of lessThan5km (5) is used. *DE* The fields relevanceDistance and ValidityDuration contain fixed values for the trailers. Nevertheless, they shall be set by the C-ITS-C in order to enable the values to be changed during trial operation. *BE(Fla), FR, NL, UK:* Not used.

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Table 6 DENM elements specific to RWW

Name	Type	Mult.	Common usage	Specific Usage
Situation Container	CT	1 [0..1]		
informationQuality	DE	1	**Content:** It can be set to 0 – 7 depending on the country providing it. **Value:** Set by application.	*AT* **Standalone RWW** (2) for simple GNSS or (3) for differential GNSS. **Augmented and TCC Triggered RWW** (4). *DE* **Standalone RWW** (2) for simple GNSS or (3) for differential GNSS. **Augmented RWW** (4), (5) or (6).
causeCode	DE	1	**Status:** Profiled **Content:** Fixed value. The causeCode is set to 3 (road works). **Value:** Set to 3	

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Table 6 DENM elements specific to RWW

Name	Type	Mult.	Common usage	Specific Usage
subCauseCode	DE	1	0 is used for unknown **Alert planned road works – mobile:** 3	*AT* **Alert planned road works – mobile:** • Stand-alone RWW: 3 (or 0 if the R-ITS-S has difficulties identifying the movement) **Closure of part of a lane, whole lane or several lanes:** • TCC Triggered RWW: 0,1,2,4,5 • Augmented RWW: 4 (or 0 if the R-ITS-S has difficulties identifying stationary use) • Stand-alone RWW: 4 (or 0 if the R-ITS-S has difficulties identifying stationary use) **Alert planned closure of road or a carriageway:** • Stand-alone, Augmented and TCC triggered RWW: 1 *DE* Stand-alone for every use case: 0 **Alert planned road works – mobile:** • Augmented: 3 **Closure of part of a lane, whole lane or several lanes:** • Augmented: 4 **Alert planned closure of road or a carriageway** • Augmented: 4 *FR* **Alert planned road works – mobile:** • Stand-alone RWW: 3 **Closure of part of a lane, whole lane or several lanes:** • TCC Triggered RWW: 0 **Alert planned closure of road or a carriageway** • 1

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Table 6 DENM elements specific to RWW

Name	Type	Mult.	Common usage	Specific Usage
Alacarte Container	CT	0..1		
lanePosition	DE	0..1		*AT* **Augmented RWW** Only used if upstream information from R-ITS-S is available. **Moving and Stationary Standalone RWW** Used for optional inclusion of pre-warner; to be set hardShoulder (0) to indicate, that the pre-warner is located on the hard shoulder (default value in Day 1). *DE* Not used *BE(Fla), FR, NL, UK* **Status:** Optional **Content:** Position of the eventPosition on lanes. **Value:** Set by application.

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Table 6 DENM elements specific to RWW

Name	Type	Mult.	Common usage	Specific Usage
closedLanes	DF	0..1	With the current CDD version 1.2.1, the CDD [16] holds the following definition of the drivingLaneStatus data element: `DrivingLaneStatus := BIT STRING {` `  outermostLaneClosed(1),` `  secondLaneFromOutsideClosed(2)` `} (SIZE (1..14))”` A lane is counted from outside boarder of the road. It is assumed that the first bit (LSB, the bit on the right) is a ‘don’t care’ (dc) bit. The value for the outermost driving lane (lane 1) is encoded by the second bit of drivingLaneStatus and so on. All lanes are encoded. The bit string has a constant length, trailing zeros are not omitted. ETSI change request 7296 was initiated to remove the need for the ‘don’t care’ bit by changing the DrivingLaneStatus element. Once the next version of the CDD (1.3.1) is published, the ‘don’t care’ bit will no longer be necessary and the ordering of lanes will reversed: a lane will no longer be counted from outside boarder of the road but from inside border of the road excluding the hardshoulder.	*AT, DE* Optional. It’s usage depends on the particular use case scenario: **Standalone RWW** Not used. **Augmented (AT: and TCC Triggered) RWW** provided by the TCC as precise as possible if the information is available. *BE(Fla), FR, NL, UK* **Status:** Optional **Content:** In case of a ‘plusstrook’, an extra narrow lane on the left side, that lane is always included with the correct status set (0=open or 1=closed) in drivingLaneStatus. In case of a hard shoulder temporarily used as a normal lane (also known as ‘hard shoulder running’), the hard shoulder shall be included as a regular lane in drivingLaneStatus if it is in use. If this lane is in use, hardShoulderStatus shall, since the hard shoulder as such no longer exists, not be used. If available, it is valid only at the eventPosition.
speedLimit	DE	0..1		*AT* **Moving and Stationary Standalone RWW** Not used. **Augmented and TCC Triggered RWW** Used if the information is available. *DE* Not used *BE(Fla), FR, NL, UK* **Status:** Optional **Content:** It is the lowest speedLimit at the eventPosition. **Value:** Set by application.

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Table 6 DENM elements specific to RWW

Name	Type	Mult.	Common usage	Specific Usage
recommendedPath	DF	0..1		*FR* Optional *AT, BE(Fla), DE, NL, UK* Not used
startingPointSpeedLimit	DF	0..1		*AT* **Moving and Stationary Standalone RWW** Not used. **Augmented and TCC Triggered RWW** Used if the information is available. *BE(Fla), FR, NL, UK* **Status:** Optional **Content:** This point is on the accuracy level of a carriageway. It is only used when the starting point is different than the eventPosition. **Value:** Set by application.
trafficFlowRule	DE	0..1		*AT* **Standalone RWW** either passToRight(2) or passToLeft(3) **Augmented RWW** The C-ITS-S shall set that information, if available from uplink information from R-ITS-S. *DE* noPassing (0), noPassingForTrucks(1), passToRight (2) oder passToLeft (3) This DE will always be set by the R-ITS-S. *BE(Fla), FR, NL, UK* **Status:** Optional **Content:** passToLeft (3) or the passToRight (2). Values 0 and 1 indicating passage rules are not used. **Value:** Set to 2 or 3 when used.

