C-ITS Message Profiles

C-ROADS Platform

Working Group 2 Technical Aspects

Taskforce 3 Infrastructure Communication

30/06/2023

Publication History

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2.0.0	13/07/2021	Release 2.0 Update of geonetworking; addition of IVIM profile for automated driving support use cases;	R
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2.0.3	17/03/2022	Release 2.0.3 Reintroduction of SPATEM, MAPEM, SREM, SSEM; Addition of a general CAM profile;	R
2.0.4	27/06/2022	Release 2.0.4 Addition of the IVI-HDT profile and editorial updates of other IVI based DE descriptions; addition of a topology information profile (MAPEM) for road segments	R
2.0.5	04/10/2022	Release 2.0.5 Addition of a specific IVIM profile for Destination Travel Time (DTT)	R
2.0.7	15/03/2023	Release 2.0.7 Clarification of detectionTime (DENM); amendments of the DENM profile in accordance to DENM Release 2; Corrected reference in DENM introduction; rephrasing of the operational specifications / triggering conditions;	R
2.0.8	30/06/2023	Release 2.0.8 Update of IVIM / IVS Profiles based on discussion about C2C-CC IVIM requirements; improvements of the DENM profiles; Addition of legacy notes for current vehicle implementations, which do not adhere to C-Roads specifications; changing “regional” (1.10 in SPATEM profile) from mandatory to optional	R

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Acronyms

API	Application Programming Interface
AVG	Automated Vehicle Guidance
CA	Cooperative Awareness
CAM	Cooperative Awareness Message
CCTV	Closed Circuit Television
C-ITS	Cooperative ITS
C-ITS-S	Central ITS Station
C2R	Centre to roadside
CRW	Collision Risk Warning
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
DSRC	Dedicated Short Range Communication
DTI	Digital Transport Infrastructure
F	Facilities Layer
FT	Free Text
FLS	Facilities Layer Service
GBC	Geobroadcast
GLC	Geographic Location Container
GN	GeoNetworking
GNSS	Global Navigation Satellite System
HDT	HD Topology
HF	Header Field
HLN	Hazardous Location Notifications
IP	Internet Protocol
ISMS	Information Security Management Systems
ITS	Intelligent Transport Systems
ITS-G5	ITS-G5 is a European standard for ad-hoc short-range communication of vehicles among each other (V2V) and with Road ITS Stations (V2I). The ITS-G5 Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band is given in ETSI EN 302 663. ITS-G5 is a profile of the amendmend IEEE 802.11p, which has been incorporated into the main IEEE 802.11 standard, and an IEEE 802.2 LLC. It uses the 5.9 GHz frequency band to support safety- and non-safety ITS applications.
ITS-S	ITS Station
IVI	In-Vehicle Information
IVI service	In-Vehicle Information (IVI) service
IVIM	In-Vehicle Information Message

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IVS	In-Vehicle Signage
I2V	Infrastructure to vehicle
km	kilometre
m	metre
MAPEM	MAP (topology) Extended Message
ms	millisecond
MS	Member State
MSP	Mobile ITS G5 System Profile
OBU	On Board Unit
OSI	Open Systems Interconnection model
PDU	Protocol Data Unit
PKI	Public Key Infrastructure
R-ITS-S	Roadside ITS Station (the so-called RSU)
RCC	Road Configuration Container
RLT	Road and Lane Topology
R2C	Roadside to centre
R2W	Roadside to web services
RSP	ITS-G5 Roadside System Profile (abbreviated as Roadside System Profile or Infrastructure Profile)
RSU	Roadside Unit
RWW	Roadworks Warning
s	seconds
SAP	Service Access Point
SDU	Service Data Unit
SO PV	Source Position Vector
SP	Service Primitive
SPATEM	Signal Phase And Timing Extended Message
SREM	Signal Request Extended Message
SSEM	Signal request Status Extended Message
TCC	Traffic Control Centre
TLC	Traffic Light Control
TLM	Traffic Light Manoeuvre
UTC	Coordinated Universal Time
VMS	Variable Message Sign
V2I	Vehicle to infrastructure
V2V	Vehicle to vehicle
W2R	Web service to roadside

N/A	*Not Applicable*

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Glossary

ITS-S application	Uses one or more FLSs with different parameters, depending on the situation, to provide an ITS service to the user. ETSI TR 102 638 [1] e.g. is RWW, IVS and CRW.
Use Case Scenario	Denotes a more specific way to execute an ITS-S application, 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 application based on TCC data only.
Facilities Layer Service (FLS)	In this document, the term service is derived from the term ITS-S service as defined in ETSI EN 302 665 [2]. It describes a communication functionality offered by an ITS-S to an ITS-S application.

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1 Introduction

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

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

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

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

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

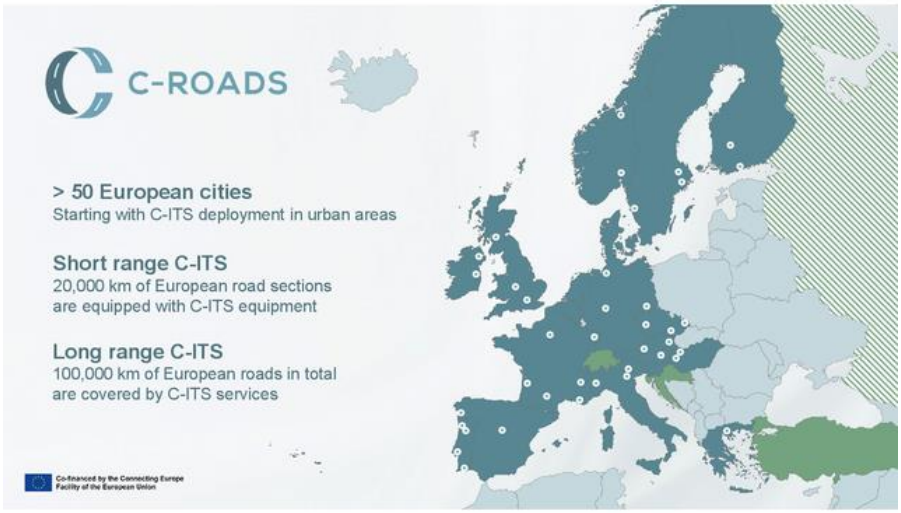

Figure 1: Overview of C-Roads coverage

1.2 Story board C-Roads C-ITS deployment documentation

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

A complete description of the story board of a C-ITS implementation project, the different stages and the related C-Roads documents is given in *Introduction to the C-Roads WG2 Deployment Documentation and Requirements.*

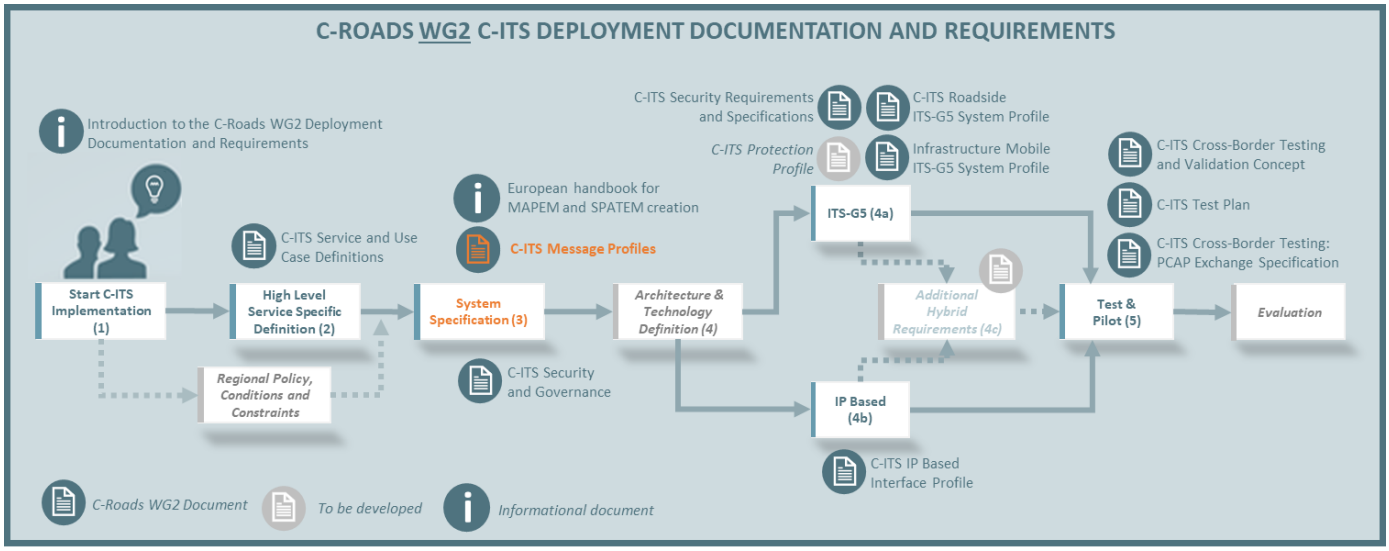

Figure 2: highlight of WG2 document in complete story board

The documents cover a wide range of aspects related to several stages as described in section 1.4 of *Introduction to the C-Roads WG2 Deployment Documentation and Requirements*. Starting with stage 3, generic requirements and the required governance are specified - those are applicable for all services, use cases and scenarios in a similar way. On stage 4a and 4b, the more detailed specifications are relevant - including service specific security requirements. Both levels, generic and specific requirements, have impact on the test cases derived on stage 5.

1.3 Scope of this document

This document is one of the documents of stage 3 in the C-Roads workflow, as described in section 1.4 of *Introduction to the C-Roads WG2 Deployment Documentation and Requirements.* This workflow reflects how information flows through the C-ITS station architecture. It starts with an ITS-S application (referred to as “Service”), which is described in the stage 2 documents. In order to perform its function, the ITS-S application decides to send out messages and in order to do so, it invokes a Service Access Point (SAP) of a Facility Layer Service (FLS). The term SAP is taken from the OSI reference model for the interfaces between layers, many people today would probably rather call it an API. The Facility Layer Service performs its task according to its specification and uses SAPs of underlying layers (transport, network, access) for doing so. The according specifications are not developed in C-Roads, standards are used for this instead, e.g. ETSI TS 103 831 [10] and ISO 103 301 [11] for the Facility Layer services.

What the stage 3 documents specify are the profiles used for these standards, depending on how the FLS is invoked. Hence, the behaviour is ITS-S application and use case specific, since different ITS-S applications – as well as the same ITS-S application in different Use Cases – invoke the FLS differently. Stage 3 describes the profiles on FLS level in the document named “Message Profiles and Parameters”, and the underlying layer aspects – where needed – in the “Roadside ITS-G5 System Profile” [4] and “Mobile ITS-G5 System Profile” [24] documents.

The present document *C-ITS Message Profiles and Parameters* describes the Facility Layer Service (FLS) that are used in the current release of the C-Roads specification. In the current version this includes the following FLS:

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- Decentralise Environmental Notification
- Infrastructure to Vehicle Information
- Traffic Light Manoeuvre
- Road and Lane Topology
- Traffic Light Control
- Cooperative Awareness Basic Service

This document provides the message profiles used by different ITS-S applications and in different use cases, and it also provides the parameters used to control the FLS behaviour when invoking the underlying layers for transport, network and access.

This document defines the common base for the C-ITS message specifications. The specification targets predominantly 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. It also covers communication from vehicles assuming special roles, such as road operator vehicles, emergency vehicles, public transport vehicles, to other conventional vehicles. The latter falls into the category of **V2V** (vehicle-to-vehicle) communication. 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.

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)

This document is structured into three sections:

- Section 1 defines verbal forms and provisions
- Section 2 lists the functional description of supported system FLS and ITS-S applications
- Section 3 provides the technical specifications of the supported FLSs.

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

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2 Provisions

2.1 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 behaviour 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

2.2 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.

2.3 Usage of data elements/data frames

The usage contains information on the use of the Data Elements/Data Frames (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 is used). The usage may contain definitions of DE/DF in accordance with corresponding standards. Table 1, Table 7, Table 15, Table 16, Table 17, Table 18 and Table 19 provide general usage information of message sets, while Table 4, Table 5, Table 6, Table 8, Table 9, Table 10, Table 11 and Table 12 provide details of ITS-S application specific's usage information. The necessity of elements is denoted with mandatory or optional.

2.4 Principles of location referencing of infrastructure-based messages

The following principles apply to location referencing.

- Infrastructure is working with map projections.
- Map projections provide equidistant points at the middle of the carriageway.
- There is no rule for the exact number and distance of points, this will be specific to the situation on the road and deviate from message to message.
- Maximum deviation between reality and map projection is determined by the number of lanes.

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3 System Facilities Layer Services (System FLSs)

3.1 5.8 GHz DSRC / 5.9 GHz C-ITS Coexistence System FLS

3.1.1 Introduction

The Coexistence FLS supports the announcement of Protected Zones, in which other ITS stations operate without interfering with CEN DSRC based tolling equipment by using mitigation methods in accordance with EN 302 571 [5]. In order to avoid harmful interference to CEN DSRC tolling systems operating at 5.8 GHz, ITS stations need to implement mitigation techniques as defined in ETSI TS 102 792 [6]. These mitigation techniques need to be applied in a Protected Zone, which is a circular area around tolling equipment.

According to ETSI TS 102 792 [6], there are three ways that mobile and personal ITS stations become aware of a protected zone:

1. Announcement of Protected Zones via Protected Zone Database.
2. Announcement of Protected zones via CAMs broadcasted from ITS-G5 stations.
3. Direct detection of the tolling signal by a detector in a vehicle (see [6] Clause 5.2.5 for details).

Fixed ITS stations (i.e. roadside installations in a fixed location) may be configured at installation time to meet the coexistence requirements of its local environment ([6], Clause 5.5.2).

Road operators can announce Protected Zones according to (1.) and (2.) above. Road operators shall ensure that their ITS stations (fixed roadside installations as well as VMS/roadworks trailers) operate according to requirements for interference mitigation for CEN DSRC and HDR DSRC in EN 302 571 [5].

Protected zone specification based on ETSI TS 102 792 [6]
As a basis for the coexistence ITS-S application, Protected Zones identify the area in which an ITS station has to ensure not to interfere with CEN DSRC equipment.

3.1.2 Announcement of Protected Zones via Protected Zone Database

To ensure that CEN-DSRC tolling stations are protected against harmful interference by ITS stations, toll chargers and road operators can provide their protected zone data to a European Protected Zone Database. Only permanent tolling installations shall be entered into the database, but not temporary toll stations and tolling enforcement vehicles.

3.1.3 Announcement of Protected zones via CAMs broadcasted from ITS-G5 roadside stations

As the manufacturers of mobile ITS stations are not required to update the equipment-internal list of Protected Zones after the equipment was built, toll chargers and road operators may announce Protected Zones also by means of the transmission of a Cooperative Awareness Message (CAM) in which the locations of CEN-DSRC tolling stations are given.

3.1.3.1 Message format

A CAM for the Coexistence ITS-S application identifies at least one single Protected Zone but may identify a list of Protected Communication Zones within the data frame *ProtectedCommunicationZonesRSU*. This list may contain up to 16 single data elements of type *ProtectedCommunicationZone*. A protected communication zone is defined at least by the type (permanent or temporary tolling) as well as latitude and longitude of the centre position. An optional radius can be specified, if the radius deviates from the default radius, as specified in ETSI EN 302 637-2 [7]. The expiry time shall be specified if the end of tolling operation is known. Chapter 4.2.5 provides detailing of the elements used.

3.1.3.2 Operational specifications

The Coexistence FLS can be used by road operators and toll chargers that intend to protect their tolling equipment. It is a prerequisite to the Coexistence FLS that Protected Zone data is made available to the roadside ITS stations (R-ITS-S) that are intended to disseminate these data via CAMs. Protected Zone data may be placed directly in the R-ITS-S or sent to the R-ITS-S from any other infrastructure component.

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EXAMPLE: In AT the Protected Zone data is provided by the TCC to the C-ITS-S; then the C-ITS-S distributes it to selected R-ITS-S which broadcast it via CAMs.

Furthermore, it needs to be ensured that the Protected Zone CAMs can be received and processed by mobile ITS stations in time by appropriate selection of the dissemination area and considering the CAM transmission rate.

3.2 Other system FLSs

There are currently no other system FLSs.

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4 Functional FLSs

4.1 Introduction

This chapter defines technical and operational specifications of the infrastructure FLSs, in line with their functional description in C_ROADS_WG2_TF2_Service Descriptions [9]. 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 chapter is structured into four subsections:

- Subsection 4.2 is based on following facilities layer service definitions based on the ETSI ITS station reference architecture / ITS-S host (ETSI EN 302 665 [2]) and the facilities layer protocols and communication requirements for infrastructure FLS ETSI TS 103 301 [11]:
    - Decentralized Environmental Notification (DEN) basic service (ETSI TS 103 831 [10]),
    - In-Vehicle Information (IVI) service (ETSI TS 103 301 [11]).
    - Road lane topology (RLT) / traffic light manoeuvre (TLM) service (ETSI TS 103 301 [11]),
    - Traffic light control (TLC) service (ETSI TS 103 301 [11]).

  This section provides the content profiles of the corresponding message sets (DENM, SPATEM, MAPEM, IVIM, SREM and SSEM). 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. Note that the tables include only the data elements / data frames from the message payload, not the content of the surrounding data structures of the lower layers including the ItsPduHeader. These data elements / data frames are described in the Roadside ITS-G5 System Profile [4].
- Subsection 4.2.3 provides operational specifications of the supported FLSs, including their triggering conditions. Service parameters of the respective facilities layer services not mentioned in this document have default values regardless of ITS-S application, use case scenario or national implementation (such general parameters are defined in chapter 3 of the Roadside ITS-G5 System Profile [4]). 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 ITS-S applications addressed. Wherever the profile indicates ‘not used’ this means: not used for current use cases, kept optional for future use cases, therefore use is not forbidden.
- 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-S 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 ITS-S applications or connected ITS-S by forwarding mechanisms.
Once message transmission is triggered, the FLSs may be configured to repeat the transmission, until the ITS-S applications request its termination or trigger another request to generate an updated message.

4.2 Service definition and message content

4.2.1 DEN Basic Service (DEN Basic FLS)

“The DEN basic service uses the services provided by the protocol entities of the ITS networking & transport layer to disseminate DENM” (ETSI TS 103 831 [10]).

“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 TS 103 831 [10]). The DENM transmission may be independent from the originating ITS-S in some situations.

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

- **new** DENM,
- **update** DENM,
- **cancellation** DENM and
- **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 ITS-S application request.

The header of DENM shall be as specified in the data dictionary ETSI TS 102 894-2 [8]. Detailed data presentation rules of the ITS PDU header in the context of DENM shall be as specified in clause B.1 of ETSI TS 103 831 [10].

Note:

Starting with Release 2.0.6, the DENM based profiles of this document support DENM (ETSI TS 103 831 [10]) and CDD (ETSI TS 102 894-2 [8]) Release 2 versions. Some of the DENM data elements have thus changed their name - these elements are clearly marked in the profile using "DENM Release 1 notes". Despite the name change, the usage of these data elements is backwards-compatible and will not break earlier implementations based on the old name or interpretation of the data elements. With the move to Release 2, the DENM standard now clearly distinguishes between an awareness area (where information is potentially applicable, like a weather warning, animal or person on the road, …) and a relevance zone (where the information is applicable for sure, like a roadworks warning, stationary road). The C-ROADS profile supports the following geographical situations for its use cases: Point-based relevance zone, Single circular awareness area, Single linear relevance zone or awareness area (see Figure 3).

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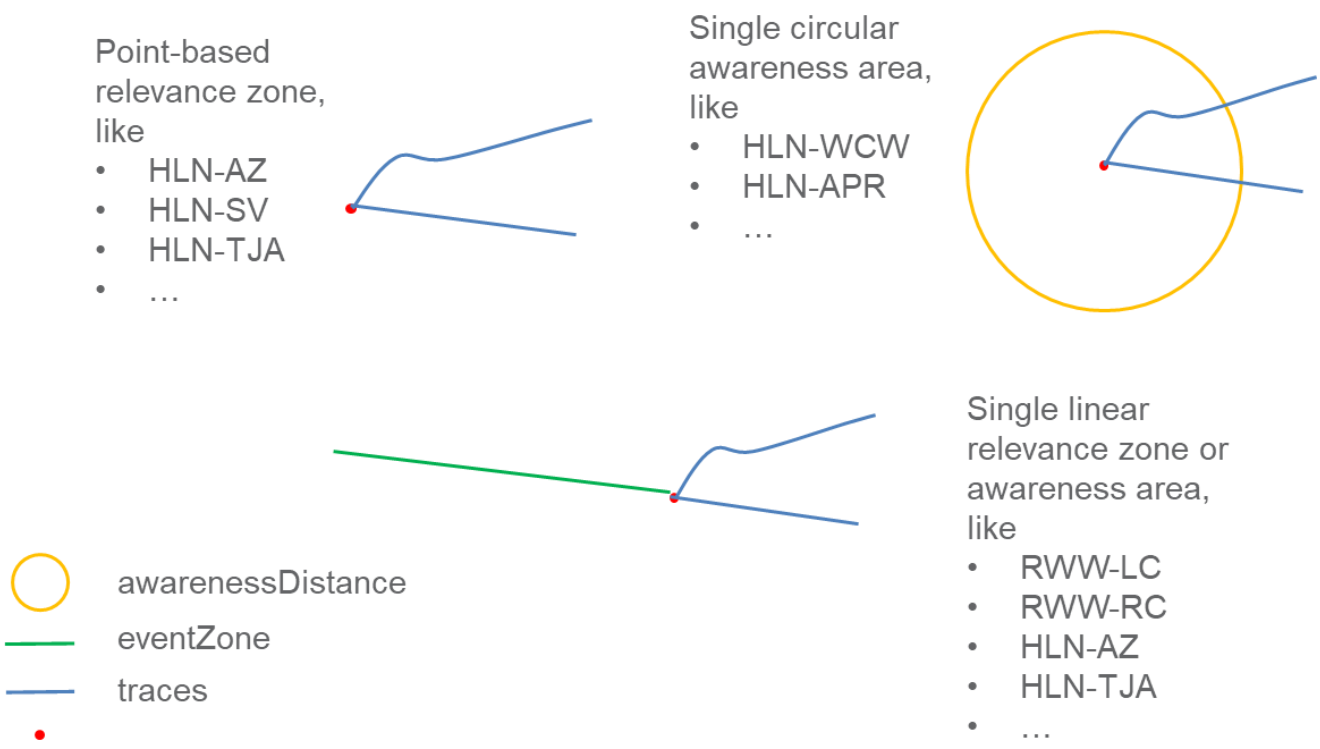

Figure 3 different event zones/areas in DENM

4.2.1.1 DENM general elements

DENM data elements, DENM data frames and service parameters shall be used according to the definitions in Table 1.

Table 1 DENM elements in general

Level	Name	M/O	Usage	Comment
0.0	**Management Container**	**Mandatory**		
0.1	actionId [ActionId]	Mandatory	**Content:** The actionId is the unique identifier of a DENM and consists of the data elements originatingStationId and sequenceNumber. originatingStationId is the stationId of either the originating ITS-S that detects an event for the first time or the virtual stationId of a central entity (like e.g. a TCC) that provides the information to the ITS-S. In case of centrally detected events, the system shall provide the same actionId for all messages relating to the same event, regardless which ITS-S is sending out the message. In case of locally detected events that are not being sent out by more than one R-ITS-S, individual actionIds may be used, i.e. the generating station may use its own originatingStationId. Once the actionId is set, it shall not change for messages relating to the same event, even if they are frequently updated.	-

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Table 1 DENM elements in general

Level	Name	M/O	Usage	Comment
			Value: not pre-defined, shall be set by system which generates the message (consistent with standard)	
0.2	detectionTime [TimestampIts]	Mandatory	**Content:** Initially this DE shall be set to the time the event was detected. The time shall come from a local time source in the ITS-S (this also includes ITS stations mounted on stationary trailers) in case of locally detected events. In case of centrally detected events, the detectionTime shall initially be set to the time that the ITS-S 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. **Value:** detectionTime shall initially be set at the start time of the event (new DENM) then updated (set to the time, when the DENM update is generated) for each DENM update. For the DENM termination, this DE shall be the time at which the termination of the event is detected	-
0.3	referenceTime [TimestampIts]	Mandatory	**Content:** Following the DENM standard, the referenceTime shall be set to the time the DENM message is generated or updated. **Value:** Set automatically	-
0.4	termination [Termination]	Optional	**Content:** This DE shall be used in case message management is done using cancellation. A DENM where this DE is used will render all other messages with the same actionId invalid. **Value:** Shall be set to 0 (isCancellation)	
0.5	eventPosition [ReferencePosition]	Mandatory	**Content:** In the I2V use case scenario, 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 national regulation in individual member states whether the blockage is the trailer itself or the first cone in front of the trailer. The accuracy should be on the level of a lane, but shall at least be on the accuracy level of the carriageway.	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9] **Legacy Note:** Current vehicle implementations require • positionConfidenceEllipse ○ semiMajorConfidence: Max 10m (unavailable is not acceptable)

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Table 1 DENM elements in general

Level	Name	M/O	Usage	Comment
			The DF positionConfidenceEllipse expresses the precision of the given event position coordinates. **Value:** The DE Altitude can be used or set to the value 0 (unavailable). The DF positionConfidenceEllipse shall be set to an appropriate value. If no precise value can be given, the DEs semiMajorConfidence and semiMinorConfidence shall be set to 4095 (unavailable). The DEs latitude and longitude shall be filled as specified in the CDD [8].	○ semiMinorConfidence: Max 10m (unavailable is not acceptable) ○ semiMajorOrientation: anything EXCEPT unavailable • altitude ○ altitudeValue: value 0 (unavailable) is not accepted, an accurate value needs to be provided. The maximum possible deviation from the value determined by the receiving vehicle is unknown at the moment
0.6	awarenessDistance (formerly relevanceDistance)	Optional	**Content:** awarenessDistance describes a circle around the eventPosition where the event indicated in the DENM is potentially applicable. This DE shall be used when describing a single circular awareness area as described in the DENM standard. When awarenessDistance is present, eventZone shall be absent (and vice versa). **Value:** All values available in the CDD [8] can be used. **DENM Release 1 note:** This DE was previously called “relevanceDistance” in older Releases of the DENM standard. Despite the name change, the usage of this DE is backwards-compatible and will not break earlier implementations based on “relevanceDistance”.	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
0.7	awarenessTrafficDirection (formerly relevanceTrafficDirection)	Optional	**Content:** This DF indicates for which traffic direction the message is relevant (from the perspective of the eventPosition). May be used for single circular or single linear awareness areas as well as point based, or single linear relevance zones as defined in the DENM standard. **Value:** allTrafficDirections (0), upStreamTraffic (1), downstreamTraffic (2) **DENM Release 1 note:** This DE was previously called “relevanceTrafficDirection” in older Releases of the DENM standard. Despite the name change, the usage of this DE is backwards-compatible and will not break earlier implementations based on “relevanceTrafficDirection”.	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]

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Table 1 DENM elements in general

Level	Name	M/O	Usage	Comment
0.8	validityDuration	Mandatory	**Content:** 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). See also 4.3. **Value:** Set by ITS-S application. Shall be set to an appropriate value for the specific use case.	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9] **Legacy Note:** Current vehicle implementations accept all values in the allowed range (0-86400 seconds) but drop messages after 60s.Therefore it is recommended to use a validityDuration of 60s and update the message accordingly. This behaviour is verified for RWW use cases.
0.9	transmissionInterval	Optional	Not used	
0.10	stationType	Mandatory	**Content:** The stationType shall be set according to the type of C-ITS station. For vehicles the stationType shall be set according to the TS 102 894-2 [8] which reflects the vehicle registration. Note: The stationType does not reflect the role of the vehicle, e.g., a police car can have stationType passengerCar (5) but the vehicle role in the CAM is emergency (6) when being in service. **Value:** Shall be set to the following values depending on the vehicle type • 15 (roadSideUnit): for road side unit (fixed and portable) • 9 (trailer): for static and towed trailers • 10 (specialVehicle): for vehicles of category M, N or O for conveying passengers or goods and for performing a special function for which special body arrangements and/or equipment are necessary • 6 (bus): for bus • 11 (tram): for tram	
1.0	**Situation Container**	**Mandatory**		
1.1	informationQuality	Mandatory	**Content:** informationQuality expresses the likelihood of occurrence of an event and not the quality of the location information of the event, which is	

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Table 1 DENM elements in general

Level	Name	M/O	Usage	Comment
			expressed by eventPosition and positionConfidence. **Value:** See Table 2 for definitions of information quality values 2, 4 and 6. Shall be set according to the use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9] or the process described in Table 3.	
1.2	eventType	Mandatory	**Content:** This DF is used to indicate the event type which the DENM informs about. Combination of DE causeCode and DE subCauseCode. **Value:** See ITS-S application specific parts in the following subsections and the use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]	
1.3	linkedCause	Optional	**Content:** May be used to link the current message to a set of causeCode / subCauseCode (similar to eventType) to provide further information **Value:** Same possible values as for eventType	-
1.4	eventZone (formerly eventHistory)	Optional	**Content:** This DE may be used when describing single linear relevance or awareness as described in the DENM standard, when the endpoint of the physical blockage can be determined. If so, it shall describe the start of a blockage to the end of the blockage, or to the start of a new blockage (another DENM). Note that in the context of single linear relevance or awareness zones, the eventPoint values are provided without corresponding eventDeltaTime, since the points describe a geospatial extent and not a trajectory. The DE informationQuality inside the eventZone shall be set to the same value as the above specified informationQuality of the whole DENM. The principles of location referencing, defined in 2.4 shall be fulfilled. When eventZone is present, awarenessDistance shall be absent (and vice versa). **Value:**	This profile optionally uses this DE when describing single linear relevance or awareness zones as described in the DENM standard. In a relevance zone, the event extends with high certainty over the entire area, in an awareness zone, the event is located somewhere within the area. Note that in the context of single linear relevance or awareness zones, the eventPoint values are provided without corresponding eventDeltaTime, since the points describe a geospatial extent and not a trajectory.

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Table 1 DENM elements in general

Level	Name	M/O	Usage	Comment
			up to 23 eventPoints may be used **DENM Release 1 note:** This DE was previously called "eventHistory" in older releases of the DENM standard. Despite the name change, the usage of this DE is backwards-compatible and will not break earlier implementations based on "eventHistory".	
2.0	**Location Container**	**Optional**		
2.1	eventSpeed	Optional	**Content:** This DF provides the speed of a moving event and is therefore not used for stationary events. This DF consists of speedValue and speedConfidence. **Value:** The value shall be chosen from all values available in the CDD [8].	**Legacy Note:** Current vehicle implementations require an eventSpeed. This means that speedValue and speedConfidence shall be provided.
2.2	eventPositionHeading	Optional	**Content:** Heading information shall only be provided for moving events via eventPositionHeading. For stationary events, this DF shall not be used. **Value:** The value of this DF will be provided as an angle value and angle confidence	
2.3	traces	Mandatory	**Content:** traces represent the detection zone information defined by the DENM standard, a trace being a list of well-ordered waypoints that forms an itinerary approaching towards the event position. The principles of location referencing, defined in 2.4 shall be fulfilled. **Value:** At least one trace shall be provided. Where needed and possible, multiple (up to seven) traces should be provided for different approaches to the event position. Nevertheless, the number of traces possible is limited by the size of the DENM. It is recommended for road operators to use design method one of SAE J2945/1 (2016-03) [26] for traces generated in mobile units / vehicles. No matter what method is used, mobile units / vehicles shall take appropriate measures that their trace always is a usable, linear trajectory leading up to current position of the vehicle. For traces generated centrally (in the TCC or C-ITS-S) for RSU-based dissemination, a method that ensures that the density of points in the trace is dependent on the curvature of the road should be used (exact method to be defined in a later	

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Table 1 DENM elements in general

Level	Name	M/O	Usage	Comment
			revision). For existing systems and if that is not possible for the road operator, equidistant points can be used instead. The most relevant trace should have up to 40 equidistant points and a maximum of 3 additional traces with each up to 40 equidistant points should be used in order not to overload the resulting DENM with trace points. Note: a suitable method that ensures the placement of points based on curvature of the road has been published in the "Automotive requirements for the Infrastructure to vehicle information (IVI) service" (RS_ARI_47 & 48) published by C2C-CC. [27] C-Roads is in the process of harmonisation of that method with C2C-CC. In all cases, the most relevant trace should have a minimum length of 600m. The possible traces leading to the event position are prioritized by relevance (which is the type of road).	
2.4	roadType	Optional	**Content:** This DE can be used to indicate the type of the road segment **Value:** The value shall be chosen from all values available in the CDD [8].	
3.0	**Alacarte Container**	**Optional**		
3.1	lanePosition	Optional	**Content:** This DE can be used to indicate the affected lane. This DE is provided for the relevant traffic direction only. **Value:** The value shall be chosen from all values available in the CDD [8].	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
3.2	impactReduction	Optional	Not used	
3.3	externalTemperature	Optional	Not used	
3.4	roadWorks	Optional	**Content:** This container shall only be used in case of RWW use cases. **Value:** The content is specified in detail in 4.2.1.3.	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
3.5	positioningSolution	Optional	Not used for I2V, but may be used for V2V by road operator vehicles.	
3.6	stationaryVehicle	Optional	Not used in Day 1. (Might be used for equipped pre-warners in future)	

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4.2.1.2 Information Quality and Triggering Conditions

The following values for Information Quality are used in the DENM Situation Container.

Table 2 Information Quality Values

Information Quality (value)	General definition in relation to EN 16157-3 (DATEX II)*	Guidance on the source of information
Certain (6)	The source is completely certain of the occurrence of the situation or event.	Recent human verification of a detected event by a qualified person who belongs to the same organisation as the source or originator of the ITS message (e.g. road operator or operator of ITS stations). Human verification can be provided by a qualified person who is on-site or observes the event via CCTV.
probable (4)	The source has a reasonably high level of confidence of the occurrence of the situation or event.	Automatic detection under conditions or within an environment, where detections are predictable.
risk of (2)	The source has a moderate level of confidence of the occurrence of the situation or event.	Automatic detection under conditions where the results are not very reliable. Or reports from experienced or trustworthy third-party organisations.
Note: DATEX II definitions in EN 16157-3 on ProbabilityOfOccurrence relate “situation record version content”, not to events in the C-ROADS terminology.		

Table 3 Information Quality related to message type (new, update, cancellation)

Message Type	Use of Information Quality
New	Information quality shall be used according to the definitions in Table 2.
Update	Information quality shall be reduced from 6 to 4 during the validity duration of the event after an update, if this update is generated automatically without reliable re-confirmation of the event. A re-confirmation should be given by a qualified person. If such re-confirmation by a qualified person is given, then the informationQuality stays at or returns to 6. Information quality is upgraded from 2 or 4 to 6 in case of human verification of the event. Note: Events can be updated by human operators or automated detection systems. If an automated detection system reports updated sensor information, then the DENM can also be updated.
Cancellation	For cancellation, the informationQuality is not relevant. The information dissemination can be ended by either sending a cancellation DENM or by no longer repeating the message. If an automated detection system reports the end of the event, then the DENM should be terminated. Note: there may be a latency between the actual end time of the event and the time of the message.

Example for changing information quality during the validity duration of an event:

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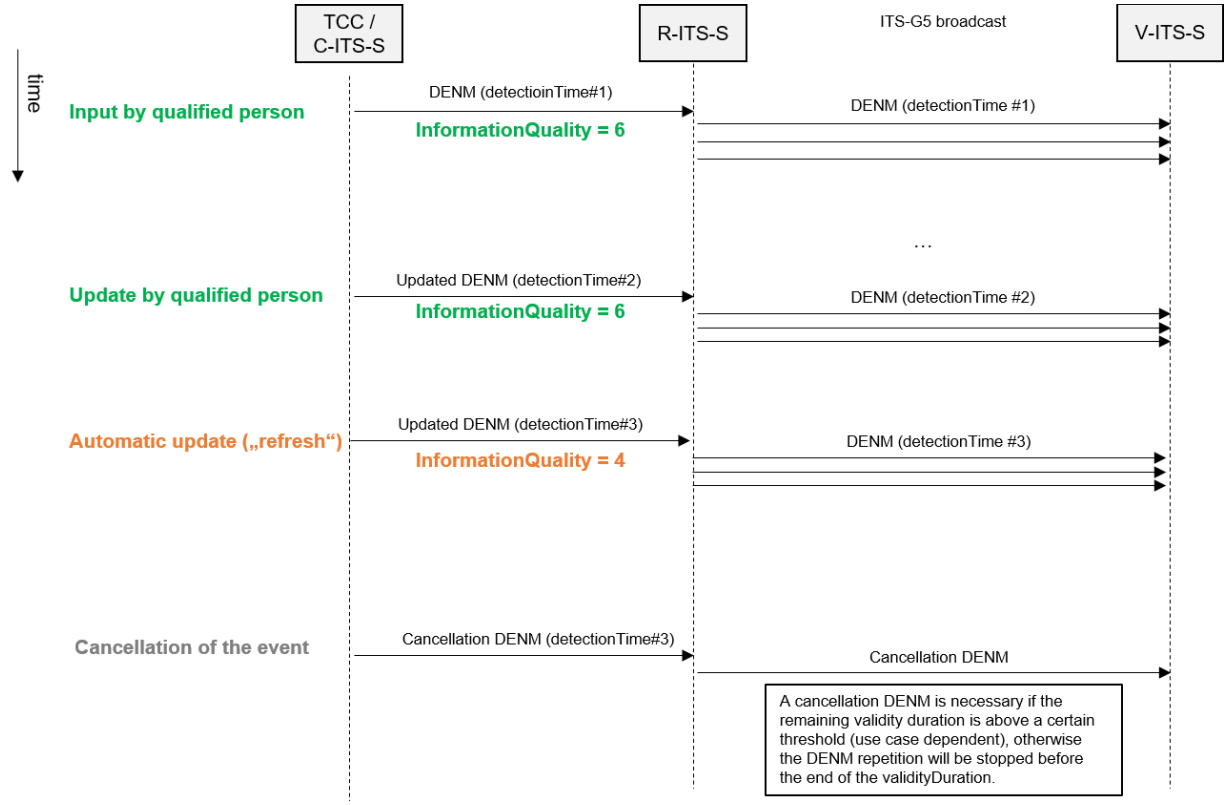

Figure 4: Example sequence diagram of informationQuality in the lifecycle of an event

4.2.1.3 Roadworks Warning (RWW)

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

Table 4 RWW and use case scenarios

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

The RWW specific usage of DENM data elements and DENM data frames is defined in Table 5.