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Table 6 DENM elements specific to RWW

Name	Type	Mult.	Common usage	Specific Usage
referenceDenms	DF	0..1	RWW DENMs belonging to the same roadwork situation will be linked in the C-ITS-S by listing all actionIDs belonging together in the referenceDenms data element of each message	*AT* **Moving and Stationary Standalone RWW** Not used. **Augmented and TCC Triggered RWW** Used if the information is available. *BE(Fla), FR, NL, UK* Optional

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Table 7 Service parameters associated with DEN Basic Service with national choices

Service Parameters					
Name	**Type**	**Layer**	**AT**	**DE**	**NL**
repetitionInterval	P	A or F	*Standalone RWW* 500 milliseconds. *Augmented and TCC Triggered RWW* 1000 milliseconds	200 milliseconds	Between 250 and 1000 milliseconds.
repetitionDuration	P	A or F	-	Not mentioned in the German specification	Equal to validityDuration
Life Time	HF	GN	-	Not mentioned in the German specification -	-
itsGnMaxGeoAreaSize	P	GN	-	Not mentioned in the German specification	Managed (1)
Flags	HF	GN	*Standalone RWW* Mobile (1) *Augmented and TCC Triggered RWW* Stationary (0)	Not mentioned in the German specification -	This parameter is Stationary (0) for R-ITS-S.
Country Code	HF	GN	232	Not mentioned in the German specification -	-

3.1.1.3 Other Hazardous Location Notifications (OHLN)

The following use case scenario description is derived from [6].

In the C-ITS-S, event information from the TCC is mapped to DENM and forwarded to geographically relevant R-ITS-S and sent out via ITS-G5. V-ITS-S driving through the coverage area of a relevant R-ITS-S receives these DENMs.

The specific usage of DENM data elements and DENM data frames is defined in Table 8. Service parameters are as in the use case RWW (see Table 7).

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Table 8 DENM elements specific to Other Hazardous Location Notifications (OHLN)

Name	Type	Use	Common Usage	Specific Usage
Management-Container	**CT**	**1**		
eventPosition	DF	1		*AT* TCC will deliver the exact position of the hazardous location, which can directly be used in the information processing chain downwards. TCC will however not deliver altitude information, as there is no data source of sufficient quality. *FR* In the case of ITSS-VG “operator mode”, it is set to the position of the vehicle in case of the following use case scenarios “temporarily slippery road” and “end of queue”. Otherwise, this value is not available. TCC Triggered scenario (via Scoop@F platform (C-ITS-S), the position is given by the TCC for all use cases scenarios (temporarily slippery road, animal or people on the road, obstacle on the road, breakdown vehicles, accident area, reduced visibility, unmanaged blockage of a road, exceptional weather conditions and end of queue). *NL* DENM messages focus on the safety related aspects. DENMs thus primarily communicate the position of obstacles. Similar to RWW, this will for this use case be the point where a lane is physically closed and thus the position of the traffic inspector's vehicle. The accuracy shall be on the level of a lane (not carriageway). For this use case this will generally be the hard shoulder. Value: Set by application. deltaAltitude and positionConfidenceEllipse are not used and thus set to the values corresponding with unavailable.
relevanceDistance	DE	0..1		*AT* lessThan5km (5) *FR, NL* Not Used
Situation Container	CT	1 [0..1]		

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Table 8 DENM elements specific to Other Hazardous Location Notifications (OHLN)

Name	Type	Use	Common Usage	Specific Usage
informationQuality	DE	1		*AT* Set to validated positions (4) *FR* Same as in 3.1.1.1 (RWW use case) *NL* simple GNSS (2) and differential GNSS (3) are used. See also Table 3.
eventType	DF	1	• causeCode 1 subCauseCode 0 (traffic condition) • causeCode 2 subCauseCode 0-5, 7 (accident) • causeCode 6 subCauseCode 0-9 (adhesion) • causeCode 9 subCauseCode 0, 1, 4, 5, 7 (surface condition) • causeCode 10 subCauseCode 0-5 (obstacle on the road) • causeCode 11 subCauseCode 0, 2, 4 (animal on the road) • causeCode 12 subCauseCode 0-2 (human presence on the road) • causeCode 14 subCauseCode 2 (wrong way driving) • causeCode 15 subCauseCode 0 (rescue and recovery work in progress) • causeCode 17 subCauseCode 1, 2, 4 (extreme weather condition) • causeCode 18 subCauseCode 0-6 (visibility) • causeCode 19 subCauseCode 0, 1 (Precipitation) • causeCode 26 subCauseCode 1, 3 (slow vehicle)	*AT* • causeCode 1 subCauseCode 0 (Traffic condition) • causeCode 2 subCauseCode 0,1,3,4,5 (Accident) • causeCode 6 subCauseCode 4-6 (Adverse weather condition - adhesion) • causeCode 9 subCauseCode 0 (Hazardous location - Surface condition) • causeCode 10 subCauseCode 1,4 (Hazardous location - Obstacle on the road) • causeCode 11-12 subCauseCode 0 (Animal or human presence on the road) • causeCode 13 subCauseCode 0 (Wrong way driving) • causeCode 15 subCauseCode 0 (Rescue and recovery work in progress) • causeCode 17 subCauseCode 1-2 (Adverse weather condition – extreme weather condition) • causeCode 18 subCauseCode 1 (Adverse weather condition - visibility) • causeCode 19 subCauseCode 1 (Adverse weather condition - precipitation) • causeCode 26 subCauseCode 3 (Slow vehicle) • causeCode 94 subCauseCode 2 (Stationary vehicle) • causeCode 99 subCauseCode 0 (Dangerous situation) *ESP* • causeCode 1 subCauseCode 0 (Traffic jam) • causeCode 2 subCauseCode 0, 7 (Accident) • causeCode 6 subCauseCode 0-8 (Adhesion) • causeCode 9 subCauseCode 0, 1, 5 (Surface Condition) • causeCode 10 subCauseCode 0-5 (Obstacle) • causeCode 11 subCauseCode 0, 2, 4 (Animal) • causeCode 12 subCauseCode 0-2 (Human presence) • causeCode 17 subCauseCode 1 (Extreme weather condition)

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Table 8 DENM elements specific to Other Hazardous Location Notifications (OHLN)