Table 5 DENM elements specific to RWW

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level	Name	M/O	Usage	Comment
1.0	**Situation Container**	**Mandatory**		
1.2	eventType (causeCode – subCauseCode)	Mandatory	**Content:** This DF lists the relevant eventTypes for RWW use cases. **Value:** One of the following values shall be used: • causeCode 3 subCauseCode 0-6 • causeCode 15 subCauseCode 0-5, 7 • causeCode 26 subCauseCode 0-8 • causeCode 95 subCauseCode 0-2	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]

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level	Name	M/O	Usage	Comment
3.0	**Alacarte Container**	**Optional**		
3.4	**roadWorks**	**Mandatory**		
3.4.1	lightBarSirenInUse	Optional	Not used	
3.4.2	closedLanes	Optional	**Content**: This DF should be used to indicate for each lane if it is usable for driving or closed. This DF consists of innerhardShoulderStatus, outerhardShoulderStatus and drivingLaneStatus. **Value**: The lanes are counted from inside border of the road excluding the hard shoulder.	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
3.4.3	restriction	Optional	Not Used	
3.4.4	speedLimit	Optional	**Content:** This DE may be used to indicate a speed limit. **Value:** The value shall be chosen from all values available in the CDD [8].	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
3.4.5	Incident Indication	Optional	Not used.	
3.4.6	recommendedPath	Optional	**Content:** This DF should be used to indicate a recommended path to be followed. **Value:** A list of waypoints	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
3.4.7	startingPointSpeedLimit	Optional	Not used	
3.4.8	trafficFlowRule	Optional	**Content:** This DE should be used to indicate the side of the road to which the traffic should flow around a roadwork. **Value:** The value shall be chosen from all values available in the CDD [8].	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
3.4.9	referenceDenms	Optional	**Content:** This DE may be used to list the actionIds of related DENMs. **Value:** List of actionIds	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]

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4.2.1.4 Hazardous Location Notifications (HLN)

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

Table 6 DENM elements specific to Hazardous Location Notifications (HLN)

Level	Name	M/O	Usage	Comment
0.0	**Management-Container**	**Mandatory**		
0.7	awarenessTrafficDirection	Mandatory	**Content:** See Table 1 **Value:** The values shall be: upstreamTraffic (1) or downstreamTraffic (2)	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]
1.0	**Situation Container**	**Mandatory**		
1.2	eventType	Mandatory	**Content:** This DF lists the relevant eventTypes for HLN use cases. **Value:** One of the following values shall be used: • 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 3 (slow vehicle) • causeCode 27 subCauseCode 0 (Dangerous end of queue) • causeCode 94 subCauseCode 0, 2, 4 (Stationary vehicle)	See use case specific specifications in the interoperability requirements of each DENM based use case specified in C_Roads_WG2_TF2_Service and Use Case Definitions [9]

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Table 6 DENM elements specific to Hazardous Location Notifications (HLN)

Level	Name	M/O	Usage	Comment
			• causeCode 95 subCauseCode 0, 1 (Emergency vehicle approach) • causeCode 97 subCauseCode 1 (collision risk) • causeCode 99 subCauseCode 0, 1 (dangerous situation)	

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4.2.2 Infrastructure to Vehicle Information (IVI) Service (IVI FLS)

“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 roadworks warnings. IVIM either provides information of physical road signs such as static or variable road signs, virtual signs or roadworks” (ETSI TS 103 301 [11]).

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

Four types of IVIMs are generated by the IVI FLS:

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

“The type of the IVI to be generated upon an ITS-S application request" (ETSI TS 103 301 [11]).

The header of IVIM shall be as specified in the data dictionary ETSI TS 102 894-2 [8].

The data elements of the IVIM message payload are defined in CEN ISO/TS 19321 [12].

Data elements, data frames and service parameters shall be used according to the definitions in Table 7.

4.2.2.1 IVIM general elements

Table 7 IVIM elements in general

Level	Name	M/O	Usage	Comment
0.0	**IviManagementContainer**	**Mandatory**		
0.1	serviceProviderId [Provider]	Mandatory	serviceProviderId consists of data elements countryCode and providerIdentifier. countryCode is a bitstring indicating the country code according to ISO 3166-1 [13]. For Austria, for example, the bitstring stands for AT (Bitstring Code: A (11000) and T (00001) 1100000001 according to ISO 14816 [14]). IssuerIdentifier indicates the identifier of the service provider as registered. Together with iviIdentificationNumber, this is the unique identifier for messages for the receiving V-ITS-S.	
0.2	iviIdentificationNumber [IviIdentificationNumber]	Mandatory	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 service provider and can be used by other related messages as a reference.	
0.3	timestamp [TimestampIts]	Mandatory	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.	
0.4	validFrom [TimestampIts]	Optional	This component may hold the start time of the validity period of the message. It shall be present if the contained information is not yet applicable at the point in time when the message is transmitted.	

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Table 7 IVIM elements in general

Level	Name	M/O	Usage	Comment
			It shall be omitted if the contained information is applicable at the point in time when the message is transmitted. Temporal restrictions of individual signs (when a sign is either valid or invalid only for a certain time period) shall be encoded with suitable ISO14823Attributes (DTM, EDT) in the DF roadSignCodes and not by using either validFrom or validTo of the overall IVIM.	
0.5	validTo [TimestampIts]	Optional	validTo may be used to encode an end time for the overall IVI message. For an IVIM with status "new" or "update", validTo (if used) shall be set to a time at least 1 hour ahead of the time indicated by the DE timestamp. Note: Providing this end time can serve the purpose of avoiding an issue of perpetually valid IVIM in case cancellation is missed repeatedly. Hence, this component is not used for either message management or indication of the validity of the signage information. It just provides a fallback measure. Note: The minimum duration of 1 hour at the time of first transmission shall ensure that the entire area affected by the IVIM can be traversed even at slow speed and/or with pauses without the message timing out Temporal restrictions of individual signs (when a sign is either valid or invalid only for a certain time period) shall be encoded with suitable ISO14823Attributes (DTM, EDT) in the DF roadSignCodes and not by using either validFrom or validTo of the overall IVIM.	
0.6	connectedIviStructures (1..8) [IviIdentificationNumber]	Optional	IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM. connectedIviStructures may be used to connect individual, self-contained IVIMs belonging to the same event or scenario, only if the event or scenario cannot be fit into one IVIM.	
0.7	iviStatus [IviStatus]	Mandatory	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. New, update, cancellation: used. Negation: not used	

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Table 7 IVIM elements in general

Level	Name	M/O	Usage	Comment
			Message management of the IVIM is done via update and cancellation of messages based on the following principles: iviStatus shall be set to “new” for new information in the IVIM, e.g. when a new sign is activated on a previously inactive VMS or when changes in the geographic location (GLC, RCC) occur iviStatus shall be set to “update” when the information in the IVIM changes, e.g. when signs change from one state to another on a VMS without changes in the overall geographic location (GLC, RCC) iviStatus shall be set to “cancellation” when the information in the IVIM is no longer valid, e.g. when signs are switched off on a VMS or the geographical location (GLC, RCC) changes	
0.8	connectedDenms [ConnectedDenms]	Optional	List of actionIds of DENMs which are semantically connected to the IVIM.	
1.0	**GeographicLocationContainer**	**Mandatory**	**IVIM can contain more than one Geographical Location Container (GLC). An additional GLC should only be included in an IVIM if required zones cannot be defined within the value range constraints of the DF DeltaPositions towards the referencePosition.**	
1.1	referencePosition [ReferencePosition]	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 the position where the information is shown (sign or text only), and is the first point of zone definitions for Relevance Zone(s) and Detection Zone(s). The Altitude may be set to unavailable if unknown. If the altitude is provided, it is the altitude of the road.	
1.2	referencePositionTime [TimestampIts]	Optional	Not used.	
1.3	referencePositionHeading [Heading]	Optional	Not used	
1.4	referencePositionSpeed [Speed]	Optional	Not used.	
1.5	parts [GlcParts]	Mandatory	Up to 16 GlcParts can be defined in one Geographic Location Container.	

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Table 7 IVIM elements in general

Level	Name	M/O	Usage	Comment
			The definition of all geographical zones should be included in as few GlcParts as possible. IVIM shall be self-contained: definition of all zones referred to within the IVIM shall be included in the same IVIM.	
1.5.0	**GlcPart**	**Mandatory**		
1.5.1	zoneId [Zid]	Mandatory	Note: zoneId value "32" shall indicate "not used" and shall therefore not be used in the GLC as an active zoneId. This is necessary because zone assignment in the RCC can happen either in the RccPart or in the individual laneConfiguration, but due to an error in the IVI standard, zoneId is mandatory in both, without a clear definition of "not used". This definition will be added in the next version of the standard.	
1.5.2	laneNumber [LanePosition]	Optional	Mandatory if single lanes are described in this location container. Default is absent (no lane information).	
1.5.3	zoneExtension [INTEGER (0..255)]	Optional	Not used.	
1.5.4	zoneHeading [HeadingValue]	Optional	Can be used for relevance zones only to convey the effective direction of applicability of the sign at the first point of the zone, indicating the traffic direction.	
1.5.5	Zone [Zone]	Mandatory	Definition of a zone using the DF zone consisting of the choice DF segment, DF area or DF computedSegment. The Segment option shall be used 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).	
2.0	**RoadConfigurationContainer**	**Mandatory** (with exceptions, see usage)	Describes the configuration of all physically available lanes for all zones used as relevance zones. RCC shall be provided, except if the road operator does not have the information, then both RCC and applicable lanes in the GeneralIviContainer (GIC) should be omitted and only signs valid for all legally drivable lanes on the entire carriageway shall be transmitted	
2.1	**RccPart**	**Mandatory**	RccPart(1..16). One part is used for all zones in an IVIM that have the same overall characteristics, i.e. same number of driving lanes at the beginning and end	
2.1.0	relevanceZoneIds [ZoneIds]	Mandatory	List of Identifier(s) of the definition(s) of the Zone(s), to which the RccPart applies.	

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Table 7 IVIM elements in general

Level	Name	M/O	Usage	Comment
2.1.2	roadType [RoadType]	Mandatory	of all physically available lanes for all zones used as relevance zones	
2.1.3	laneConfiguration [LaneConfiguration]	Mandatory	Is a list of (1..16) instances of LaneInformation. The number of elements in the list represents the total number of lanes (including hard shoulders) of the directional carriageway.	
2.1.3.1.0	**LaneInformation**	**Mandatory**	One instance provides information about one lane. Each lane shall be represented only once.	
2.1.3.1.1	laneNumber [LanePosition]	Mandatory	Identifier of the lane. See ETSI/TS 102 894-2 [8]	
2.1.3.1.2	Direction [Direction]	Mandatory	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction. Always set to sameDirection(0).	
2.1.3.1.3	validity [InternationalSign-applicablePeriod]	Optional	Per default absent. May be set if known in case of lane management if laneType = emergency and laneStatus = provisionallyOpen.	
2.1.3.1.4	laneType [LaneType]	Mandatory	See ISO/TS 19321:2020 [12]	For motorway use cases one of the following values are typically used: `traffic (0)` `acceleration (3)`, `deceleration (4)`, emergency (18),
2.1.3.1.5	laneStatus [LaneStatus]	Mandatory	Indicates the lane status (e.g. open, closed, merge) of the Lane identified by laneNumber	
2.1.3.1.6	laneWidth [IviLaneWidth]	Optional	Should be provided if available for the road operator. Contains the width of the lane in centimetres measured at the first position of the polygonal line indicated by ZoneIds	

4.2.2.2 In-Vehicle Signage (IVS)

The In-Vehicle Signage (IVS) ITS-S application is implemented using In-Vehicle Information (IVI) messages according to (ISO 19321) [12].

IVI messages are used for the IVS ITS-S application in Austria (ECo-AT_SWP2.1_InVehicleInformation [16]), for the IVS ITS-S application in case of Roadworks (DUTCH C-ITS Corridor Profile [17]) 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) [12], Table 8 describes how respective data elements and data frames are applied. The IviManagementContainer, GeographicLocationContainer and RoadConfigurationContainer are used as profiled in chapter 4.2.2.1.

Table 8 IVIM elements specific to IVS

Level	Name	M/O	Usage	Comment
2.0	**GeneralviContainer**	**Mandatory**	Mandatory for In-Vehicle Signage (IVI-IVS). When used for other IVI based profiles, it is mandatory only when signs are present.	
2.1	**GicPart**	**Mandatory**	One GicPart per traffic sign	

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Table 8 IVIM elements specific to IVS

Level	Name	M/O	Usage	Comment
			Note: while one GicPart could in theory support up to 4 traffic signs via RSCode, these are reserved for additional signs (subsigns) that may be attached to the main sign	
2.1.1	detectionZoneIds [ZoneIds]	Mandatory	List of Identifier(s) of the definition(s) of the Detection Zone(s), using the DE Zid (1..8)	
2.1.2	its-Rrid [VarLengthNumber]	Optional	Not used.	
2.1.3	relevanceZoneIds [ZoneIds]	Mandatory	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)	
2.1.4	direction [Direction]	Mandatory	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction. Always set to sameDirection(0).	
2.1.5	driverAwarnessZoneIds [ZoneIds]	Optional	Not used.	
2.1.6	minimumAwarenessTime [INTEGER (0..255)]	Optional	Not used.	
2.1.7	applicableLanes [LanePositions]	Optional	If applicable to all lanes on a carriageway this DF may be absent. Otherwise mandatory if lane specific. Should not be used if the RCC is not provided.	
2.1.8	iviType [IviType]	Mandatory	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.	
2.1.9	iviPurpose [IviPurpose]	Optional	Not used.	
2.1.10	laneStatus [LaneStatus]	Optional	Indicates the lane status (e.g. open, closed, merge) of the applicableLanes.	
2.1.11	vehicleCharacteristics [VehicleCharacteristicsList]	Optional	vehicleCharacteristics is a sequence of CompleteVehicleCharacteristics which contains the DFs tractor, trailer and train. If present, it shall contain the definition of the characteristics of the vehicles to which the GeneralIviContainer is applicable. The component "train“, if present, shall contain the characteristics applicable to the entire vehicle train.	
2.1.12	driverVehicleCharacteristics [DriverCharacteristics]	Optional	Not used.	
2.1.13	layoutId [INTEGER(1..4,...)]	Optional	Not used.	
2.1.14	preStoredLayoutId [INTEGER(1..64,...)]	Optional	Not used.	

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Table 8 IVIM elements specific to IVS

Level	Name	M/O	Usage	Comment
2.1.15	roadSignCodes [RoadSignCodes]	Mandatory	Shall contain the definition of the road sign code. It allows different options pointing to different pictogram catalogues. The pictogram catalogue used in C-ROADS is ISO 14823. roadSignCodes specifies one road sign (including additional (sub)signs attached to it) applicable to a relevance zone. Additional attributes to the ISO 14823 road sign code can be added as provided by the ISO14823Attributes List of 1...4 of RSCode	UK RSCode - MPH not KPH for particular signs including speed
2.1.16	extraText [ConstraintTextLines1]	Optional	Can be used to present additional text associated to a sign (subpanel text) only if there is no subpanel code available in ISO 14823. One line of Text with a maximum of 32 letters per RSCode (sign or subsign) used in the GicPart. Ordered, so the first line of text corresponds to the first RSCode, the second line to the seconds RSCode, with a maximum of 4 lines. If a roadsign does not have extra text, a string with a single NULL character (ASCII 0x00) shall be added. Consists of the data elements “layoutComponentId”, “language” and “textContent” In order to be backwards compatible to version 1 of the ISO 19321 standard, layoutComponentId is mandatory here and statically set to “1” The DE language uses a bitstring representing the language according to ISO 639-1 [18], e.g. German text is encoded as DE (D (10010) and E (10000) 1001010000 according to ISO 14816 [14]). The actual text can be found in the DE textContent, which is restricted to 32 letters. Note: May be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data	
2.1.15.1	**RSCode**	**Mandatory**	It contains layoutComponentId and a code.	

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Table 8 IVIM elements specific to IVS

Level	Name	M/O	Usage	Comment
2.1.15.1.1	layoutComponentId [INTEGER(1..8,...)]	Optional	This data frame can be used to associate RSCode to the layout component of referenced layout.	
2.1.15.1.2	code [Choice]	Mandatory	For sign-coding the choice iso14823 of type ISO 14823Code (according to ISO/TS 14823 [15]) shall be used.	
2.1.15.1.2.1	**iso14823Code**	**Mandatory**	Describes the ISO 14823 encoding for an individual sign according to [15]	
2.1.15.1.2.1.1.0	**pictogramCode**	**Mandatory**	Describes the serviceCategory and pictogramCategory of individual signs according to [15]	
2.1.15.1.2.1.1.1	countryCode [OCTET STRING (SIZE (2))	Optional	Country code stipulated by ISO 3166-1 , used to distinguish the country where the individual sign is provided	
2.1.15.1.2.1.1.2	serviceCategory Code [Choice]	Mandatory	Service Category for individual signs according to [15]	
2.1.15.1.2.1.1.3	pictogramCategoryCode	Mandatory	Nature and serialNumber for individual signs according to [15]	
2.1.15.1.2.1.2.0	**attributes [ISO14823Attributes]**	**Optional**	A choice of (1..8) instances of ISO14823Attribute. Restrictions for individual signs in regard to • Validity in time (DMT, EDT) • Lane Flow (DFL) • Vehicle dimensions (VED) • Speed (SPE) • Rate if Incline (ROI) • Distance between vehicles (DBT) • Destination (DDD) shall be encoded using the appropriate attributes.	

4.2.2.3 Free Text (FT)

The Free Text (FT) ITS-S application is implemented using In-Vehicle Information (IVI) messages according to (ISO 19321) [12].

IVI messages are used for the FT ITS-S application in Austria (ECo-AT_SWP2.1_InVehicleInformation [16]), for the IVS ITS-S application in case of Roadworks (DUTCH C-ITS Corridor Profile [17]) 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) [12], Table 9 describes how respective data elements and data frames from the TextContainer are applied. The IviManagementContainer, GeographicLocationContainer, GeneralIviContainer and RoadConfigurationContainer are used as profiled in chapter 4.2.2.1, with the only difference that the GeneralviContainer is optional in a Free Text scenario.

Table 9 IVIM elements specific to FT

Level	Name	M/O	Usage	Comment
2.0	**GeneralviContainer**	**Optional**	Only to be used if the Free Text Information also contains a traffic sign. Used as profiled in chapter 4.2.1.1	
3.0	**TextContainer**	**Mandatory**		
3.1	TcPart	Mandatory	All free text information belonging to one zone in one TcPart	

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Table 9 IVIM elements specific to FT

Level	Name	M/O	Usage	Comment
3.1.1	detectionZoneIds [ZoneIds]	Mandatory	List of Identifier(s) of the definition(s) of the Detection Zone(s), using the DE Zid (1..8)	
3.1.3	relevanceZoneIds [ZoneIds]	Mandatory	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)	
3.1.4	direction [Direction]	Mandatory	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction. Always set to sameDirection(0).	
3.1.5	driverAwarnessZoneIds [ZoneIds]	Optional	Not used.	
3.1.6	minimumAwarenessTime	Optional	Not used.	
3.1.7	applicableLanes [LanePositions]	Optional	If applicable to all lanes on a carriageway this DF may be absent. Otherwise used if lane specific.	
3.1.8	iviType [IviType]	Mandatory	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.	
3.1.10	laneStatus [LaneStatus]	Optional	Indicates the lane status (e.g. open, closed, merge) of the applicableLanes.	
3.1.11	vehicleCharacteristics [VehicleCharacteristicsList]	Optional	vehicleCharacteristics is a sequence of CompleteVehicleCharacteristics which contains the DFs tractor, trailer and train. If present, it shall contain the definition of the characteristics of the vehicles to which the GeneralIviContainer is applicable. The component "train“, if present, shall contain the characteristics applicable to the entire vehicle train.	
3.1.12	text [TextLines]	Mandatory	textLines is a sequence [1..4] of DF Text, containing the Free Text Information. The complete Free Text information can be represented in one instance of the DF Text, which has no size restriction. Other instances of DF Text can be used to express the same text in different languages. DF Text consists of the mandatory data elements “language” and “textContent” The DE language data uses a bitstring representing the language according to ISO 639-1 [18], e.g. German text is encoded as DE (D (10010) and E (10000) 1001010000 according to ISO 14816 [14]). The actual Free Text can be found in the DE textContent, which is an UTF8String without a size restriction.	

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Table 9 IVIM elements specific to FT

Level	Name	M/O	Usage	Comment
			Note: May be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data.	
3.1.13	Data [OctetString]	Mandatory	Meant for a binary representation of text in a picture. Due to an error in the standard, this DE is mandatory and therefore will be set to an empty string.	
4.1.3.1.6	laneWidth [IviLaneWidth]	Optional	If present, contains the width of the lane in centimetres measured at the first position of the polygonal line indicated by ZoneIds	

4.2.2.4 Automated Vehicle Guidance (AVG)

The Automated Vehicle Guidance (AVG) ITS-S application is implemented using In-Vehicle Information (IVI) messages according to (ISO 19321) [12].

IVI messages are used for the Automated Driving application in Austria (C-ITS for Automated Driving - SWP1.2 - Functional Specification v01.00 [23]).

Since all implementations are making use of the IVI standard (ISO 19321) [12], Table 10 describes how respective data elements and data frames from the AutomatedVehicleContainer are applied. The IviManagementContainer, GeographicLocationContainer and RoadConfigurationContainer are used as profiled in chapter 4.2.2.1.

Table 10 IVIM elements specific to AVG

Level	Name	M/O	Usage	Comment
2.0	**AutomatedVehicleContainer**	**Mandatory**		
2.1.0	**AvcPart**	**Mandatory**	AcvPart (1..16). Up to 16 AvcParts can be defined in one AutomatedVehicleContainer. It contains at least two zones, one for relevance and one for detection.	
2.1.1	detectionZoneIds [ZoneIds]	Mandatory	List of Identifier(s) of the definition(s) of the Detection Zone(s), using the DE Zid (1..8)	
2.1.2	relevanceZoneIds [ZoneIds]	Mandatory	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)	
2.1.3	direction [Direction]	Mandatory	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction. Always set to sameDirection(0).	
2.1.4	applicableLanes (1..8) [LanePositions]	Optional	If applicable to all lanes on a carriageway this DE may be absent. Otherwise used if lane specific.	
2.1.5	vehicleCharacteristics	Optional	vehicleCharacteristics is a sequence of CompleteVehicleCharacteristics which contains the DFs tractor, trailer and train. If present, it shall contain the definition of the characteristics of the vehicles to which the Automated Vehicle container is applicable. The component "train“, if present, shall contain the characteristics applicable to the entire vehicle train.	
2.1.6.0	**automatedVehicleRules**	**Mandatory** (for UC: SAE Level Guidance,		

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Table 10 IVIM elements specific to AVG

Level	Name	M/O	Usage	Comment
	[List of AutomatedVehicleRule]	otherwise absent)		
2.1.6.1.0	**AutomatedVehicleRule**	**Mandatory**	AutomatedVehicleRule (1..5). Up to 5 rules can be defined in AutomatedVehicleRules	
2.1.6.1.1	Priority [PriorityLevel]	Mandatory	Level of priority of the information. 0 is lowest, 2 is highest. Shall be set to value 0 for use case SAE Level Guidance.	
2.1.6.1.2	allowedSaeAutomationLevels [SaeAutomationLevel]	Mandatory	A list of automation levels (0-5) according to SAE J3016. As the use case SAE Level Guidance informs about SAE levels road operators find unsuitable for automated driving on a selected segment, the respective opposite levels shall be encoded in this DE. If for example SAE levels 4 and 5 are unsuitable from the road operator's point of view, levels 0, 1, 2, and 3 shall be put into allowedSaeAutomationLevels. Note: See use case description for any further information about the use case.	
2.1.6.1.3	minGapBetweenVehicles [GapBetweenVehicles]	Optional	A recommendation for the minimum distance between vehicles when using automated driving functions, measured from the rear bumper of the preceding vehicle to the front bumper of the following automated vehicle, in meters.	
2.1.6.1.4	recGapBetweenVehicles [GapBetweenVehicles]	Optional	A recommendation for the optimal distance between vehicles when using automated driving functions, measured from the rear bumper of the preceding vehicle to the front bumper of the following automated vehicle, in meters.	
2.1.6.1.5	automatedVehicleMaxSpeedLimit [SpeedValue]	Optional	A recommendation for the maximum speed when using automated driving functions, applicable to all vehicle types listed in vehicleCharacteristics, in km/h.	
2.1.6.1.6	automatedVehicleMinSpeedLimit [SpeedValue]	Optional	A recommendation for the minimum speed when using automated driving functions, applicable to all vehicle types listed in vehicleCharacteristics, in km/h.	
2.1.6.1.7	roadSignCodes [RoadSignCodes]	Optional	Shall contain the definition of the road sign code. It allows different options pointing to different pictogram catalogues. The pictogram catalogue used in C-ROADS is ISO 14823. Therefore, if used, DE code in DF RSCode shall be set to iso14823. roadSignCode specifies which road signs are applicable for a Relevance Zone. Additional attributes to the ISO 14823 road sign code can be added as provided by the ISO14823Attributes.	
2.1.6.1.8	extraText [ConstraintTextLines2]	Optional	Can be used to present additional text associated to a sign (subpanel text). One line of Text with a maximum of 32 per letters per RSCode (sign or subsign) used in the GicPart. Ordered, so the first line of text	

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Table 10 IVIM elements specific to AVG

Level	Name	M/O	Usage	Comment
			corresponds to the first RSCode, the second line to the seconds RSCode, with a maximum of 4 lines. If a roadsign does not have extra text, a string with a single NULL character (ASCII 0x00) shall be added. Consists of the data elements “language” and “textContent” The DE language uses a bitstring representing the language according to ISO 639-1 [18], e.g. German text is encoded as DE (D (10010) and E (10000) 1001010000 according to ISO 14816 [14]). The actual text can be found in the DE textContent, which is restricted to 32 letters Note: May be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data.	
2.1.7.0	**platooningRules [List of PlatooningRule]**	**Mandatory** (for UC: Platoon Support Information , otherwise absent)		
2.1.7.1.0	**PlatooningRule**	**Mandatory**	PlatooningRule (1..5). Up to 5 rules can be defined in AutomatedVehicleRules	
2.1.7.1.1	Priority [PriorityLevel]	Mandatory	Level of priority of the information. 0 is lowest, 2 is highest. Shall be set to value 0 for use case SAE Level Guidance.	
2.1.7.1.2	allowedSaeAutomationLevels [SaeAutomationLevel]	Mandatory	A list of automation levels (0-5) according to SAE J3016. As the use case Platoon Support Information informs about SAE levels road operators find unsuitable for platooning on a selected segment, the respective opposite levels shall be encoded in this DE. If for example SAE levels 4 and 5 are unsuitable for platooning from the road operator’s point of view, levels 0, 1, 2, and 3 shall be put into allowedSaeAutomationLevels. Note: See use case description for any further information about the use case.	
2.1.7.1.3	maxNoOfVehicles [MaxNoOfVehicles]	Optional	A recommendation for the maximum allowed number of vehicles in the platoon including the platoon leader.	
2.1.7.1.4	maxLenghtOfPlatoon [MaxLenghtOfPlatoon]	Optional	A recommendation for the maximum length of the platoon in units of 10 meters.	
2.1.7.1.5	minGapBetweenVehicles	Optional	A recommendation for the minimum distance between vehicles when using platooning, measured from the rear bumper of the	

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Table 10 IVIM elements specific to AVG

Level	Name	M/O	Usage	Comment
	[GapBetweenVehicles]		preceding vehicle to the front bumper of the following automated vehicle, in meters.	
2.1.7.1.6	platoonMaxSpeedLimit [SpeedValue]	Optional	A recommendation for the maximum speed when using platooning, applicable to all vehicle types listed in vehicleCharacteristics, in km/h.	
2.1.7.1.7	platoonMinSpeedLimit [SpeedValue]	Optional	A recommendation for the minimum speed when using platooning, applicable to all vehicle types listed in vehicleCharacteristics, in km/h.	
2.1.7.1.8	roadSignCodes [RoadSignCodes]	Optional	Shall contain the definition of the road sign code. It allows different options pointing to different pictogram catalogues. The pictogram catalogue used in C-ROADS is ISO 14823. Therefore, if used, DE code in DF RSCode shall be set to iso14823. roadSignCode specifies which road signs are applicable for a Relevance Zone. Additional attributes to the ISO 14823 road sign code can be added as provided by the ISO14823Attributes.	
2.1.7.1.9	extraText [ConstraintTextLines2]	Optional	Can be used to present additional text associated to a sign (subpanel text). One line of Text with a maximum of 32 per letters per RSCode (sign or subsign) used in the GicPart. Ordered, so the first line of text corresponds to the first RSCode, the second line to the seconds RSCode, with a maximum of 4 lines. If a roadsign does not have extra text, a string with a single NULL character (ASCII 0x00) shall be added. Consists of the data elements “language” and “textContent” The DE language uses a bitstring representing the language according to ISO 639-1 [18], e.g. German text is encoded as DE (D (10010) and E (10000) 1001010000 according to ISO 14816 [14]). The actual text can be found in the DE textContent, which is restricted to 32 letters Note: May be ignored by receiving vehicles (i.e. neither evaluated nor shown to the driver) and should only be used for informative and not regulatory data.	

4.2.2.5 HD Topology (HDT)

The HD Topology (HDT) ITS-S application is implemented using In-Vehicle Information (IVI) messages according to (ISO 19321) [12].

Since all implementations are making use of the IVI standard (ISO 19321) [12], Table 11 describes how respective data elements and data frames from the RoadConfigurationContainer are applied. The IviManagementContainer and the GeographicLocationContainer are used as profiled in chapter 4.2.2.1. The GeneralIviContainer is used as profiled in chapter 4.2.2.1.

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Table 11 IVIM elements specific to HDT

Level	Name	M/O	Usage	Comment
1.0	**RoadConfiguration Container**	**Optional**	Describes the topology and driving lane configuration for a road section	
1.1	**RccPart**	**Mandatory**	RccPart(1..16). One part is used for all zones in an IVIM that have the same overall characteristics, i.e. same number of driving lanes at the beginning and end	
1.1.0	relevanceZoneIds [ZoneIds]	Mandatory	Set to 32 (“not used”) as the specific information about relevance zones is indicated for each lane individually in the laneConfiguration / LaneInformation. Note: the standard indicates to use “0” in that case, which is not possible, as Zid is defined as Zid::= INTEGER (1..32,...). This will be corrected in the next revision in the standard	
1.1.2	roadType [RoadType]	Mandatory	Defined in ETSI/TS 102 894-2 [8]	
1.1.3	laneConfiguration [LaneConfiguration]	Mandatory	Is a list of (1..16) instances of LaneInformation. One lane can be represented multiple times if the topology changes.	
1.1.3.1.0	**LaneInformation**	**Mandatory**	One instance provides information about one lane. One lane can be represented multiple times if the topology changes.	
1.1.3.1.1	laneNumber [LanePosition]	Mandatory	Identifier of the lane. See ETSI/TS 102 894-2 [8]	
1.1.3.1.2	Direction [Direction]	Mandatory	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction. Always set to sameDirection(0).	
1.1.3.1.3	validity [InternationalSign-applicablePeriod]	Optional	Per default absent. May be set if known in case of lane management if laneType = emergency and laneStatus = provisionallyOpen.	

1.1.3.1.4	laneType [LaneType]	Mandatory	See ISO/TS 19321:2020 [12]	For motorway use cases one of the following values are typically used:
				`traffic (0)`
				`acceleration (3),`
				`deceleration (4),`
				`emergency (18)`

1.1.3.1.5	laneStatus [LaneStatus]	Mandatory	Indicates the lane status (e.g. open, closed, merge, diverge) of the Lane identified by laneNumber	
1.1.3.1.6	laneWidth [IviLaneWidth]	Optional	If present, contains the width of the lane in centimetres measured at the first position of the polygonal line indicated by ZoneIds	
1.1.3.1.7	detectionZoneIds [ZoneIds]	Mandatory	Indicate the identifier(s) of the detection zone(s) for the individual lane	
1.1.3.1.7	relevanceZoneIds [ZoneIds]	Mandatory	Indicate the identifier(s) of the relevance zone(s) for the individual lane	

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Table 11 IVIM elements specific to HDT

Level	Name	M/O	Usage	Comment
1.1.3.1.8.0	**lanecharacteristics [LaneCharaceristics]**	**Mandatory**		
1.1.3.1.8.1	zoneDefinitionAccuracy [DefinitionAccuracy]	Mandatory	Indicates the accuracy of the zone's geographic information in the centimeter or meter range, from oneCm(0) to oneMeter(6) in various steps. Set to unavailable if not known.	
1.1.3.1.8.2	existinglaneMarkingStatus [LaneMarkingStatus]	Mandatory	Indicates the status of the pre-existing, original lane markings. Set to TRUE if the original markings are still in effect, set to FALSE if they are not.	
1.1.3.1.8.3	newLaneMarkingColour [MarkingColour]	Mandatory	Indicates the colour of new lane markings. Set to unvailable if no new lane markings are used.	

1.1.3.1.8.4	laneDelimitationLeft [LaneDelimitation]	Mandatory	Indicates the type of lane delimitation on the left side of the lane in direction of traffic.	`noDelimitation(0)`
				`lowLaneSeparator (1): continuous or discontinuous separator(s) of total height inferior to 10 cm.`
				`highLaneSeparator(2): discontinuous separator(s) of total height superior to 10 cm`
				`wall(3): continuous separator of height superior to 10 cm`
				`curb(4): curb of e.g. a sidewalk`
				`unpaved(5)`
				`guardrail(6)`

1.1.3.1.8.5	laneDelimitationRight [LaneDelimitation]	Mandatory	Indicates the type of lane delimitation on the left side of the lane in direction of traffic.	Same as above
1.1.3.1.8.6	mergingWith [Zid]	Mandatory	Indicates the id of zone(s) with which the lane is merging or diverging. As this is a mandatory DE, the maximum value of "32" shall be used to indicate "not used" if there is no merging or diverging occurring.	

4.2.2.6 Destination Travel Time (DTT)

The Destination Travel Time (DTT) ITS-S application is implemented using In-Vehicle Information (IVI) messages according to (ISO 19321) [12].

Since all implementations are making use of the IVI standard (ISO 19321) [12], Table 10 describes how respective data elements and data frames from the ISO14823Code [15] are applied in the GeneralIviContainer. The rest of elements and data frames are used as profiled in chapter 4.2.2.1. Table 11, on the other hand, describes the respective data elements and data frames of GDD attribute, InternationalSign-DestinationInformation.

The IviManagementContainer, GeographicLocationContainer and RoadConfigurationContainer are used as profiled in chapter 4.2.2.1.

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Table 12 IVIM elements specific to DTT

Level	Name	M/O	Usage	Comment
1.0	**RSCode**	**Mandatory**	It contains layoutComponentId and a code.	
1.1	layoutComponentId [INTEGER(1..8,...)]	Not used	This data frame can be used to associate RSCode to the layout component of referenced layout.	
1.2	code [Choice]	Mandatory	For destination travel time, the choice iso14823 of type ISO 14823Code (according to ISO/TS 14823 [15]) shall be used. This data frame includes several DFs and DEs. 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	
1.2.1	**iso14823Code**	**Mandatory**	Describes the ISO 14823 Code encoding for an individual sign according to [15]	
1.2.1.1.0	**pictogramCode**	**Mandatory**	Describes the serviceCategory and pictogramCategory of individual signs according to [15]	
1.2.1.1.1	countryCode [OCTET STRING (SIZE (2))	Optional	Country code stipulated by ISO 3166-1 is used to distinguish the country where the individual sign is provided	
1.2.1.1.2	serviceCategoryCode [Choice]	Mandatory	For destination travel time, the choice – **informative** shall be used.	
1.2.1.1.3	pictogramCategoryCode	Mandatory	For destination travel time, nature – **1**, serialNumber – **11** shall be used, if no specific reason (e.g. traffic jam) for the travel time is given.	
1.2.1.2	**attributes [ISO14823Attributes]**	**Mandatory**	For Destination Travel Time, **ddd** [**InternationalSign-destinationInformation]** attribute shall be used	

Table 13 GDD attribute elements specific to Destination Information (DDD)

2.0	**ddd [IntenationalSign-destionationInformation]**	**Mandatory**		
2.1	junctionDirection [INTEGER(1..128)]	Optional	Should only be used, if a digital representation of a VMS/road sign is sent. Not used otherwise	
2.2	roundaboutCwDirection [INTEGER(1..128)]	Optional	Should only be used, if a digital representation of a VMS/road sign is sent. Not used otherwise	
2.3	roundaboutCcwDirection [INTEGER(1..128)]	Optional	Should only be used, if a digital representation of a VMS/road sign is sent. Not used otherwise	

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2.4	**ioList [DDD-IO-LIST]**	**Mandatory**	a list of (1..8) instances of DDD-IO. At least 1 DDD-IO is mandatory	
2.4.1.0	**DDD-IO**	**Mandatory**	A sequence of the following sub-DFs. A single DDD-IO represents a sequence of destination and the corresponding travel time	Multiple DDD-IO can be added for a single destination if there are more than 1 route (hence different travel time)
2.4.1.1	ArrowDirection [INTEGER(0..7)]	Mandatory	Direction of the arrow associated with the Sign Destination.	Interpretation of the values: 0 north, 1 north-east, 2 east, 3 south-east, 4 south, 5 south-west, 6 west, 7 north-west
2.4.1.2	destPlace [DestinationPlaces]	Optional	**Mandatory** if the destination is a place	
2.4.1.2.1.0	**destinationPlace**	**Mandatory**	A sequence of destType, destRScode, destBlob, placeNameIdentification, placeNameText	
2.4.1.2.1.1	destType	Mandatory	DestinationType: Code that indicates the type of area that may serve as a destination on a trip. INTEGER { none (0), importantArea (1), principalArea (2), generalArea (3), wellKnownPoint (4), country (5), city (6), street (7), industrialArea (8), historicArea (9), touristicArea (10), culturalArea (11), touristicRoute (12), recommendedRoute (13), touristicAttraction (14), geographicArea (15) } (0..15, ...)	
2.4.1.2.1.2	destRScode [GddStructure]	Optional	Not used	
2.4.1.2.1.3	destBlob [OCTET STRING]	Optional	Additional information associated to a destination place such as an image.	
	placeNameIdentification [INTEGER(1..999)]	Mandatory	Place name identification using integer.	Shall be unique for each place
	PlaceNameText [UTFString]	Mandatory	Place name using text.	
2.4.1.3	destRoad [DestinationRoads]	Optional	**Mandatory** if the destination is a road	
2.4.1.3.1.0	**destinationRoad**	**Mandatory**	A sequence of derType, roadNumberIdentifier, roadNumberText	
2.4.1.3.1.1	derType [DestinationRoadType]	Mandatory	DestinationRoadType – Code that indicates the type of roadway. INTEGER { none (0), nationalHighway (1), localHighway (2), tollExpresswayMotorway (3),	Integer 12, 13, 14, 15 are reserved for future use

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			internationalHighway (4), highway (5), expressway (6), nationalRoad (7), regionalProvincialRoad (8), localRoad (9), motorwayJunction (10), diversion (11), rfu1 (12), rfu2 (13), rfu3 (14), rfu4 (15) } (0..15, ...)	
2.4.1.3.1.2	roadNumberIdentifier [INTEGER 1..999]	Mandatory	An identifier of the road using integer.	Shall be unique for each road
2.4.1.3.1.3	roadNumberText [UTFString]	Mandatory	An identifier of the road using text.	
2.4.1.5	streetName [INTEGER 1..999]	Optional	An identifier of the street using integer.	Shall be unique for each street
2.4.1.6	StreetNameText [UTFString]	Optional	An identifier of the street using text. This can be used to show different travel time via a particular street in each DDD-IO (data element 2.4.1.0) for a same destination.	For example: DDD-IO 1: destinationPlace-cityHall, streetNameText: X, 10 min DDD-IO 2: destinationPlace – cityHall, streetNameText: Y, 17 min
2.4.1.7	distanceToDivergingPoint [DistanceOrDuration]	Optional	Not used	
2.4.1.8.0	distanceToDestinationPlace [DistanceOrDuration]	Mandatory	Distance or duration to the destination place.	
2.4.1.8.1	value [INTEGER (1..16384)	Mandatory	Distance or duration expressed in integer	
2.4.1.8.2	Unit [Code-Units]	Mandatory	A code that identifies the units of measurement. Value 9 (minuteOfTime) shall be used INTEGER { kmperh (0), milesperh (1), kilometre (2), metre (3), decimetre (4), centimetre (5), mile (6), yard (7), foot (8), minutesOfTime (9), tonnes (10), hundredkg (11), pound (12), rateOfIncline (13), durationinminutes (14) — value 15 reserved for future use } (0..15)	

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4.2.3 Traffic Light Manoeuvre (TLM) and Road and Lane Topology (RLT) Service (TLM FLS and RLT FLS)

Traffic Light Manoeuvre (TLM)

The TLM FLS is one instantiation of the infrastructure services to manage the generation, transmission and reception of SPATEM messages. The TLM FLS includes safety-related information for supporting traffic participants (vehicles, pedestrians, etc.) to execute safe manoeuvres in an intersection area. The goal is to enter and exit an intersection "conflict area" in a controlled way. The TLM FLS informs in real-time about the operational states of the traffic light controller, the current signal state, the residual time of the state before changing to the next state, the allowed manoeuvres and aids with crossing. Additionally, the TLM FLS foresees the inclusion of detailed green way advisory information and the status for public transport prioritization.