Name	Type	Use	Common Usage	Specific Usage
			• causeCode 27 subCauseCode 0 (Dangerous end of queue) • causeCode 94 subCauseCode 0, 2 (Stationary vehicle) • causeCode 95 subCauseCode 0, 2 (Emergency vehicle approach) • causeCode 97 subCauseCode 1 (collision risk) • causeCode 99 subCauseCode 0, 1 (dangerous situation)	• causeCode 18 subCauseCode 0-6 (Visibility) • causeCode 19 subCauseCode 1 (Precipitation) • causeCode 94 subCauseCode 0, 2 (Stationary vehicle) • causeCode 95 subCauseCode 0 (Emergency vehicle approach) • causeCode 99 subCauseCode 1 (Dangerous situation) *FR* • causeCode 2 subCauseCode 0-5, 7 (Unprotected accident area) • causeCode 6 subCauseCode 0-9 (Temporarily slippery road) • causeCode 9 subCauseCode 0, 1, 4, 5, 7 (Unmanaged blockage of a road) • causeCode 10 subCauseCode 4 (Obstacle on the road) • causeCode 11-12 subCauseCode 0 (Animal or person on the road) • causeCode 14 subCauseCode 2 (Wrong way driving) • causeCode 15 subCauseCode 0 (Rescue and recovery work in progress) • causeCode 17 subCauseCode 1, 4 or causeCode 19 subCauseCode 1 (Exceptional weather conditions) • causeCode 18 subCauseCode 0, 5 (Reduced visibility) • causeCode 26 subCauseCode 1 (Slow vehicle) • causeCode 27 subCauseCode 0 (End of queue) • causeCode 94 subCauseCode 0, 2 (Breakdown vehicles) • causeCode 95 subCauseCode 2 (Emergency vehicle approaching) • causeCode 99 subCauseCode 1 (Dangerous situation) *NL* causeCode set to 97 subCauseCode set to 1
Other DFs / DEs			All other DFs and DEs are the same as specified in the general table (Table 3).	*AT* Use case scenario: Augmented and TCC Triggered RWW *FR* Use case scenario: ITSS-VG “operator mode”

Service Parameters
See the service parameters in the use case of RWW.

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3.1.2 Infrastructure to Vehicle Information (IVI) Service

“IVI service is one instantiation of the infrastructure services to manage the generation, transmission and reception of the IVIM messages. An IVIM supports mandatory and advisory road signage such as contextual speeds and road works warnings. IVIM either provides information of physical road signs such as static or variable road signs, virtual signs or road works” (ETSI 103 301) [17].

The I-VI service instantiated in an ITS-Station shall provide either the transmission or the reception service.

Four types of IVIMs are generated by the IVI services:

- **new** IVIM
- **update** IVIM
- **cancellation** IVIM and
- **negation** IVIM.

“The type of the IVI to be generated upon an application request" (ETSI 103 301) [17].

The header of IVIM shall be as specified in the data dictionary ETSI TS 102 894-2 [16].

The data elements of the IVIM message payload are defined in CEN ISO/TS 19321 [18].

Data elements, data frames and service parameters shall be used according to the definitions in tables Table ***9*** and Table ***10***.

Table 9 IVIM elements in general

Name	Type	Multi.	Common Usage	Specific Usage
IVI ManagementContainer		1		
serviceProviderId	DE	1	It identifies the organisation that provided the IVI, containing a country code according to ISO 3166-1 and ISO 14816 and a provider identifier.	
iviIdentificationNumber	DE	1	This DE is the identifier of the IVI Structure, as assigned by the Service Provider. This component serves as the ID of the message per serviceProvider and can be used by other related messages as a reference.	
timestamp	DE	1 [0..1]	This DE is the timestamp representing the time at which the IVI message is generated or when the last content change of the messages had occurred.	
validFrom	DE	1 [0..1]	This component may hold the start time of the validity period of the message. If start time is unknown to the system, validFrom is not present or equal to timestamp.	
validTo	DE	1 [0..1]	End time of the validity period of the message duration.	
connectedIviStructures (1..8)	DE	0..1	This component holds a list of other iviIdentificationNumbers identifying other IVI messages.	*AT, FR* Not used
iviStatus	DE	1	This component holds the status of the IVI Structure. This can be set to; new (0), update (1), cancellation (2) or negation (3). Is used for message handling.	
Geographic Location	CT	1 [0..1]		
referencePosition	DE	1	**Under SCT: Common Location** This component provides a reference Position for the definition of a zone.	

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Table 9 IVIM elements in general

Name	Type	Multi.	Common Usage	Specific Usage
referencePositionTime	DE	0 [0..1]	Not used.	
referencePositionHeading	DE	0..1	Optional data element with different usage within C-ROADS, details can be found in the "specific usage" column.	*NL* Effective direction of applicability of the sign at the Reference Position, indicating the traffic direction *FR* FR will always provide this element for determining message relevance in case the detectionZone is not matching: as long as the approach angle is only deviating +/- 30 degrees maximum from the message heading, the message should be considered valid for the vehicle.
referencePositionSpeed	DF	0 [0..1]	Not used.	
zoneId	DE	1	Identifier of the definition of the zone. Up to 32 IDs can be defined within one IVI structure. There shall be at least 1 zone (e.g. the detection zone).	
laneNumber	DE	0..1	Mandatory if single lanes are described in this location container. Default is absent (no lane information).	*FR* Not used
zoneExtension	DE	0 [0..1]	Not used.	
zoneHeading	DE	0 [0..1]	Not used	
zone	DF	1 [0..1]	Definition of a zone using the DF Zone consisting of the choice DF Segment, DF PolygonalLine or DF computedSegment. C-ROADS will use the Segment option : with PolygonalLine as a line (constructed with deltaPosition as for DENM traces) and with laneWidth optionally (only used when a single lane is referenced within the zone).	
IVI Application Container	CT	1 [0..1]		
detectionZoneIds	DE	1 [0..1]	List of Identifier(s) of the definition(s) of the Detection Zone(s), using the DE Zid (1..8)	
its-Rrid	DF	0 [0..1]	Not used.	
relevanceZoneIds	DE	1 [0..1]	List of Identifier(s) of the definition(s) of the Relevance Zone(s), to which the IVI Container applies, using the DE Zid (1..8)	
direction	DE	1 [0..1]	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction.	