Road and Lane Topology (RLT)

The RLT FLS is one instantiation of the infrastructure services to manage the generation, transmission and reception of a digital topological map, which defines the topology of an infrastructure area. It includes the lane topology for e.g. vehicles, bicycles, parking, public transportation and the paths for pedestrian crossings and the allowed maneuvers within an intersection area or a road segment.. Examples for describing topology with the data structures offered by MAPEM are provided in Annex G of ISO TS 19091 [21] and the European handbook for MAPEM and SPATEM creation [25].

Operational parameters and relevant standards

The TLM and RLT FLSs including operational parameters are defined in ETSI TS 103 301 [11], which refers to ISO TS 19091 [21], which in turn refers to SAE J2735 [22]. Data elements, data frames and service parameters shall be used according to the definitions in Table 15 to 15.9 and Table 16 to 16.7. Wherever the profile indicates ‘not used’ this means: not used for current ITS-S application, kept optional for future ITS-S application, therefore use is not forbidden. The header of MAPEM/SPATEM shall be as specified in the data dictionary ETSI TS 102 894-2 [8].
The relationships of the tables of MAPEM are depicted in Figure 5 and in Figure 6 for the relationship of the SPATEM tables.

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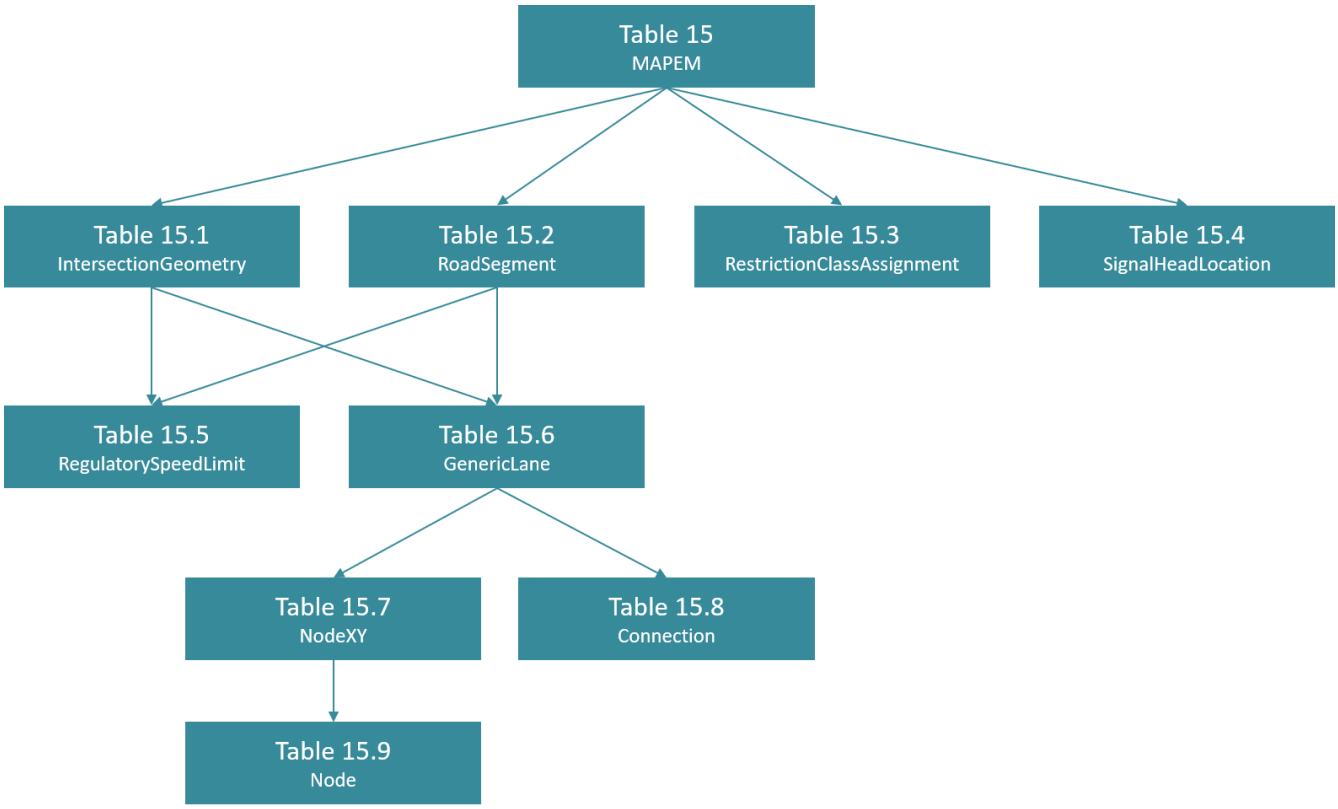

Figure 5 relationship of MAPEM data element tables

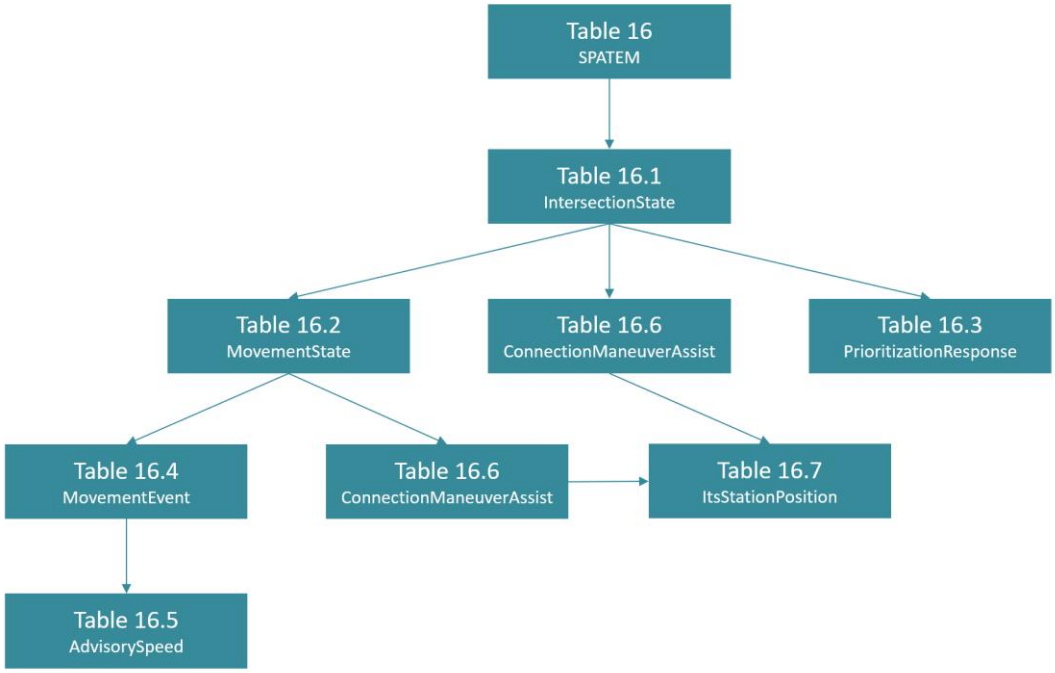

Figure 6 relationship of SPATEM data element tables

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4.2.3.1 Parameter settings

The parameters in the table below are cited in the requirement tables.

Table 14 Service parameters associated with TLM and RLT FLS

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
dRangeIdUnique	5	km	Radius around every intersection within which the *IntersectionID* tuple shall be unique	5	--	--
pLateralNodeOffset	3	m	Maximum lateral offset to the center of the lane for the node points within a MAP	--	--	--
pLaneAngleDeviation	5	°	Maximum angle between the connection of the node points and the corresponding tangent to the lane center	--	--	--
pMaxPerpendDistLaneCenter	3	m	Maximum perpendicular distance between the linear connection of two consecutive lane nodes and the actual center of the lane	--	--	--
pMaxNoOfNodesPerLane	18	--	Maximum allowed number of nodes per lane Note: It is a recommendation to stay below this number to control the message size, however for the sake of functionality exceptions are possible.	--	--	--
pMinLaneWidth	2.6	m	Minimum (normal) width of a merging/diverging lane before enabling/disabling the taper to left / right indication	--	--	--
pMinIngressLaneLength	300	m	Minimum length of an ingress lane representation in MAPEM, unless the lane ends earlier for example at the adjacent intersection	--	--	--
pSpeedLimitHigh	60	kph	Allowed speed limit above which the required minimum ingress lane length is increased	--	--	--
pMinIngressLaneLengthHighSpeed	500	m	Minimum length of an ingress lane representation in MAPEM for an allowed speed limit above *pSpeedLimitHigh*	--	--	--
pMinEgressLaneLength	5	m	Minimum length of an egress lane representation in MAPEM	--	--	--
pTimeMarkUnknown	36001	1/10 s	Value to indicate an unknown *TimeMark*	--	--	[SAE J2735 2016-01]
pTimeMarkMin	0	1/10 s	Minimum value of *TimeMark*	--	--	[SAE J2735 2016-01]
pTimeMarkOutOfRange	36000	1/10 s	Value to indicate an instant which is not in the UTC hour of the referenced instant	--	--	[SAE J2735 2016-01]
tTimeOfChangeAccuracy	500	ms	Accuracy of phase state change time information for signal controllers operating at fixed time	--	--	--
tDelayFailureTransmission	200	ms	Maximum allowed delay between the instant the traffic light controller goes into failure until the information is being transmitted	--	--	--

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4.2.3.2 MAPEM general elements

Table 15 MAPEM data elements

Level	Name	Type	M/O	Usage	Comment
0.0	mapData	DF	Mandatory		
0.1	timeStamp	DE	Optional	Not used.	
0.2	msgIssue Revision	DE	Mandatory	Set to 0. As defined in ISO TS 19091.	
0.3	layerType	DE	Optional	Not used.	
0.4	layerID	DE	Optional	If needed, fragmentation can be applied as defined in ISO 19091 section G.8.3.2 on DE_LayerID	There do not exist requirements on logical fragmentation, e.g. full lanes, approaches or otherwise. Fragmentation is simply size- based. Also there do not exist requirements on the order of reception of fragments. The receiver shall be able to assemble the messages. The revision number of the MAPEM assures which fragments belong together. Validation of MAPEM shall be done on the message level, not the fragment level.
0.5	intersections (1..32)	DF	Optional	IntersectionGeometryList ::= SEQUENCE (SIZE(1..32)) OF IntersectionGeometry (see table 15.1) The component 'intersections' shall be present in any MAPEM that describes one or more intersection areas or other areas that include traffic lights such as urban intersections, roundabouts or toll stations. Not used when MAPEM only provides road segments. In case of tolling stations, every direction at the tolling station shall be encoded in a dedicated intersection. Therefore, the number of intersections in intersections field of MapData reflects all the available traffic direction at the tolling station.	
0.6	roadSegments (1..32)	DF	Optional	RoadSegmentList ::= SEQUENCE (SIZE(1..32)) OF RoadSegment (see table 15.2) Mandatory to describe roadway segments without intersections (e.g. roadworks) and without traffic lights.	No SPAT message can be linked to a MapData described with RoadSegments.
0.7	dataParameters	DF	Optional		
0.7.1	processMethod	DE	Optional	Not used.	

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Table 15 MAPEM data elements

Level	Name	Type	M/O	Usage	Comment
0.7.2	processAgency	DE	Optional		
0.7.3	lastCheckedDate	DE	Optional	as: yyyy-mm-dd	
0.7.4	geoidUsed	DE	Optional	Not used.	
0.8	restrictionList (1..32)	DF	Optional	RestrictionClassList ::= SEQUENCE (SIZE(1..254)) OF RestrictionClassAssignment (see table 15.3).	
0.9	regional	DE	Optional	REGION.Reg-MapData. Not used.	
0.9.1	signalHeadLocations	DF	Optional	SignalHeadLocationList ::= SEQUENCE (SIZE(1..64)) OF SignalHeadLocation (see table 15.4) Not used.	

Table 15.1 IntersectionGeometryList → IntersectionGeometry

Level	Name	Type	M/O	Usage	Comment
1.0	intersectionGeometry	DF	Mandatory	Mandatory if 'intersections' is used.	
1.1	name	DE	Optional	Typically, human readable and recognizable by road authority.	
1.2	id	DF	Mandatory	(IntersectionReferenceID) The id shall be identical to the appropriate id tuple of the corresponding SPATEM 'intersectionState'. The combination of region and id shall be unique within a country.	This applies specifically to cases where multiple intersections are conveyed in one MAPEM/SPATEM combination.
1.2.1	region	DE	Mandatory		RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs to intersections.
1.2.2	id	DE	Mandatory	The region-id combination shall be unique within a radius of *dRangeIdUnique* around each intersection.	The uniqueness within a radius is to ensure backwards compatibility with short-range communication deployments.
1.3	revision	DE	Mandatory	The revision number must be increased by 1 each time the MapData of this intersection changes. The revision numbers of SPATEM and MAPEM must be the same as an indication that the right MAPEM revision is used. As defined in ISO TS 19091.	

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Table 15.1 IntersectionGeometryList → IntersectionGeometry

Level	Name	Type	M/O	Usage	Comment
1.4	refPoint	DF	Mandatory	The reference point shall be roughly at the centre of the conflict area, which is demarcated by the 1st nodes of the ingress and egress lanes.	
1.4.1	lat	DE	Mandatory		
1.4.2	long	DE	Mandatory		
1.4.3	elevation	DE	Optional	Not used. Replaced by regional Reg-Position3D.	
1.4.4	regional	DF	Optional	REGION.Reg-Position3D-addGrpC. Optional. When given provides altitude.	
1.4.4.1	altitude	DF	Mandatory	Consists of altitudeValue and altitudeConfidence	
1.4.4.1.1	altitudeValue	DE	Mandatory		
1.4.4.1.2	altitudeConfidence	DE	Mandatory	When not available set to (15) = unavailable.	
1.5	laneWidth	DE	Optional	Provides the default width of the intersection, while deviations from this lane width are provided using dWidth. Also see *pMinLaneWidth.*	
1.6	speedLimits (1..9)	DF	Optional	SpeedLimitList ::= SEQUENCE (SIZE(1..9)) OF RegulatorySpeedLimit (see table 15.5).	
1.7	laneSet (1..255)	DF	Mandatory	LaneList shall include all vehicle lanes of an intersection and all other lanes of an intersection that have signalized connections (e.g. including lanes for pedestrians (crosswalk), cyclists (bikeLane), tracked vehicles (trackedVehicles) and busses (vehicle)). In case of tolling stations, LaneSet shall contain all ingress and egress lanes at the tolling barrier for the current intersection geometry. Thus, the number of lanes in laneSet shall include at least two times the number of tolling lanes LaneList ::= SEQUENCE (SIZE(1..255)) OF GenericLane (see table 15.6).	In case of tolling stations, LaneSet shall contain all ingress and egress lanes at the tolling barrier for the current intersection geometry. Thus, the number of lanes in laneSet should include at least two times the number of tolling lanes
1.8	preemptPriorityData (1..32)	DF	Optional	Not used. Data elements within are not further profiled.	

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Table 15.1 IntersectionGeometryList → IntersectionGeometry

Level	Name	Type	M/O	Usage	Comment
1.9	regional	DF	Optional	Not used. REGION.Reg-IntersectionGeometry- addGrpC.	

Table 15.2 RoadSegmentList → RoadSegment

Level	Name	Type	M/O	Usage	Comment
1.0	RoadSegment	DF	Mandatory	Mandatory if 'roadSegment' is used.	
1.1	name	DE	Optional	Typically, human readable and recognizable by road authority.	
1.2	id	DF	Mandatory	(RoadSegmentReferenceID) The combination of region and id shall be unique within a country.	
1.2.1	region	DE	Mandatory		RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs to road segments.
1.2.2	id	DE	Mandatory	The region-id combination shall be unique within a radius of *dRangeIdUnique* around each road segment.	The uniqueness within a radius is to ensure backwards compatibility with short-range communication deployments.
1.3	revision	DE	Mandatory	The revision number must be increased by 1 each time the MapData of this road segment changes. As defined in ISO TS 19091.	
1.4	refPoint	DF	Mandatory	The reference point can be at the beginning or end of the road section described.	
1.4.1	lat	DE	Mandatory		
1.4.2	long	DE	Mandatory		
1.4.3	elevation	DE	Optional	Not used. Replaced by regional Reg-Position3D.	
1.4.4	regional	DF	Optional	REGION.Reg-Position3D-addGrpC. Optional. When given provides altitude.	
1.4.4.1	altitude	DF	Optional	Consists of altitudeValue and altitudeConfidence. Only present for altitude with altitudeConfidence when they are known and can be provided.	
1.4.4.1.1	altitudeValue	DE	Optional		

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Table 15.2 RoadSegmentList → RoadSegment

Level	Name	Type	M/O	Usage	Comment
1.4.4.1.2	altitudeConfidence	DE	Optional		
1.5	laneWidth	DE	Optional	Provides the default width of a lane for the road segment, while deviations from this lane width are provided using dWidth.	
1.6	speedLimits (1..9)	DF	Optional	SpeedLimitList ::= SEQUENCE (SIZE(1..9)) OF RegulatorySpeedLimit (see table 15.5).	
1.7	laneSet (1..255)	DF	Mandatory	LaneList shall include all vehicle lanes and should include all delimitations or barriers of a road segment (e.g. including road boundaries). Depending on the use case it may also include other types of lanes such as bicycle or pedestrian lanes. For further details see C_ROADS_WG2_TF2_Service Descriptions [9] LaneList ::= SEQUENCE (SIZE(1..255)) OF GenericLane (see table 15.6).	
1.9	regional	DF	Optional	Not used. REGION.Reg-IntersectionGeometry- addGrpC.	

Table 15.3 RestrictionClassList → RestrictionClassAssignment

Level	Name	Type	M/O	Usage	Comment
2.0	restrictionClassAssignment	DF	Mandatory	Mandatory if 'restrictionList is used.	
2.1	id	DE	Mandatory		
2.2	users	DF	Mandatory	RestrictionUserTypeList ::= SEQUENCE (SIZE(1..16)) OF RestrictionUserType	
2.2.1	restrictionUserType	DF	Mandatory		
2.2.1.1	basicType	DE	Optional	Used.	
2.2.1.2	regional (1..4)	DF	Optional	REGION.Reg-RestrictionUserType-addGrpC. Optional to provide emission restrictions.	

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Table 15.3 RestrictionClassList → RestrictionClassAssignment

Level	Name	Type	M/O	Usage	Comment
2.2.1.2.1	emission	DE	Optional		
2.2.1.2.2	fuel	DE	Optional		

Table 15.4 SignalHeadLocationList → SignalHeadLocation

Level	Name	Type	M/O	Usage	Comment
3.0	SignalHeadLocation	DF	Optional		
3.1	nodeXY	DF	Mandatory		
3.2	nodeZ	DE	Mandatory		
3.3	signalGroupID	DE	Mandatory		

Table 15.5 SpeedLimitList → RegulatorySpeedLimit

Level	Name	Type	M/O	Usage	Comment
4.0	regulatory SpeedLimit	DF	Mandatory	Mandatory if 'speedLimits' is used.	
4.1	type	DE	Mandatory		
4.2	speed	DE	Mandatory		

Table 15.6 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
5.0	genericLane	DF	Mandatory	Mandatory if 'laneSet' is used. ingress/egress not used if roadSegments are used. For each ingress approach at least one ingress lane of type vehicle shall be present. Vehicle ingress and egress lanes shall follow the main road with priority and have a minimum length of pMinIngressLaneLenght and *pMinEgressLaneLength respectively*. Minor side-roads along the ingress	

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Table 15.6 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
				lanes should not be described or interrupt the lane, while non-right-of-way merging lanes shall start at the diverge/merge point. At intersections with higher speed limits allowed (> *pSpeedLimitHigh*) the vehicle ingress lanes shall be minimum *pMinIngressLaneLengthHighSpeed* long. If an adjacent intersection is closer than *pMinIngressLaneLength* or in case the lane ends before *pMinIngressLaneLength*, ingress lanes shall be shortened to the first egress point of the adjacent intersection or to where the lane ends. If no MAPEM is transmitted for the adjacent intersection, the ingress lanes shall be shortened such that they don't intersect the adjacent intersection's conflict area.	
5.1	laneID	DE	Mandatory	When an IVI message describes the same area, the lane identifiers as provided by the IVI message shall be used.	
5.2	name	DE	Optional		
5.3	ingressApproach	DE	Optional	Not used when DF roadSegments is used. The following description of the usage is valid when DF intersections is used. Each ingress lane must have the ApproachID set. Ingress and egress approaches of the same arm have the same ApproachID. For unidirectional ingress lanes, the data element 'ingressApproach' (of type DE_ApproachID) shall be present and used. For lanes that cross both the ingress- and egress approach of an intersection arm (crosswalks) both data elements 'ingressApproach' and 'egressApproach (of type DE_ApproachID) shall be present and used to indicate the approaches that are crossed. For further details on how to use these data elements, see ISO /TS 19091:2019 G.8.2.6. All bicycle lanes (separated from vehicle lanes) in one quadrant of an intersection have the same ingress ApproachID which is unique within	Note: If a non-priority road is included into the ingress structure, all lanes of the non-priority roads should be grouped into one or several separate approaches that only represent these non-priority roads.

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Table 15.6 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
				the intersection. Bicycle lanes at safe islands have the ApproachID set in the same manner as pedestrian lanes, i.e. the ingress or egress ApproachID of the approach they cross. For lanes of type vehicle (LaneAttributes.LaneTypeAttributes = vehicle), ingress lanes of a common drive direction towards the intersection shall have a common ingress approach ID as a mandatory attribute.	
5.4	egressApproach	DE	Optional	Not used when roadSegments is used. The following description of the usage is valid when intersections is used. Each egress lane must have the ApproachID set. Ingress and egress approaches of the same arm have the same ApproachID. For unidirectional egress lanes, the data element 'engressApproach' (of type DE_ApproachID) shall be present and used. For lanes that cross both the ingress- and egress approach of an intersection arm (e.g. crosswalks) both data elements 'ingressApproach' and 'egressApproach (of type DE_ApproachID) shall be present and used to indicate the approaches that are crossed. For further details on how to use these data elements, see ISO /TS 19091:2019 G.8.2.6. All bicycle lanes (separated from vehicle lanes) in one quadrant of an intersection have the same egress ApproachID which is unique within the intersection. Bicycle lanes at safe islands have the ApproachID set in the same manner as pedestrian lanes, i.e. the ingress or egress ApproachID of the approach they cross.	Note: If a non-priority road is included into the ingress structure, all lanes of the non-priority roads should be grouped into one or several separate approaches that only represent these non-priority roads.
5.5	laneAttributes	DF	Mandatory		
5.5.1	directionalUse	DE	Mandatory		RoadSegments shall be provided as egressPath unless it is a bidirectional lane.

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Table 15.6 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
5.5.2	sharedWith	DE	Mandatory	With bits as defined: overlappingLaneDescriptionProvided (0) multipleLanesTreatedAsOneLane (1) -- not permitted in profile as all lanes shall be described. otherNonMotorizedTrafficTypes (2) -- e.g. horse drawn individualMotorizedVehicleTraffic (3) -- passenger cars busVehicleTraffic (4) taxiVehicleTraffic (5) pedestriansTraffic (6) cyclistVehicleTraffic (7) trackedVehicleTraffic (8) pedestrianTraffic (9) -- use 6 instead (error)	
5.5.3	laneType	DF	Mandatory	Mandatory. Used in this profile: vehicle crosswalk bikeLane sideWalk median trackedVehicle -- see ISO TS19091 for pedestrian crossing examples.	
5.5.3.1	Vehicle	DE	Optional	(choice)	
5.5.3.2	crosswalk	DE	Optional	(choice)	
5.5.3.3	bikeLane	DE	Optional	(choice)	
5.5.3.4	sidewalk	DE	Optional	(choice)	
5.5.3.5	median	DE	Optional	(choice)	It can be used to indicate the kind of physical separation between traffic flows.
5.5.3.6	striping	DE	Optional	Not used.	
5.5.3.4	trackedVehicle	DE	Optional	(choice)	
5.5.3.5	parking	DE	Optional	Not used.	
5.5.4	regional	DF	Optional	Reg- LaneAttributes-addGrpC. .	
5.5.4.1	maxVehicleHeight	DE	Optional		
5.5.4.2	maxVehicleWeight	DE	Optional		
5.6	maneuvers	DE	Optional	The data element ‘maneuvers’ (of type DE_AllowedManeuvers) shall not be present in any instance of a ‘generic lane’ within a MAPEM.	
5.7	nodeList	DF	Mandatory	For toll stations, node list shall start at the tolling barrier and end where the tolling lanes merge to the motorway lanes for both ingress and egress lanes. Since the main highway road section may contain fewer lanes than the total number of channels, multiple lanes may be merged at their last	Definition: For intersections description, a ‘conflict area’ is the area of the intersection that is limited by the first nodes of ingress / egress vehicle lanes, first nodes of ‘ingresspath’ crosswalk lanes, and stop lines of bicycle lanes. For a better understanding, see also e.g. Figure G.6 in [ISO/TS 19091 2019-06].

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Table 15.6 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
				point.	
5.7.1	nodes (2..63)	DF	Mandatory	NodeSetXY ::= SEQUENCE (SIZE(2..63)) OF NodeXY (see table 15.7) Mandatory if 'nodeList' is used. Recommended use for curved lanes is to add an additional node when the centre line of the GenericLane deviates from the actual centre line more than 0.5m. When intersections is used, the first node of any vehicle lane shall be the node of the lane which is closest to the centre of the intersection. When roadSegments is used, the first node of any vehicle lane shall be the node of the lane the traffic flow reaches first. The number of node points shall be limited to pMaxNoOfNodesPerLane nodes per lane (for both ingress and egress lanes). The perpendicular distance between the linear connection of two node points and the center of the lane shall be less than pMaxPerpendDistLaneCenter. The number of nodes of a lane may exceed pMaxNoOfNodesPerLane to keep the perpendicular distance between the linear connection of two node points and the centre of the lane lower than pMaxPerpendDistLaneCenter, to fulfil pMinIngressLaneLength. The angle between the linear connection of two node points and the corresponding tangent to the lane center shall not be greater than pLaneAngleDeviation.	
5.7.2	computed	DF	Optional	Not used.	
5.8	connectsTo (1..16)	DF	Optional	ConnectsToList ::= SEQUENCE (SIZE(1..16)) OF Connection (see table 15.8). The data element 'connectsTo' (of type DF_ConnectsToList) shall be present at least for every ingress lane of an intersection that is controlled by	

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Table 15.6 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
				a traffic light. When intersections is used, the data field 'connectsTo' shall include every possible connection between ingress and egress lanes of one intersection. The contained connections shall however not include those requiring lane changes in the conflict area (if applicable). U-turns are optional and only included if they are allowed by traffic rules. When u-turns are provided they must have a separate connection which has a signalGroupID that represents a virtual traffic signal for which SPATEM must contain movementPhaseState (9): caution-conflicting-traffic in case the maneuver is active. There shall be no duplicate connections indicated via 'connectsTo' between the same ingress and egress lanes for the same direction. The only exception may be userclass. When roadSegments is used, the data field 'connectsTo' shall include every possible connection between two lanes of a road segment.	
5.9	overlays	DF	Optional	Not used.	
5.10	regional	DF	Optional	REGION-Reg-GenericLane. To provide ConnectionTrajectory-addGrpC. Relevant for use case scenario safe intersection manoeuvre. Not used when roadSegments is used.	
5.10.1	nodes	DF	Mandatory		
5.10.2	connectionID	DE	Mandatory		

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Table 15.7 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
6.0	nodeXY	DF	Mandatory	Mandatory if 'nodes' is used. The absolute lateral offset of node points to the center of the lane shall be less than *pLateralNodeOffset*.	The angle between the linear connection of two node points and the corresponding tangent to the lane center shall not be greater than *pLaneAngleDeviation*. In more formal wording: let be the vector representing the linear connection of two node points, and be the vector representing the shortest distance of vector to the center of the lane (that is, is perpendicular to the tangent of the center line of the lane at the foot of the dropped perpendicular). Then for it shall always hold that *pLaneAngleDeviation*. For (i.e. crosses the lane center) the angle α between and the tangent to the lane center at the intersection point with the lane center shall be less than *pLaneAngleDeviation*.
6.1	delta	DF	Mandatory		
6.1.1	node-XY1	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
6.1.2	node-XY2	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
6.1.3	node-XY3	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
6.1.4	node-XY4	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
6.1.5	node-XY5	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
6.1.6	node-XY6	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
6.1.7	node-LatLon	DF	Optional	The data element node-LatLon shall not be used for the Signalized Intersections use cases. Instead additional nodes shall be added.	
6.1.8	regional	DF	Optional	REGION.Reg-NodeOffsetPointXY. Not used.	
6.2	attributes	DF	Optional	This DE provides any optional attributes which are needed. This includes changes to the current lane width and elevation. All attributes are provided in the order of the nodes (as opposed to the driving direction). Also left/right indications by attributes must be interpreted based on the order of the nodes.	'Merge point' definition: as all attributes are provided in the order of the nodes, a 'merge point' designates a node of a lane where the lane is split into two lanes in driving direction towards an intersection (ingress). On the other hand, a merge point on an egress lane is located, where two lanes end in one lane in driving direction. The opposite applies for 'diverge points.

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Table 15.7 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
6.2.1	localNode (1..8)	DF	Optional	NodeAttributeXYList:: = SEQUENCE (SIZE (1..8)) OF NodeAttributeXY Node attributes Stopline, mergePoint and divergePoint are mandatory when applicable. The first node of an ingress lane, which is not a diverge or merge point, shall be the node that shall not be passed by a vehicle when movement is not allowed (from regulations, typically this is the stop line on the street). The node attribute 'stopLine' shall be used to indicate where the do-not-block section starts. In addition, the doNotBlock segment-attribute shall be appropriately enabled/disabled to indicate the do-not-block area. Each diverge or merge point (of type DF_NodeXY) shall be explicitly marked with corresponding node attribute (DF_NoteAttributeSetXY) "divergePoint" or "mergePoint". For diverging / merging lanes one node shall be defined as diverge / merge point. This node shall be present with the same absolute position with an accuracy of 0,1 meter in the ongoing lane and as first / last node in the diverging / merging lane. Note: this high accuracy can be achieved by calculating the cumulative node offset position relative to the referencePosition of both nodes.	'Merge point' definition: as all attributes are provided in the order of the nodes, a 'merge point' designates a node of a lane where the lane is split into two lanes in driving direction towards an intersection (ingress). On the other hand, a merge point on an egress lane is located, where two lanes end in one lane in driving direction. The opposite applies for 'diverge points. When ingress and egress approaches are not used, a merge point designates a node where two lanes end in one lane following the order of the nodes list. A diverge point designates a point where the lane is split into two lanes. Note: This adds on to [ISO/TS 19091 2019-06] where it is only stated that the first node "should be the node closest to the geometric centre of the intersection and is typically at the stop line". This is only part of the informative text – see [ISO/TS 19091 2019-06], 6.5.7. Note: For further details see [ISO/TS 19091 2019-06] 'localNode'.
6.2.1.1	nodeAttributeXY	DE	Mandatory	Mandatory if localNode is used.	
6.2.2	disabled (1..8)	DF	Optional	SegmentAttributeXYList ::= SEQUENCE (SIZE(1..8)) OF SegmentAttributeXY Subject to case. It is encouraged to use at least the segment attributes from the following categories, for which guidelines are provided in ISO TS 19091:	Note on tapers: the area where two lanes (partially) cover each other can be called taper-zone. The dimension of this zone is important for the path guidance of vehicles. It is expected that this zone covers the area where the real world lane width (i.e. the distance between the lane markings) is below pMinLaneWidth. This requirements cannot be checked

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Table 15.7 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
				- General items - Porous lane states and merging - Bike lane needs - Lane geometry details - doNotBlock - taperToLeft - taperToRight A SegmentAttributeXY of value 'doNotBlock' shall be present in the 'disabled' list at the first node of the lane thereafter, which may again be blocked by a vehicle. **Tapers** Tapers shall be described with a minimum of 2 nodes where the segmentAttributeXY of value "taperToLeft" or "taperToRight" is applied according to the following requirements. A SegmentAttributeXY of value 'taperToLeft' or 'taperToRight' shall be present in the 'enabled' list of the first node of the diverging lane (i.e. at the diverge point). For a diverging lane with tapering, the same 'taperToLeft' or 'taperToRight' shall be disabled via a SegmentAttributeXY in the 'disabled' list at the following node where the real world lane width exceeds pMinLaneWidth for the first time. A SegmentAttributeXY of value 'taperToLeft' or 'taperToRight' shall be present in the disabled' list of the last node of the merging lane (i.e. at the merge point). For a merging lane with tapering (as described above), the same 'taperToLeft' or 'taperToRight' shall be enabled via a SegmentAttributeXY in the 'enabled' list of the preceding node where the real world lane width falls below pMinLaneWidth for the first time. Note: This note provides a descriptive summary of the above requirements. For ingress lanes: in case of a fanout, the node farthest from the intersection is the merge point where 'taperToLeft' or 'taperToRight' is disabled, the other node is where the two lanes do not overlap anymore and the 'taperToLeft' or 'taperToRight' is enabled. In case of a lane-drop, the	based only on MAPEM-information because according to ISO 19091, clause G.8.2.8 DF_NodeAttributeSetXY, the reported laneWidth for a diverging or merging lane does not shrink towards the diverge- or merge-point.

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Table 15.7 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
				node closest to the intersection is the diverge point where 'taperToLeft' or 'taperToRight' is enabled, the other node is where the two lanes do not yet overlap and the 'taperToLeft' or 'taperToRight' is disabled. Left and right should in all cases be seen from the order of the nodes. The whiteLine attribute is used to indicate when the line on the inside of the node is continuous. Note: the lane width in the MAPEM is not affected throughout the taper segment (i.e. the use of dWidth is not required). However, as long as a taper is enabled it shall be assumed that 2 vehicles cannot driver side-by-side. Note: For further details see [ISO/TS 19091 2019-06] 'G.8.2.8 DF_NodeAttributeSetXY'.	
6.2.2.1	segmentAttributeXY	DE	Mandatory	Mandatory if disabled is used.	
6.2.3	enabled (1..8)	DF	Optional	SegmentAttributeXYList ::= SEQUENCE (SIZE(1..8)) OF SegmentAttributeXY Subject to case. It is encouraged to use at least the segment attributes from the following categories, for which guidelines are provided in ISO TS 19091: - General items - Porous lane states and merging - Bike lane needs - Lane geometry details - doNotBlock - taperToLeft - taperToRight - whiteLine A SegmentAttributeXY of value 'doNotBlock' shall be present in the 'enabled' list at the first node of the lane that shall not be blocked by a vehicle in case of a queue in front of the traffic light. For tapers and whiteLine see the usage as defined in level 6.2.2 'disabled'.	
6.2.3.1	segmentAttributeXY	DE	Mandatory	Mandatory if enabled is used.	

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Table 15.7 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
6.2.4	data	DF	Optional	Not used when roadSegments is used.	
6.2.4.1	pathEndPointAngle	DE	Optional	Not used.	
6.2.4.2	pathEndPointAngle	DE	Optional	Not used.	
6.2.4.3	laneCrownPointCenter	DE	Optional	Not used.	
6.2.4.4	laneCrownPointLeft	DE	Optional	Not used.	
6.2.4.5	laneCrownPointRight	DE	Optional	Not used.	
6.2.4.6	laneAngle	DE	Optional	Not used.	
6.2.4.7	speedLimits (1..9)	DE	Optional	SpeedLimitList ::= SEQUENCE (SIZE(1..9)) OF RegulatorySpeedLimit (see table 15.5). (choice)	
6.2.4.8	regional	DF	Optional	REGION.Reg-LaneDataAttribute. Not used.	
6.2.5	dWidth	DE	Optional	The default lane width of the intersection is provided by laneWidth. Any significant lane width difference of at least 0.3 meters to this default width, shall be expressed. dWidth should not be used when no road marking exists (e.g. at toll stations) and lanes are not clearly indicated.	The location of road markings is deduced from the location of central line in the lane and the width of the lane.
6.2.6	dElevation	DE	Optional		
6.2.7	regional	DF	Optional	REGION.Reg-NodeAttributeSet-addGrpC. Mandatory for merging and diverging nodes when roadSegments is used.	
6.2.7.1	ptvRequest	DE	Optional		
6.2.7.2	nodeLink	DF	Mandatory	NodeLink ::= SEQUENCE SIZE (1..5) OF Node (see table 15.9)	

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Table 15.8 ConnectsToList → Connection

Level	Name	Type	M/O	Usage	Comment
7.0	connection	DF	Optional	Mandatory if 'connectsTo' is used.	
7.1	connectingLane	DF	Mandatory		
7.1.1	lane	DE	Mandatory		
7.1.2	maneuver	DE	Mandatory	The information in the data element 'maneuver' in 'connectingLane' shall be based on the lane marking arrows on the lane itself (if present). For data element 'maneuver' in 'connectingLane' exactly one of the first four bits of DE_AllowedManeuvers (i.e. exactly one direction indication per connectingLane) shall be set. The maneuver indication "maneuverleft-/maneuverRightTurnonRedAllowed" and "maneuverLaneChangeAllowed" shall not be used. These permissions must be expressed by MovementPhaseState in SPATEM. Note: All other bits of the DE_AllowedManeuvers may be set but will not be used by current vehicle implementations.	The use of 'maneuver' (in connectsTo) over 'manoevres' (in GenericLane) is preferred, which provides the same information only in more detail. Therefore, manoevres (in GenericLane) is not used. In case there are no lane marking arrows on the street, the responsible human message designer shall decide the content of the data element individually for every lane.
7.2	remoteIntersection	DF	Optional	Not used when roadSegments is used. Only used if the referenced intersection is part of the same MAPEM.	
7.2.1	region	DE	Optional		
7.2.2	id	DE	Mandatory		
7.3	signalGroup	DE	Optional	Not used when roadSegments is used. Mandatory for every connection that is signalised with an operational traffic light. If there is no traffic light, there is no signalGroup required. Note that there is no 1:1 relation between signal heads and connections, e.g. if a connection is controlled by 2 signals, their combined state shall be reflected in the eventState. An exception is when multiple user classes share a lane and each user class is served with separate signals (e.g. public	

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				transport). In such a case, a lane may have multiple (overlapping) connections, each with a unique signalGroup and the userClass restriction set. Every given 'signalGroup' / 'intersectionReferenceID' tuple in the MAPEM shall also be found in the SPATEM.	
7.4	userClass	DE	Optional		
7.5	connectionID	DE	Optional	Shall be used to provide a connection index when ConnectionManeuverAssist or ConnectionTrajectory-addGrpC is used. Not used when roadSegments is used.	