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Table 9 IVIM elements in general

Name	Type	Multi.	Common Usage	Specific Usage
driverAwarnessZoneIds	DE	0 [0..1]	Not used.	
minimumAwarenessTime	DE	0 [0..1]	Not used.	
applicableLanes	DE	0..1	List of identifiers of the lane(s) to which the IVS Container applies using the DE LanePosition (1..8).	
iviType	DE	1	Provides the type of IVI (e.g. immediate danger message, regulatory message, traffic information message) to allow for classification and prioritization of IVI at the receiving ITS-S.	
iviPurpose	DE	0 [0..1]	Not used.	
laneStatus	DE	0..1	Indicates the lane status (e.g. open, closed, mergeR) of the applicableLanes.	*FR* Not used
completeVehicleCharacteristics	SCT	0..1	CompleteVehicleCharacteristics shall contain the definition of the characteristics of the vehicles to which an Application Container is applicable. The component "train", if present shall contain the characteristics applicable to the entire vehicle train.	
driverVehicleCharacteristics	DE	0 [0..1]	Not used.	
layoutId	DE	0 [0..1]	Not used.	
preStoredLayoutId	DE	0 [0..1]	Not used.	
roadSignCodes	DF	1 [0..1]	It shall contain the definition of the road sign code. It allows different options pointing to different pictogram catalogues. This component specifies which road signs are applicable for a Relevance Zone. Road sign codes are dependent on the referenced classification scheme. A sending ITS-S should select the road sign from a catalogue which is known to be supported by a receiving ITS-S. Additional attributes to the road sign code can be added as provided by the options. List of 1..4 of RSCode	
RSCode	DF	1	It contains layoutComponentId and a code.	
layoutComponentId	DE	0 [0..1]	This data frame can be used to associate RSCode to the layout component of referenced layout.	
code	DE	1	For signcoding the ISO/TS 14823 [23] shall be used.	
ISO14823Code	DF	1 [0..1]	For signcoding the ISO/TS 14823 [23] shall be used. This data frame includes several DFs and DEs. It includes:	

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Table 9 IVIM elements in general

Name	Type	Multi.	Common Usage	Specific Usage
			○ pictogramCode (countryCode, serviceCategorycode and pictogramCategoryCode) ○ The attributes SET (Section) and NOL (Number of Lane) are not supported because these attributes are providing duplicated information already supported in the Application Container.	
extraText ((1..4),...)	DF	0..1	List of text lines associated to the ordered list of road sign codes. Each piece contains language code plus extra, limited-size text in the selected language using the DF text. Note: This DF can be safely overloaded to include more lines of text.	

3.1.2.1 In-Vehicle Signage (IVS)

The In-Vehicle Signage (IVS) use case is implemented using In-Vehicle Information (IVI) messages according to (ISO 19321) [18].

IVI messages are used for the IVS use case in Austria [8], for the IVS use case in case of Road Works [5] and it is specified in Scoop@F project. A harmonized specification is made between FR, NL, GB, B for IVS in the InterCor project.

Since all implementations are making use of the IVI standard (ISO 19321) [18], Table 10 describes how respective data elements and data frames are applied.

Table 10 IVIM elements specific to IVS

Name	Type	Multi.	Common Usage	Specific Usage
IVI Management Container		**1**		
serviceProviderId	DE	1	serviceProviderID consists of data elements “countryCode” and “providerIdentifier”. countryCode is a bitstring according to ISO 3166-1 [32]. For Austria, for example, the bitstring stands for “AT” (Bitstring Code: A (11000) and T (00001) 1100000001 according to ISO 14816 [22]). Together with iviIdentificationNumber, this is the unique identifier for messages for the receiving V-ITS-S.	*AT* serviceProviderID consists of data elements “countryCode” and “providerIdentifier”. countryCode is a bitstring that will be set to the decimal value of 769 (bitstring 110000000) for Austria according to ISO 3166-1 [32]. providerIdentifier will be set to “10000” for all AT based IVI messages. Together with iviIdentificationNumber, this is the unique identifier for messages for the receiving V-ITS-S. *BE(Fla), FR, NL, UK* Mandatory Numbers shall be assigned on national basis. See [32] for registration. Value: providerIdentifier: A value between 0 and 16383
iviIdentificatioNumber	DE	1	Mandatory	

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Table 10 IVIM elements specific to IVS

Name	Type	Multi.	Common Usage	Specific Usage
			Unique identifier per IVI message per service provider Value: Set by application	
timestamp	DE	1 [0..1]	Mandatory. Profiled (used) The timestamp when the message was generated for new, update or cancel. Value: set by application	
validFrom	DE	0..1	Optional Holds the start time of the validity period of the message. If start time is unknown to the system, validFrom is not present or equal to timestamp. Value: set by application	*AT* Not used
validTo	DE	1 [0..1]	Profiled (used) This DE shall always be used to determine the validity. An update shall be sent before the message times out. Value: set by application Default validity period is defined by road operator.	
connectedIviStructures (1..8)	DE	0..1	Optional This component can be used to link various IVI messages to each other. Value: set by application	
iviStatus	DE	1	Mandatory New, Update, Cancellation: used. Negation: not used Value: set by application	*AT* Supported iviStatus: new, update. iviStatus cancellation or negation will not be used
Geographic Location Cont.		**1**		
referencePosition	DE	1	Mandatory This DE is used as a reference point for all zones within GLC (Geographical Location Container). The Reference point for IVI is defined at the middle of the carriageway, at a gantry, and is the first point of zone definitions for Relevance Zone(s) and Detection Zone(s). The Altitude may be set to unavailable. Value: set by application	
referencePosition Heading	DE	0..1	Optional	*FR* Will always provide this element for determining message relevance in case the detectionZone is not matching: as long as the approach angle is only deviating +/- 30 degrees maximum from the message heading, the message should be considered valid for the vehicle.

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Table 10 IVIM elements specific to IVS

Name	Type	Multi.	Common Usage	Specific Usage
				AT considers the detectionZone the only element for determining message relevance and will only provide referencePositionHeading in case of a moving event position. If a different approach towards an event is possible, either an additional detectionZone or a separate message altogether will be provided. *BE(Fla), NL, UK* Profiled (used) Used to identify trafficDirection, this DE is preferred above the use of zoneHeading of Relevance Zone. Value: set by application
parts (1..16)	DF	1 [0..1]	Mandatory Profile : Used GlcPart (1..16). Up to 16 parts can be defined in one Geographic Location Container. The GLC contains at least two zones, one for relevance and one for detection. Value: set by application	
zoneId	DE	1	At least one detection zone and one relevance zone shall be provided for each message.	
laneNumber	DE	0..1	Optional: Mandatory if single lanes are described in this location container. Default is absent (no lane information).	
Zone	DF	1 [0..1]	Mandatory. DF Segment with a line of deltaPositions (similar to DENM) is used. referencePosition and deltaPositions are provided by the TCC. Positions are set to the middle of the carriageway	
IVI Application Container		**1**		
detectionZoneIds (1..8)	DE	1 [0..1]	Profiled (used) This is the area in which the IVI message should be detected. This DE shall refer to at least one detection zone. Value: set by application	
relevanceZoneIds (1..8)	DE	1 [0..1]	Profiled (used) This is the area in which the IVI message is applicable. This DE shall refer to at least one relevance zone. Value: set by application	
direction	DE	1 [0..1]	Profiled (used) Fixed value. Is always set to sameDirection (0). Value: sameDirection(0)	

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Table 10 IVIM elements specific to IVS

Name	Type	Multi.	Common Usage	Specific Usage
applicableLanes (1..8)	DE	0..1	Optional If applicable to all lanes on a carriageway this DE may be absent. Otherwise used if lane specific. Value: set by application	*AT* All lanes to which the iviStatus and/or laneStatus applies.
iviType	DE	1	Mandatory This shall be set depending on the scenario: - (0) Immediate danger warning - (1) IVI with regulatory information - (2) Traffic-related information messages - (3) pollution messages - (4) not traffic related information messages IVI in the context of road works is by definition used as supporting information, additional to DENM.	
laneStatus	DE	0..1	Optional Use in the use case IVS-OSI. This field may be set at 'closed' for lanes closed with a red cross sign, at 'mergeR' for lanes with an arrow sign pointing right, etc. Note that this field should be consistent with the roadSignCode (e.g. when set at 'closed' the roadSignCode should denote a sign with a red cross or equivalent). Value: set by application	
vehicleCharacteristics	DF	0..1	To be provided if IVI is applicable to specific types of vehicles only. - Train and Ranges are mandatory if vehicleCharacteristics component is present - equalTo is mandatory for classes Mandatory for classes: N: Trucks / Lorries N1: Trucks / Lorries < 3.5 tons N2: Trucks / Lorries > 3.5 tons N3: Trucks / Lorries > 7.5 tons M: busses M2: Busses < 5 tons M3: Busses > 5 tons Otherwise absent - euVehicleCategory and euVehicleCategoryN are set by C-ITS-S based on TCC information	

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Table 10 IVIM elements specific to IVS

Name	Type	Multi.	Common Usage	Specific Usage
			- comparisonOperator is greaterThan(0) - vehicleMaxLadenWeigh is (0) - vehicleTrainMaximumWeight is weight in 10 kg units - vehicleWeightUnladen is (0) Value: set by application	
extraText ((1..4),...)	DF	0..1	Optional Can be used to send a message for clarification or additional information. Due to an error in the currently published version of (ISO 19321) [18], the layoutComponentId data element is mandatory at the moment, even if no layoutContainer (lac) is present. It will be statically set to "1" until an update of (ISO 19321) [18] which rectifies this error is available. The language data element uses a bitstring representing the language according to [28], e.g. German text is encoded as "DE" (D (10010) and E (10000) 1001010000 according to [22]). The actual text can be found in the textContent data element. Value: set by application	*FR* Coding of sub-roadsign panel is coded between "//" (example : //25km//) in the first container of extraText. If well interpreted, it will be displayed properly on HMI. If not, users may understand it well enough. So that it is a solution respecting standard constraints, without any interoperability issue generated.
Other DFs / DEs	All other DFs and DEs in the IVI standard are not used.			

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3.2 Operational Specifications / Triggering Conditions

This section describes the information management of the different message sets. Note, that different triggering conditions don't cause interoperability issues. As long as the information enclosed in the messages is interoperable, different update or cancellation mechanisms don't cause semantic problems.

3.2.1 The principle of DENM transmission conditions

This paragraph covers the following principles of DENM transmission are described for the RWW use case, the principles are also valid for the use cases of Other Hazardous Location Notifications.

AT

There are different scenarios of the RWW use case which differ in where the information is created (C-ITS-S or R-ITS-S) and where the basic information is received from (from TCC, from safety trailers at the roadside, or from a fusion of both sources).

In the scenario of TCC triggered RWWs, the Central ITS station (C-ITS-S) conveys the RWW messages (on behalf of TCC) to a set of selected, suitable R-ITS-S for transmission. Transmitting the DENMs is triggered by the transmission of the DENMs from C-ITS-S to R-ITS-S.

In the scenario of a trailer triggered RWW, an R-ITS-S generates the DENM autonomously; the trailer activation is acting as a trigger.

In both cases a DENM will be updated whenever the event content changes, either according to the TCC or due to changed values from the local systems on the trailer. Note that the latter implies that DENMs for moving roadworks are updated frequently due to trailer movement (changing data elements depending on trailer location).

Even if the event content is not changed, the DENM will be updated after half of the initial validity duration has expired. This is needed to ensure that DENMs received by vehicles have a sufficient remaining lifetime to ensure that the message content is still processed when the vehicle finally reaches the relevant location.

A DENM will be terminated by simply stopping its transmission in the sending station. This occurs automatically at latest when the end of its validity (detectionTime + validityDuration) is reached. The C-ITS can stop the transmission earlier by updating the DENM with a shorter validityDuration.

Note that even if the latter mechanism is used, some vehicles may have received the message with the longer validity but not the update with the shortened validity. Hence, the timing parameters in AT are chosen to strike a good balance between reaction time of the system when ending a RWW and the frequency of DENM updates required.

Also, note that the use of cancellation messages would suffer the same problem and hence would not change the situation. In particular, even when using cancellation messages there is a risk in using long validityDuration values.