Table 15.9 NodeLink → Node

Level	Name	Type	M/O	Usage	Comment
8.0	Node	DE	Optional		
8.1	id	DE	Mandatory	Id of the linked node.	As current use is only for merging and diverging points, it is the id of the node from another lane that is at the same position as this node.
8.2	lane	DE	Mandatory	Identifier of lane from which node has been issued shall be given.	
8.3	connectionID	DE	Optional	Not used.	
8.4	intersectionID	DF	Optional	Not used.	

4.2.3.3 SPATEM general elements

Table 16 SPATEM data elements

Level	Name	Type	M/O	Usage	Comment
0.0	Spat	DF	Mandatory		
0.1	timeStamp	DE	Optional	Not used	
0.2	name	DE	Optional	Not used	

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Table 16 SPATEM data elements

Level	Name	Type	M/O	Usage	Comment
0.3	Intersections (1..32)	DF	Mandatory	IntersectionStateList ::= SEQUENCE (SIZE(1..32)) OF IntersectionState (see table 16.1).	
0.4	regional (1..4)	DF	Optional	REGION.Reg-SPAT. Not used.	

Table 16.1 IntersectionStateList → IntersectionState

Level	Name	Type	M/O	Usage	Comment
1.0	intersectionState	DF	Mandatory		
1.1	name	DE	Optional	Used, but kept optional Based on a numbering scheme used by the road authority.	
1.2	id	DF	Mandatory	(IntersectionReferenceID) The id must be identical to the appropriate ID tuple of the corresponding MAPEM 'intersectionGeometry'. The combination of region and id shall be unique within a country.	This applies specifically to cases where multiple intersections are conveyed in one MAPEM/SPATEM combination.
1.2.1	region	DE	Mandatory		RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs to intersections.
1.2.2	id	DE	Mandatory		
1.3	revision	DE	Mandatory	The revision number must be increased by 1 each time the MapData of this intersection changes. The revision numbers of SPATEM and MAPEM must be the same as an indication that the right MAPEM revision is used. As defined in ISO TS 19091.	
1.4	status	DE	Mandatory	Typically used based on EN 12675 are: manualControlIsEnabled (0) – typically in case of an incident at the intersection. Shall be combined with (13), stopTimeIsActivated (1) – not used, failureFlash (2) – typically in case the traffic light controller is out of order. Shall be combined with (13), preemptIsActive (3) – not used as the DE 'stateChangeReason' offers more detailed information, signalPriorityIsActive (4) – not used as the DE 'stateChangeReason' offers more detailed information, fixedTimeOperation (5), - operation of signals is based on time only, trafficDependentOperation (6), operation of signals is based on different levels of traffic parameters,	Definition: 'Traffic Dependent (or actuated) refers to an operation mode of the traffic light controller that dynamically adapts the changes to the current traffic situation (i.e., the cycle of the traffic phases is not static but may change over time). Definition: A traffic light is considered 'operational', if the corresponding traffic light controller is neither switched off nor in any kind of failure mode. This means that also traffic lights showing some kind of "standby" (e.g. at night) are considered operational.

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Table 16.1 IntersectionStateList → IntersectionState

Level	Name	Type	M/O	Usage	Comment
				standbyOperation (7) – typically in case some or all signals are off. Shall be combined with (13), failureMode (8) – typically in case the traffic light controller is not able to operate properly (i.e. worse than (2)). Shall be combined with (13) , off (9) – typically in case the traffic light controller is not powered. Shall be combined with (13), recentMAPmessageUpdate (10) – not used as such information is available in the MAPEM, recentChangeInMAPassignedLanesIDsUsed (11) - not used as such information is available in the MAPEM, noValidMAPisAvailableAtThisTime (12) – only used in case the absence of a valid MAPEM is intentional. noValidSPATisAvailableAtThisTime (13) – used in combination with one of the bits (0), (2), (7), (8), (9). If one of these states is detected, the bit should be sent within less than *tDelayFailureTransmission* after the traffic light goes into failure mode. The eventStates “0” (unavailable) should be provided alongside.	
1.5	moy	DE	Mandatory	Also used to validate the reference time of the TimeMarks. The data element ‘moy’ (DE_MinuteOfTheYear) in IntersectionState shall be set to the time of information generation, that is the time when the ‘timeChangeDetails’ are determined.	
1.6	timeStamp	DE	Mandatory	The data element ‘timeStamp’ (DE_DSecond) in IntersectionState shall be set to the time of information generation, i.e. the time when the ‘timeChangeDetails’ are determined.	
1.7	enabledLanes	DF	Optional	Mandatory if the revocableLane bit is used in any of the lane descriptions, otherwise not used.	
1.8	states (1..16)	DF	Mandatory	MovementList ::= SEQUENCE (SIZE(1..255)) OF MovementState (see table 16.2). The ‘states’ (DF_MovementList) shall be given at least for all connections through the intersection area with operational traffic lights if the intersection status is either “fixedTimeOperation” (5) or “trafficDependentOperation” (6). Moreover, every given ‘signalGroup’ /	

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Table 16.1 IntersectionStateList → IntersectionState

Level	Name	Type	M/O	Usage	Comment
				'intersectionReferenceID' tuple in the SPATEM shall be found in the MAPEM. An IntersectionState instance in SPATEM *should* not include duplicate MovementState instances in MovementList which over time only differ in the assigned SignalGroupID. Note 1: Depending on the operation mode it is possible that in certain hours of the day two different MovementState instances (SignalGroups) have identical states. Note 2: This implies that multiple lanes in MAPEM may observe the same SignalGroupID, in case the exact same movement rules apply to them at all times.	
1.9	maneuverAssistList (1..16)	DF	Optional	ManeuverAssistList ::= SEQUENCE (SIZE(1..16)) OF ConnectionManeuverAssist (see table 16.6). Not used, therefore not further profiled on this level.	
1.10	regional (1..4)	DF	Optional	REGION.Reg-IntersectionState-addGrpC. Used to to ensure interoperability with existing public transport prioritisation systems.	
1.10.1	activePrioritizations	DF	Optional	PrioritizationResponseList ::= SEQUENCE SIZE(1..10) OF PrioritizationResponse (see table 16.3)	

Table 16.2 MovementList → MovementState

Level	Name	Type	M/O	Usage	Comment
2.0	movementState	DF	Mandatory	Mandatory if 'states' is used.	
2.1	movementName	DE	Optional		
2.2	signalGroup	DE	Mandatory	Every given 'signalGroup' tuple in the SPATEM shall be found in the MAPEM and vice versa.	
2.3	state-time-speed	DF	Mandatory	MovementEventList ::= SEQUENCE (SIZE(1..16)) OF MovementEvent Mandatory (1-16). (see table 16.4). All events in 'state-time-speed' shall be sorted in the order of their appearance at the traffic light.	Definition: 'Phase' is a general term denoting all the movement phase states strictly allowing or prohibiting to proceed into an intersection (so the "Reds" and "Greens" as summarized in SAE J2735). Definition: 'Transition' is a general term

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Table 16.2 MovementList → MovementState

Level	Name	Type	M/O	Usage	Comment
				Enough MovementEvent instances shall be included to provide at least the end time of the current green phase or the beginning of the next green phase. In this latter case, the green phase itself shall also be provided to confirm the MovementPhaseState. In other words and as a general rule, at least MovementEvent instances for the current phase state, the next phase and all transitions in between shall be included in 'state-time-speed' (DF_MovementEventList). Additional MovementEvent instances may be included. Note: If the current phase state is a transition, the current transition and the next phase have to be included.	denoting all the movement phase states which are not covered by the term phase (so the "Yellows / Ambers" as summarized in SAE J2735). Definition: Phase state is a general term that covers all movement phase states as defined in SAE J2735, i.e. 'phase state' includes both phases and transitions.
2.4	maneuverAssistList (1..16)	DF	Optional	ManeuverAssistList ::= SEQUENCE (SIZE(1..16)) OF ConnectionManeuverAssist (see table 16.6). Used to convey queue length for speed advisory calculation.	
2.5	regional (1..4)	DF	Optional	REGION.Reg-MovementState. Not used.	

Table 16.3 PrioritizationResponseList → PrioritizationResponse

Level	Name	Type	M/O	Usage	Comment
3.0	PrioritizationResponse	DF	Optional		
3.1	stationId	DE	Mandatory		
3.2	priorState	DE	Mandatory		
3.3	signalGroup	DE	Mandatory		

Table 16.4 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
4.0	movementEvent	DF	Mandatory	Mandatory if 'state-time-speed' is used. In case multiple signal lamps apply to one connection (e.g. a combination of a full signal head with one green arrow signal for the right turn), a singular MovementPhaseState shall	

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Table 16.4 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				reflect what the vehicle is allowed to do for the associate manoeuvre, which reflects the combined MovementPhaseState of all applicable signals. If a failure of the traffic light controller is detected (i.e. the IntersectionStatusObject is (0), (2), (7), (8) or (9)), the bit noValidSPATisAvailableAtThisTime should be sent within less than *tDelayFailureTransmission* after the traffic light goes into failure mode. The eventStates "0" (unavailable) should be provided alongside.	
4.1	eventState	DE	Mandatory	The data element 'eventState' (of type DE_MovementPhaseState) shall be set to represent the actual allowed movement state permissions according to the applicable traffic rules as indicated by the traffic lights. Note: The cars need to know the applicable permissions and not the physical representation / colour of the physical traffic lights, i.e. the applicable traffic rules are of relevance. If no information can be given, "unavailable" shall be used rather than "dark". The data element 'eventState' shall be set to the applicable value considering the distinction between protected and permissive movements. Defined as follows: (0) unavailable (unknown or error) (1) dark shall not be used. (2) stop-then-Proceed (e.g. red light combined with road sign with green arrow for turn movement). (3) stop-and-remain (when vehicles on corresponding lanes are not allowed to enter the conflict zone (e.g. red light)) (4) pre-Movement (transitions that directly precede the phase "permissive-Movement-Allowed" or "protected-Movement-Allowed" (e.g. red/amber as used in some EU countries before green signal)) (5) permissive-Movement-Allowed (when vehicles on	Note that there is no 1:1 relation between signal heads and connections, e.g. if a connection is controlled by 2 signals, their combined state shall be reflected in the eventState.

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Table 16.4 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				corresponding lanes are allowed to enter the conflict zone but there still might occur conflicting traffic which they have to pay attention for (e.g. green "full ball" light, with potential conflicting traffic, especially while turning left or right)). (6) protected-Movement Allowed (when vehicles on corresponding lanes are allowed to enter the conflict zone and there shouldn't be any conflicting traffic according to the traffic rules (e.g. green "arrow" light, with no conflicting traffic or pedestrians while crossing the conflict area)). (7) permissive clearance (when vehicles on corresponding lanes are allowed to enter the conflict zone if they are not able to stop before the stop line shall clear the conflict zone and have to be attentive of potential conflicting traffic (e.g. amber "full ball" light, prepare to stop. Used after a "green" signal state)). (8) protected clearance (when vehicles on corresponding lanes are allowed to enter the conflict zone if they are not able to stop before the stop line, shall clear the conflict zone and there shouldn't be any conflicting traffic according to the traffic rules (e.g. amber "arrow" light, Directional prepare to stop. Used after a "green arrow" signal state)). (9) caution-Conflicting-Traffic (shall be used for signalGroups belonging to lanes of minor roads if none of the aforementioned MovementPhaseStates are applicable (e.g. if the traffic light controller is in standby mode). It shall indicate that vehicles are allowed to proceed but have to	

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Table 16.4 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				give way to conflicting traffic when present (e.g. Amber light blinking; Proceed with caution, Conflicting traffic may be present in the intersection conflict area)).	
4.2	timing	DF	Optional	The data field 'timing' (of type TimeChangeDetails shall be present for every instance of MovementEvent in SPATEM containing an instance of MovementPhaseState representing one of the values 2, 3, 4, 5, 6, 7 or 8 (i.e. reds, greens and yellows other than flashing-yellow). For example timing data may not be available when 'eventState' is 0, 1 or 9. All TimeMarks are defined as an offset to the UTC full hour (see TS19091) and not for functional safety, but informative related to signal timing. likelyTime with confidence or minEndTime with maxEndTime are both measures for probability which can be used interchangeably subject to availability.	For traffic signal controllers operating fixed time, where the time of change is known, 'minEndTime', 'likelyTime' and 'maxEndTime' shall be equal, if they are present. Let tAbsMinEndTime, tAbsLikelyTime and tAbsMaxEndTime be the instants which 'likelyTime', 'minEndTime' and 'maxEndTime refer to, they shall suffice the following condition: tAbsMinEndTime <= tAbsLikelyTime <= tAbsMaxEndTime.
4.2.1	startTime	DE	Optional	Not used.	
4.2.2	minEndTime	DE	Mandatory	The data element 'minEndTime' (DE_TimeMark) shall be set for every signal group to the earliest time possible at which the phase state of the respective signal group could change, including unpredictable events like pedestrian crossing or pre-emption for emergency and other priority vehicles (e.g. public transport). The risks of force majeure such as technical failures shall not be considered in the determination of 'minEndTime'. Note: That means the minEndTime may be the currentTime + the time it takes to change the signal if a prioritization request occurred at the current time (i.e. as an indication of the safety range based on what can at the very most can happen). The data element 'minEndTime' shall have a value between *pTimeMarkMin* and *pTimeMarkOutOfRange*. Note: This means that the value *pTimeMarkUnknown* (unknown) shall not be used.	

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Table 16.4 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				In successive SPATEM transmissions, the instant, which the 'minEndTime' of one MovementState refers to, shall not move to an earlier point in time. It may however progress to a later point in time. Note: In relative terms this means that the remaining time until 'minEndTime' shall not decrease faster than the time passes. For traffic signal controllers operating fixed time, where the time of change is known, 'minEndTime' shall be accurate to the displayed change of the traffic light within *tTimeOfChangeAccuracy*. For use cases where the end time is unknown (e.g. toll stations), minEndTime shall be set to 36001 to indicate that end time of the current phase is unknown Note: by definition, tollgate clearance depends on the time of the next transaction so it cannot be known in advance.	
4.2.3	maxEndTime	DE	Optional	Mandatory in case of signalised intersection use cases, not used for toll station use cases; The data element 'maxEndTime' (DE_TimeMark) shall be set to the latest time possible at which the phase state could change (i.e. as an indication of the safety range based on what can at the very most can happen). In case 'maxEndTime' is infinite (e.g. for traffic lights that only change in case of pedestrian requests), the value shall be set to *pTimeMarkOutOfRange*. Note: This includes the case when the actual maxEndTime is not known. For 'maxEndTime' the value *pTimeMarkUnknown* (unknown) shall not be used. The instant, which 'maxEndTime' refers to, shall not progress to a later point in time. It may however move to an earlier point in time. Note: In relative terms this means that the remaining time until 'maxEndTime' shall not increase.	The data element 'maxEndTime' (DE_TimeMark) shall also be present for actuated traffic light operation.

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Table 16.4 MovementEventList → MovementEvent

<table>
<tr><th>Level</th><th>Name</th><th>Type</th><th>M/O</th><th>Usage</th><th>Comment</th></tr>
<tr><td>4.2.4</td><td>likelyTime</td><td>DE</td><td>Optional</td><td>Mandatory in case of signalised intersection use cases, not used for toll station use cases

In case of e.g. fixed time control identical to minEndTime and maxEndTime which indicates high probability.

Generally, the ‘likelyTime’ shall be used to convey the most likely time the phase state changes.

For the data element ‘likelyTime’ the value pTimeMarkUnknown (unknown) shall not be used.</td><td>The data element likelyTime (DE_TimeMark) shall also be present for actuated traffic light operation.
Note: the confidence for the likelyTime is given in the DE "confidence" (DE_TimeIntervalConfidence).</td></tr>
<tr><td>4.2.5</td><td>confidence</td><td>DE</td><td>Optional</td><td>Mandatory in case of signalised intersection use cases, not used for toll station use cases

Confidence shall be interpreted as the 95% probability that the real phase change occurs within ± time-interval of the indicated likelyTime.
Note 1: This means that the 95% probability for likelyTime – confidence <= phase change time <= likelyTime + confidence shall be indicated.
In addition to the standard, the values are encoded as time-interval classes (in seconds) with proposed values listed in the table below. This table replaces the table in the standard. Time-interval values are intentionally arranged in such a way to align with the probabilities-scale in the standard.

<table><tr><th>Value</th><th>Time-interval</th></tr><tr><td>0</td><td>>15.0</td></tr><tr><td>1</td><td>13.5</td></tr><tr><td>2</td><td>12.0</td></tr><tr><td>3</td><td>10.5</td></tr><tr><td>4</td><td>9.0</td></tr><tr><td>5</td><td>7.5</td></tr><tr><td>6</td><td>6.5</td></tr><tr><td>7</td><td>5.5</td></tr><tr><td>8</td><td>4.5</td></tr><tr><td>9</td><td>3.5</td></tr><tr><td>10</td><td>2.5</td></tr><tr><td>11</td><td>2.0</td></tr><tr><td>12</td><td>1.5</td></tr><tr><td>13</td><td>1.0</td></tr><tr><td>14</td><td>0.5</td></tr><tr><td>15</td><td>0</td></tr></table>If no prediction is available, the confidence of ‘likelyTime’ shall be disseminated with the value "0".</td><td>Definition: Information provided with a ‘confidence level’ of 95% means that the true value is inside the time interval or the confidence area for at least 95% of the data points in a given statistical base.

Note: if the data element ‘likelyTime’ is present, the confidence of ‘likelyTime’ shall be present as well.