Type of messages: **new** DENM and **update** DENM

DE

A DENM message is initially triggered in all use case scenarios by a safety trailer. RWW always starts standalone, where the activation of the trailer is acting as the actual trigger. Note that the system is already capturing its trajectory before in order to allow calculating the traces data frame at the time the transmission is triggered.
If a connection to the TCC is available, the scenario can be switched to augmented RWW (German terminology: 'basic service') in which the C-ITS-S provides additional information based on fusing the trailer generated message with TCC data from a digital map and a roadworks management system, if available.
A DENM will be updated whenever

- the event data from the trailer changes (e.g. direction of arrow sign)
- as a result of TCC data fusion
- or after half of the validity duration.

A DENM is terminated by stopping sending it. This occurs when the end of its validity (detectionTime + validityDuration) is reached.

Type of messages: new DENM and update DENM

FR

There are two use case scenarios; either TCC triggered RWWs or standalone. In the scenario of TCC triggered RWWs, the Scoop@F platform (C-ITS-S) conveys the RWW messages (on behalf of TMC) to a set of suitably selected R-ITS-S (ITS-S R in the French terminology) for transmission. On two-way roads, two DENMs will be sent for each direction.

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In the standalone scenario, DENM transmission is triggered by ITSS-VG - passenger car with OBU in operator mode - manually if equipment are not connected or automatic if connected.

A DENM will be updated whenever the event information changes according to the TMC, and maximum validity duration of DENM may be shorter than the duration of RWW.

Note:

Due to the functional description of the TCC Triggered RWW use case scenario in [30], the duration of RWW may last longer than 24h which is an indication for a Long-term RWW, which are not handled in this release.

A DENM can only be terminated by TMC via the platform (C-ITS-S) if it was centrally triggered. In the standalone scenario, DENM is terminated manually by the road operator agent or automatically (i.e. when equipment stops working). The Scoop@F platform does not have the right to negate the DENMs transmitted by another ITS station.

Type of messages: **new** DENM, **update** DENM and **cancellation** DENM.

NL

The scenario that is adapted in the DUTCH C-ITS profile is TCC Triggered RWWs. In the scenario of TCC triggered RWWs, the C-ITS-S (on behalf of the TMC) conveys the RWW messages to a pre-selected R-ITS-S for transmission.

A DENM will be updated whenever an event update is detected or after half of the validity duration. The DE validityDuration is set at a fixed value. Different approaches like setting validityDuration at a high value are also allowed.
By means of a direction termination, a DENM is terminated via the C-ITS-S (on behalf of the TCC). If the originating stationID is the same as the ID of the station that terminates the message, a cancellation message shall be sent. otherwise, the negation option shall be used.
Type of messages: new DENM, update DENM, cancellation DENM, and negation DENM.

3.2.1.1 Roadworks Warning (RWW)

A warning message about roadworks is broadcasted as DENM message using Basic Transport Protocol and GeoNetworking.

The specific usage of DENM service primitives is defined in Table 11.

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Table 11 DENM service primitives for RWW

Name	AT	DE	FR	NL
DENM Trigger	*Augmented RWW* The DENM is triggered by the C-ITS-S if all information from the trailer is available. RWW always starts with Standalone RWW. If a connection to TCC is possible and additional information in the TCC exists, the TCC sends the Augmented RWW to the R-ITS-S which stops updating the Standalone RWW and triggers the transmission of the Augmented RWW. *Standalone RWW* The DENM is triggered at the moment the trailer board is activated. *TCC Triggered RWW* The DENM is triggered by the C-ITS-S based on available TCC information. When the TCC signals the end of a roadwork, the C-ITS-S stops updating the DENM and subsequently the	*Augmented RWW* All RWW start as Standalone RWW. In case the augmentation is successful, the message will be updated, but the trigger is always only in Standalone mode. *Standalone RWW* The DENM is triggered at the moment the trailer board is activated. RWW always starts with Standalone RWW. If a connection to TCC is possible and additional information in TCC exist, the scenario changes from Standalone to Augmented.	*Planned roadwork - Standalone RWW (ITSS-VG "operator mode")* In the case of ITSS-VG: the DENM is triggered manually if equipment are not connected. Automatic if (automatic :light arrow OR an other equipment is activated). *Planned roadwork - TCC Triggered RWW (via platform (C-ITS-S)* The DENM is triggered by the TCC. *Road operator's intervention - Standalone RWW (ITSS-VG "operator mode")* In the case of causeCodeType rescueAndRecoveryWorkInProgress (15), the DENM is either triggered manually or automatically (((manual activation) XOR (automatic: speed ≤ Vstop* AND (beacon OR an other equipment is activated)))) In the case of causeCodeType slowVehicle (26), the DENM is either triggered manually or automatically ((automatic: Vstop* < speed ≤ Vslow* OR (beacon OR an other equipment is activated)))) In the case of causeCodeType emergencyVehicleApproaching (95), the DENM is either triggered manually or automatically ((automatic: beacon OR an other equipment is activated))) road maintenance - Standalone RWW (ITSS-VG "operator mode") In the case of causeCodeType slowVehicle (26) and subCauseCode snowPlough (6), the DENM is either triggered manually or automatically (automatic: snow blade is down)) In the case of causeCodeType slowVehicle (26) and subCauseCode saltingVehicle (8), the DENM is triggered by fulfilling both conditions:	*TCC Triggered RWW* The DENM is centrally triggered at the (best estimate for the) moment the physical blockage of the lane due to the roadworks.

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Table 11 DENM service primitives for RWW

Name	AT	DE	FR	NL
	DENM transmission ends.		Triggering conditions for 26/6 are not reached) AND (manually or automatically (automatic: salting is on)) road maintenance - TCC Triggered RWW (via platform (C-ITS-S) In the case of the causeCodeType roadWork (3) and subCauseCode winterService (6), the DENM is by fulfilling triggering conditions for 26/6 or 26/8 is not reached).	
DENM Update	*Augmented RWW* The DENM is updated when its content changes or when the age (current system time minus DENM detection time) is greater than or equal to half of its validity time. *Standalone RWW - Mobile* The DENM is updated when its content changes (e.g. change of arrow sign) or when the age (current system time minus DENM detection time) is greater than or equal to half of its validity time. *Standalone RWW - Stationary* The DENM is updated when its content changes or when the age (current system time minus DENM	*Augmented RWW & Standalone RWW - Mobile* The DENM is updated when its content changes or when the age (current system time minus DENM detection time) is greater than or equal to half of its validity time. Content changes may be changing location or change of arrow position. *Augmented RWW & Standalone RWW - Stationary* The DENM is updated when its content changes or when the age (current system time minus DENM detection time) is greater than or equal to half of its validity time. *TCC Triggered RWW* Not supported	*Planned roadwork - Standalone RWW (ITSS-VG "operator mode")* 1 s . Field to be updated: trace, eventposition, eventspeed, referenceTime, detectionTime. The time elapsed to validity duration (600s) is reinitialised. In case of a manual update of the event position, the DENM is sent without a trace. *Planned roadwork - TCC Triggered RWW (via platform (C-ITS-S)* If the subCauseCode is unavailable (0) and the roadwork is more than 24 hours, an update messages (86400 s) is generated; The time elapsed to validity duration is reinitialised. If the subCauseCode is slowMovingRoadMaintenance (3) and the position changes in the TCC, the time elapsed to validityDuration is reinitialised. *Road operator's intervention - Standalone RWW (ITSS-VG "operator mode")* In the case of causeCodeType rescueAndRecoveryWorkInProgress (15), the DENM message is updated upon the validityDuration (600s). The same message is sent if the triggering conditions are respected. The time elapsed to validity duration is reinitialised. In the case of manual update of the event	*TCC Triggered RWW* The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time.

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Table 11 DENM service primitives for RWW

Name	AT	DE	FR	NL
	detection time) is greater than or equal to half of its validity time. *TCC Triggered RWW* The DENM is updated when its content changes or when the age (current system time minus DENM detection time) is greater than or equal to half of its validity time.		position, the DENM is sent without a trace. Field to update: detectionTime. In the case of causeCodeType slowVehicle (26) and emergencyVehicleApproaching (95), the DENM message is updated upon the validity duration (600 and 20s respectively). Fields to be updated each 250ms: trace, eventPosition, eventSpeed, referenceTime. The time elapsed to validityDuration is reinitialized. In case of a manual update of the event position, the DENM is sent without a trace. *Road maintenance - Standalone RWW (ITSS-VG "operator mode")* In the case of causeCodeType slowVehicle (26), the DENM message is updated upon the validity duration (600s). Fied to be updated: trace, eventPosition, eventSpeed, detectionTime. The time elapsed to validityDuration is reinitialised. In case of a manual update of the eventPosition, the DENM is sent without a trace. *Road maintenance - TCC Triggered RWW (via platform (C-ITS-S)* In the case of causeCodeType roadWork (3), the DENM message is updated upon the validityDuration of (20s). Fields to be updated each 250ms are: trace, eventPosition, eventSpeed, referenceTime, detectionTime. The time elapsed to validityDuration is reinitialised. In case of a manual update of the event position, the DENM is sent without a trace.	
DENM Termi-nation	Not used	Not used	*Planned roadwork - Standalone RWW (ITSS-VG "operator mode")* Two cases: The extinction of the equipment triggers a termination message if the V-ITSS is connected to the equipment. Manual termination by the agent.	Used

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Table 11 DENM service primitives for RWW

Name	AT	DE	FR	NL
			Planned roadwork - TCC Triggered RWW (via platform (C-ITS-S) When RWW is finished by the TCC. *Road operator's intervention - Standalone RWW (ITSS-VG "operator mode")* In the case of causeCodeType rescueAndRecoveryWorkInProgress (15), there are two cases: Manual Termination: If beacon, the vehicle can go one and continue emitting the DENM. The termination is not related to the vehicle stops. Automatic termination when equipment stops working. In the case of causeCodeType slowVehicle (26), there are two cases: Automatic termination if the R-ITSSVG sends another DENM or if speed > V defined [19] Manual termination is done by the agent. In the case of the causeCodeType emergencyVehicleApproaching (95), termination is done manually. *Road maintenance - Standalone RWW (ITSS-VG "operator mode")* In the case of causeCodeType slowVehicle (26) and subCauseCode snowPlough (6), the termination is activated in two cases: high blade or action of the agent. In the case of causeCodeType slowVehicle (26) and subCauseCode saltingVehicle (8), the termination is activated in two cases: end of salting or action of the agent. In the case of the causeCodeType roadWork (3) and subCauseCode winterService (6), the termination is activated in two cases: end of activity or action of the agent.	

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Table 11 DENM service primitives for RWW

Name	AT	DE	FR	NL
			Road maintenance - TCC Triggered RWW (via platform (C-ITS-S) The termination is activated in two cases: end of activity or action by the agent.	

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3.2.1.2 Other Hazardous Location Notifications (OHLN)

Covers Collision Risk Warning (NL), Other DENM Applications (AT) and Road Hazard Signaling (FR)

In general terms, the same principles for DENM transmission apply as described in section 3.2.1. The specific usage of DEN service primitives is defined in Table 12.

Table 12 DENM service primitives for Other Hazardous Location Notifications

Name	AT	FR	NL
DENM Trigger	The message is triggered and generated in the C-ITS-S, based on event data received from TCC. The message is then forwarded to relevant R-ITS-S for transmission.	The DENM message is triggered manually in operator vehicles (ITSS-VG). This transmission will have a lower quality level than an automatic transmission. The message can be triggered by the TMC via the C-ITS-S (Scoop@F platform) and the R-ITS-S (The TMC operator will be able to specify the type of event).	The DENM message is triggered when the traffic inspector activates a button in his vehicle.
DENM Update	TCC event data updates received by the C-ITS-S cause a DENM update whenever the event data changes. Furthermore, the C-ITS will update the DENM after half of validityDuration (≤720s) since the last update has passed.	In the case of ITSS-VG: not used (validity duration is 1200s). In the case of R-ITS-S: updates are generated in the TMC. The time elapsed to validity duration is reinitialized (validity duration is between 3600 and 7200s).	Identical to RWW. The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time.
DENM Termi-nation	The termination service primitive is not used. The C-ITS-S stops updating the DENM after it has received an information from the TCC that the event is no longer valid.	The termination service primitive is used to transmit cancellation DENMs. In the case of ITSS-VG: manual termination by the agent In the case of R-ITS-S: termination at the end of the event determined by the TCC.	The termination service primitive is used to transmit cancellation DENMs when the traffic inspector de-activates the button.

3.2.2 The principles of IVIM transmission conditions

AT

The current status of all available signs (note: only dynamic signs covered in current release) is sent out to approaching vehicles based on information provided from the TCC to the C-ITS-S. Each transmitted IVIM message has a status (iviStatus) that determines the type of message.

The end of validity duration is determined from C-ITS-S. updated after half the duration of the message $\frac{validTo-timestamp}{2}$.

A new message or any change has a new timestamp.

Type of messages: new IVIM and update IVIM

NL

The trigger of IVIM transmission is the set of a measure e.g. changing a sign from blanc in the signaling system (MTM). Operationally, C-ITS-S sends IVIM message content based on TCC incoming information. Each transmitted IVIM message has a status (iviStatus) that determines the type of message.

The data frame validTo shall always be used to determine the validity. The update is provided only when the content of sign(s) changes (for example, when the maximum speed limit is reduced during rush hour). It is not intended to use iviStatus cancellation or negation.

It can be observed that the update of IVIM message in the Austrian implementation is more frequent than in the Netherlands.

Type of messages: new IVIM and update IVIM

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3.2.2.1 In-Vehicle Signage (IVS)

Table 13 IVIM service primitives for IVS

Name	AT	NL
IVIM Trigger	IVIM is not triggered, but generated with timesamp and transmitted by C-ITS-S (based on information incoming from TCC).	There is no such a trigger as each available sign should be sent out to the drivers within. Operationally, C-ITS-S sends IVIM message content based on TCC incoming information. Each transmitted IVIM message has a status (iviStatus) that determines the type of message.
IVIM Update	End time of the validity period of the message. Will be provided by the C-ITS-S as part of the message management of IVI messages. Default validity for the IVI use case is 20 seconds. validTo will be set 20s ahead of timestamp and updated after half the duration of the message *((validTo – timestamp) / 2).*	The data frame validTo shall always be used to determine the validity. An update shall be sent when the validity of a part of a sign is changed. For example, when the maximum speed limit is reduced during rush hour or when trucks are allowed to overtake during off-peak hours.
IVIM Termination	It is not intended to use iviStatus cancellation or negation.	Not used.

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3.3 Management Entity

The Management Entity is not relevant for the messages sent from the roadside to vehicle interface. The Management Entity is relevant for configuration of a R-ITS-S and for the split in functionality between R-ITS-S and C-ITS-S. The central to roadside interface is however not in scope of this document.

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3.4 Security Principles

The Security Principles chapter comprises all functions required for secured message generation, i.e. signature generation, key and certificate handling, as well as authentication (verification) of received messages.

In order to allow continuous operation of these security functions, not only functions and processes on an isolated ITS station have to be considered, but additionally the interface towards the Public Key infrastructure (PKI) must be addressed. This covers communication with Certificate Authorities (CA) for initial enrolment of ITS stations and periodic certificate requests, as well as details related to re-keying and certificate renewal, i.e. cryptographic parameters, validity times and protocols. Several of these aspects are covered by the Certificate Policy issued by the European Commission, which serves as a normative reference for all C-ROADS implementations.

Beyond the “Security Entity” described above, additional measures are required. Only those aspects that are specific to the introduction and operation of C-ITS equipment and services can and will be detailed by TF1, other IT security requirements may be mentioned for reference but without any claim for completeness.

Such additional, rather generic “cybersecurity” aspects must be ensured by every road operator for all existing systems independent of cooperative systems. A non-exhaustive list of generic requirements comprises for example tamper-proof infrastructure components with secured interfaces, access restrictions, appropriate documentation and logging, plausibility checks on received data and misbehaviour detection, e.g. theft and access violation. Typically, all of the above is addressed by an ISMS (Information Security Management Systems), e.g. according to ISO 27001 [31] or other standards available.

Since these aspects are core responsibilities of any operator of IT networks/components, they are not addressed in depth within C-ROADS’ TF1.

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4 References

Table 14 Table of references

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[13]	ETSI EN 302 637-3 v1.2.2 (2014-11) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service

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[14]	ETSI EN 302 665 V1.1.1 (2010-09) Intelligent Transport Systems (ITS); Communications Architecture
[15]	ETSI TS 102 792 V1.2.1 (2015-06) Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range
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[17]	ETSI TS 103 301 V1.1.1 (2016-11) Intelligent Transport Systems (ITS);
[18]	ISO/TS 19321:2015 (2015-04-15) - Intelligent transport systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structures
[19]	SCOOP_2.4.1.2_Specifications of DENM fields_V2.00.
[20]	SCOOP_2.4.1_Appendix_1_ Renewal of pseudonym certificates and upload of Logs (T-Logs and U-Logs)
[21]	SCOOP_2.4.1_Common set of functional and technical specifications_V2.00
[22]	ISO 14816:2005 Road transport and traffic telematics; Automatic vehicle and equipment identification; Numbering and data structure.
[23]	ISO/TS 14823:2017. Intelligent transport systems -- Graphic data dictionary
[24]	ETSI TR 102 638 V1.1.1 (2009-06) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions
[25]	ETSI EN 302 571 V2.0.0 (2016-03) Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
[26]	ETSI EN 302 637-3 v1.2.2 (2014-11). Intelligent Transport; Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service.
[27]	ECo-AT SWP3.1 DATEX II mapping, DATEXII_Translation_IVI_V04.00.xlsx
[28]	ISO 639-1 Codes for the representation of names of languages - Part 1: Alpha-2 code

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[29]	ISO 19091: 2014— Intelligent transport systems — Co-operative ITS - Using V2I and I2V Communications for Applications Related to Signalized Intersections
[30]	SCOOP: Planned roadwork
[31]	ISO/IEC 27001:2013 Information technology -- Security techniques -- Information security management systems -- Requirements
[32]	ISO 3166-1:2013 Codes for the representation of names of countries and their subdivisions -- Part 1: Country codes
[33]	ITU 741 ANNEX
[34]	SAE J2735, Dedicated Short Range Communications (DSRC) Message Set Dictionary, March 2016
[35]	C_ROADS_WG2_TF2_Service Descriptions v1.1
[36]	InterCor_M03-Upgraded-Specifications-ITS-G5_v1.1.pdf

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