Note: Implementation of one confidence threshold for all situations on receiving side will not work. It is recommended to evaluate the confidence in relation to the prediction horizon with different thresholds for the different use cases.</td></tr>
</table>

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Table 16.4 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
4.2.6	nextTime	DE	Optional		
4.3	speeds (1..16)	DF	Optional	AdvisorySpeedList ::= SEQUENCE (SIZE(1..16)) OF AdvisorySpeed (see table 16.5).	
4.4	regional (1..4)	DF	Optional	REGION.Reg-MovementEvent-addGrpC,	
4.4.1	stateChangeReason	DE	Optional	The data element "ExceptionalCondition" element defines a list of reasons for sudden changes in eventState parameters, thereby offering a reason for extended waiting times. It includes the following types: • unknown, • publicTransportPriority, • emergencyVehiclePriority, • trainPriority, • bridgeOpen, • vehicleHeight, • weather, • trafficJam, • tunnelClosure, • meteringActive, • truckPriority, • bicyclePlatoonPriority, • vehiclePlatoonPriority, • ...	

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Table 16.5 AdvisorySpeedList → AdvisorySpeed

Level	Name	Type	M/O	Usage	Comment
5.0	advisorySpeed	DF	Mandatory	Mandatory if 'speeds' is used.	
5.1	type	DE	Mandatory	greenwave (1) = speed for a sequence of coordinated intersections (repeated at each intersection). ecoDrive (2) = speed for current intersection. transit (3) = restricted to specific vehicle type.	
5.2	speed	DE	Optional		
5.3	confidence	DE	Optional	Not used.	
5.4	distance	DE	Optional	Distance is specified upstream from the stop bar along the ingressing lane.	
5.5	class	DE	Optional		
5.6	regional (1..4)	DF	Optional	REGION.Reg-AdvisorySpeed . Not used.	

Table 16.6 ManeuverAssistList → ConnectionManeuverAssist

Level	Name	Type	M/O	Usage	Comment
6.0	connection ManeuverAssist	DF	Mandatory	Mandatory if 'maneuverAssistList' is used.	
6.1	connectionID	DE	Mandatory		
6.2	queueLength	DE	Optional		
6.3	availableStor ageLength	DE	Optional	Not used.	
6.4	waitOnStop	DE	Optional	Not used.	
6.5	pedBicycleDetec t	DE	Optional	Not used.	
6.6	regional (1..4)	DF	Optional	REGION.Reg-ConnectionManeuverAssist-addGrpC Not used.	
6.6.1	itsStationPositio n	DF	Optional	ItsStationPositionList ::= SEQUENCE SIZE(1..5) OF ItsStationPosition (see table 16.7)	

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Table 16.7 ItsStationPositionList → ItsStationPosition

Level	Name	Type	M/O	Usage	Comment
7.0	ItsStationPosition	DF	Optional		
7.1	stationdID	DE	Mandatory		
7.2	laneID	DE	Optional		
7.3	nodeXY	DF	Optional		
7.4	timeReference	DE	Optional		

4.2.4 Traffic Light Control (TLC) FLS

The Traffic Light Control service is one instantiation of the infrastructure services to manage the generation, transmission of SREM messages and SSEM messages. The TLC service supports prioritization of public transport and public safety vehicles (ambulance, fire brigade, etc.) to traverse a signalized road infrastructure (e.g. intersection) as fast as possible or using a higher priority than ordinary traffic participants. The corresponding SREM is sent by an ITS-S (e.g. vehicle) to the traffic infrastructure environment (e.g. R-ITS-S, TCC). In a signalized environment (e.g. intersection) the SREM is sent for requesting traffic light signal priority (public transport) signal pre-emption (public safety). The service may not only be requested for the approaching signalized environment but also for a sequence of e.g. intersections along a defined traffic route. In response to the request the infrastructure (e.g. R-ITS-S/TLC or TCC) will acknowledge with a SSEM notifying if the request has been granted, cancelled or changed in priority due to a more relevant signal request (e.g. ambulance). (ETSI TS 103 301 [11])

Operational parameters and relevant standards

The TLC FLS including operational parameters is defined in ETSI TS 103 301 [11], which refers to ISO TS19091 [21], which in turn refers to SAE J2735 [22]. Data elements, data frames and service parameters shall be used according to the definitions in Table 17 and Table 18. The header SREM/SSEM shall be as specified in the data dictionary ETSI TS 102 894-2 [8].

The relationships of the tables of SREM are depicted in Figure 7 and in Figure 8 for the relationship of the SSEM tables.

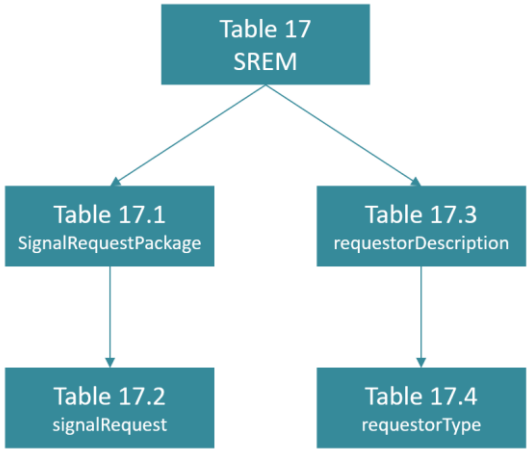

Figure 7 relationship of SREM data element tables

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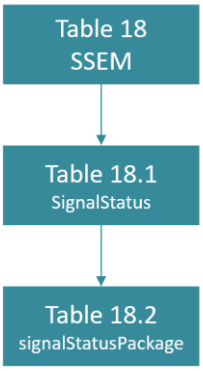

Figure 8 relationship of SSEM data element tables

4.2.4.1 SREM general elements

Table 17 SREM general elements

Level	Name	Type	M/O	Usage	Comment
0.0	SREM	DF	Mandatory		
0.1	timeStamp	DE	Mandatory		
0.2	second	DE	Mandatory		
0.3	sequenceNumber	DE	Mandatory		
0.4	requests	DE	Mandatory	SignalRequestList ::= SEQUENCE (SIZE(1..32)) OF SignalRequestPackage (see table 13.1).	
0.5	requestor	DF	Mandatory	See table 13.3.	
0.6	regional	DF	Optional	REGION.Reg-SignalRequestMessage Not used.	

Table 17.1 SignalRequestList → SignalRequestPackage

Level	Name	Type	M/O	Usage	Comment
1.0	signalRequestPackage	DF	Mandatory	Continues 'requests'	
1.1	request	DF	Mandatory	See table 17.2	
1.2	minute	DE	Optional		
1.3	second	DE	Optional		

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Table 17.1 SignalRequestList → SignalRequestPackage

1.4	duration	DE	Optional	Not used.	
1.5	regional	DF	Optional	REGION.Reg-SignalRequestPackage	

Table 17.2 request → signalRequest

Level	Name	Type	M/O	Usage	Comment
2.0	signalRequest	DF	Mandatory	Continues 'request'	
2.1	id	DE	Mandatory		
2.1.1	region	DE	Mandatory		
2.1.2	id	DE	Mandatory		
2.2	requestID	DE	Mandatory		
2.3	requestType	DE	Mandatory		
2.4	inBoundlane	DF	Mandatory	In typical use either an approach, a lane or connection shall be given, this indicates the requested path through the intersection to the degree it is known.	Note: this mechanism is distinctly different from more traditional prioritisation practices e.g. for public transport, which typically is based on vehicle or line numbers, which are known by the traffic light controller and tied to movements and signal groups. SREM is based on the concept of more specific prioritisation requests which can also extend to other vehicle classes.
2.4.1	lane	DE	Optional	(choice)	
2.4.2	approach	DE	Optional	(choice)	
2.4.3	connection	DE	Optional	(choice)	
2.5	outBoundLane	DF	Optional	In typical use either an approach, a lane or connection shall be given, this indicates the requested path through the intersection to the degree it is known.	Note: this mechanism is distinctly different from more traditional prioritisation practices e.g. for public transport, which typically is based on vehicle or line numbers, which are known by the traffic light controller and tied to movements and signal groups. SREM is based on the concept of more specific prioritisation requests which can also extend

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Table 17.2 request → signalRequest

Level	Name	Type	M/O	Usage	Comment
					to other vehicle classes.
2.5.1	lane	DE	Optional	(choice)	
2.5.2	approach	DE	Optional	(choice)	
2.5.3	connection	DE	Optional	(choice)	
2.6	regional	DE	Not used	REGION.Reg-SignalRequest-addGrpC	

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Table 17.3 requestor → requestorDescription

Level	Name	Type	M/O	Usage	Comment
3.0	requestorDescription	DF	Mandatory	Continues 'requestor'	
3.1	id	DF	Mandatory		
3.1.1	entityID	DE	Optional	Not used.	
3.1.2	stationID	DE	Mandatory	Identical to the stationID of the CAM message and may not change during pending SREM.	
3.2	type	DF	Optional	See table 17.4	
3.3	position	DF	Optional	Not used.	
3.3.1	position	DE	Optional	Not used as parent DF is not used.	
3.3.1.1	lat	DE	Optional	Not used as parent DF is not used.	
3.3.1.2	long	DE	Optional	Not used as parent DF is not used.	
3.3.1.3	elevation	DE	Optional	Not used as parent DF is not used.	
3.3.1.4	regional	DF	Optional	REGION.Reg-Position3D Not used as parent DF is not used.	
3.3.2	heading	DE	Optional	Not used.	
3.3.3	speed	DF	Optional	Not used.	
3.3.3.1	transmission	DE	Optional	Not used as parent DF is not used.	
3.3.3.2	speed	DE	Optional	Not used as parent DF is not used.	
3.4	name	DE	Optional		
3.5	routeName	DE	Optional	routeName should be used to provide information route, line and direction of the vehicle.	
3.6	transitStatus	DE	Optional		
3.7	transitOccupancy	DE	Optional	Not used.	

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3.8	transitSchedule	DE	Optional		
3.9	regional	DE	Optional	REGION.Reg-Requestor-Description-addGrpC. Not used.	
3.9.1	fuel				
3.9.2	batteryStatus				

Table 17.4 type → requestorType

Level	Name	Type	M/O	Usage	Comment
4.0	requestorType	DF	Mandatory	Continues 'type'	
4.1	role	DE	Mandatory		
4.2	subrole	DE	Optional		
4.3	request	DE	Optional		
4.4	iso3833	DE	Optional	Not used.	
4.5	hpmsType	DE	Optional	Not used.	
4.6	regional	DE	Optional	REGION.Reg-RequestorType Not used.	

4.2.4.2 SSEM general elements

Table 18 SSEM general elements

Level	Name	Type	M/O	Usage	Comment
0.0	SSEM	DF	Mandatory		
0.1	timeStamp	DE	Mandatory		
0.2	second	DE	Mandatory		
0.3	status	DF	Mandatory	SignalStatusList ::= SEQUENCE (SIZE(1..32)) OF SignalStatus See table 18.1.	
0.4	regional	DF	Optional	REGION.Reg-SignalStatus-Message Not used.	

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Table 18.1 SignalStatusList → SignalStatus

Level	Name	Type	M/O	Usage	Comment
1.0	signalStatus	DF	Mandatory	Continues 'status'.	
1.1	sequenceNumber	DE	Mandatory		
1.2	id	DF	Mandatory		
1.2.1	region	DE	Optional		
1.2.2	id	DE	Mandatory		
1.3	sigStatus	DF	Mandatory	SignalStatusPackageList ::= SEQUENCE (SIZE(1..32)) OF SignalStatusPackage See table 18.2.	
1.4	regional	DF	Not used	REGION.Reg-SignalStatus-addGrpC.	

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Table 18.2 SignalStatusPackageList → signalStatusPackage

Level	Name	Type	M/O	Usage	Comment
2.0	signalStatusPackage	DF	Mandatory	Continues 'sigStatus'	
2.1	requestor	DF	Mandatory		
2.1.1	id	DE	Mandatory		
2.1.1.1	entityID	DE	Optional	Choice: not used.	
2.1.1.2	stationID	DE	Mandatory	Choice	
2.1.2	request	DE	Mandatory		
2.1.3	sequenceNumber	DE	Mandatory		
2.1.4	role	DE	Optional	Not used.	
2.1.5	typeData	DE	Mandatory		
2.1.5.1	role	DE	Mandatory		
2.1.5.2	subrole	DE	Optional		
2.1.5.3	request	DE	Optional	Not used.	
2.1.5.4	iso3833	DE	Optional	Not used.	
2.1.5.5	hpmsType	DE	Optional	Not used.	
2.1.5.6	regional	DF	Optional	REGION.Reg-RequestorType Not used.	
2.2	inBoundlane	DF	Mandatory		
2.2.1	lane	DE	Optional	(choice)	
2.2.2	approach	DE	Optional	(choice)	
2.2.3	connection	DE	Optional	(choice)	
2.3	outBoundLane	DF	Optional		
2.3.1	lane	DE	Optional	(choice)	
2.3.2	approach	DE	Optional	(choice)	

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2.3.3	connection	DE	Optional	(choice)	
2.4	minutes	DE	Mandatory		
2.5	second	DE	Mandatory		
2.6	duration	DE	Optional		
2.7	status	DE	Mandatory		
2.8	regional	DF	Optional	REGION.Reg-SignalStatus-Package-addGrpC Not used.	
2.8.1	synchToSchedule		Optional		
2.8.2	rejectedReason		Optional		

4.2.5 Cooperative Awareness Basic Service (CA Basic FLS)

The Cooperative Awareness Basic Service and the Cooperative Awareness Message (CAM) are intended to realize cooperative awareness (i.e. locate vehicles or cooperative infrastructure in real time and signal position and state of vehicles). CAM are transmitted regularly by the V-ITS-S and R-ITS-S, all ITS stations within range can receive and process them.

The following description is based on the ETSI standard EN 302 637-2 V1.4.1 (2019-04) [7].

The CAM structure is described in following figure. It is composed of mandatory data (ITS PDU header, Basic container containing in particular the ID and the last geographic positions of the ITS station as well as the High Frequency (HF) container containing the vehicle's fast-changing data) and optional data, which should be specified based on the message's sender.

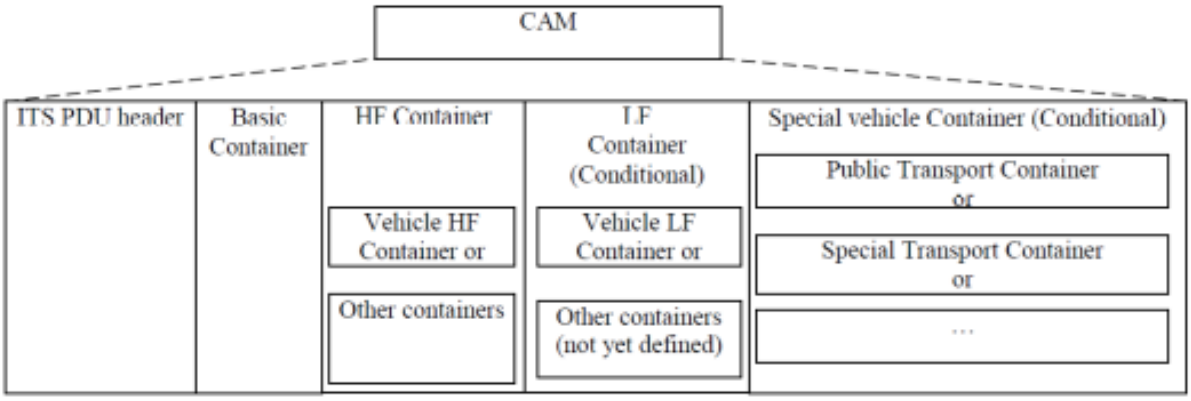

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Table 19 CAM elements

Level	Name	M/O	Usage	Comment
1.0	**CAM**	**Mandatory**		
1.1	header [ItsPduHeader]	Mandatory	**Content:** As specified in the data dictionary ETSI TS 102 894-2 [8] **Value:** protocolVersion = 2, messageID = cam(2)	
1.2	cam [CoopAwareness]	Mandatory	As described below	
2.0	**CoopAwareness**	**Mandatory**		
2.1	generationDeltaTime [GenerationDeltaTime]	Mandatory	**Content:** type is "INTEGER { oneMilliSec(1) } (0..65535)". It is the generation time of the CAM. **Value:** The value of the DE shall be wrapped to 65 536. This value shall be set as the remainder of the corresponding value of TimestampIts divided by 65 536: generationDeltaTime = TimestampIts mod 65 536.	
2.2	camParameters [CamParameters]	Mandatory	As described in the following table.	

The camParameters DF is described in the table below.

Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
1.0	**BasicContainer**	**Mandatory**		
1.1	stationType [StationType]	Mandatory	**Content:** For completely stationary units (e.g. roadside units) and when using the RSP: roadsideUnit(15). For potentially mobile units (e.g. trailers, or special vehicles, trams) and when using the MSP: trailer(9) for trailers, moped(3), motorcycle(4), passengerCar(5), bus(6), lightTruck(7), heavyTruck(8) for normal vehicles using their actual stationType, specialVehicles(10) for special vehicles, tram(11) for trams. **Value:** Between 3 and 11 or 15. Cf. ETSI TS 102 894-2 [8]	

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Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
1.2	referencePosition [ReferencePosition]	Mandatory	**Content:** R-ITS-S or V-ITS-S position and related precision, as specified in chapter 6.2 in ETSI EN 302 890-2. This position is updated in real time; it shall correspond to the current position of the station. This measurement is made on the temporal basis of GenerationDeltaTime. **Value:** See next 4 lines.	-
1.2.1	latitude [Latitude]	Mandatory	Latitude of the station, as specified in chapter 6.2 in ETSI EN 302 890-2.	
1.2.2	longitude [Longitude]	Mandatory	Longitude of the station, as specified in chapter 6.2 in ETSI EN 302 890-2.	
1.2.3	positionConfidenceEllipse [PositionConfidenceEllipse]	Mandatory	PositionConfidenceEllipse is defined for a 95% confidence level. If such a level cannot be achieved, it shall be set to unavailable.	See RS_RSP_003(1)
1.2.4	altitude [Altitude]	Mandatory	Altitude is defined for a 95% confidence level. If such a level cannot be achieved, AltitudeConfidence shall be set to unavailable.	
2.0	**HighFrequencyContainer**	**Mandatory**	Choice of either the **rsuContainerHighFrequency** or the **basicVehicleContainerHighFrequency**	
2.1	**rsuContainerHighFrequency**		Mandatory for completely stationary units and when using the Roadside ITS G5 System Profile	
2.1.1	protectedCommunicationZonesRSU	Optional	CAMs transmitted from R-ITS-S shall use this field if they want to communicate DSRC protected communication zones (toll stations). It is a sequence of 1 to 16 elements of the DF ProtectedCommunicationZone (see next 6 elements).	A protected zone shall comply with RS_RSP_100.
2.1.1.1	protectedZoneType [ProtectedZoneType]	Mandatory	Type of protected zone, ETSI TS 102 792 distinguishes between permanent CEN DSRC tolling (type “0”) and temporary CEN DSRC tolling (type “1”).	
2.1.1.2	expiryTime [TimestampIts]	Optional	Time at which the validity of the protected communication zone will expire. The expiry time shall be specified if the end of operation is known.	
2.1.1.3	protectedZoneLatitude [Latitude]	Mandatory	Latitude of the center point of the protected communication zone.	
2.1.1.4	protectedZoneLongitude [Longitude]	Mandatory	Longitude of the center point of the protected communication zone.	
2.1.1.5	protectedZoneRadius	Optional	Radius of the protected communication zone in meters.	

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Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
	[ProtectedZone Radius]		Note: If the radius data element is omitted, the default radius of 55m applies (ETSI TS 102 792)	
2.1.1.6	protectedZoneI D [ProtectedZone ID]	Optional	Identifier of the protected zone. If the same zone is defined in the European Protected Zone database, the same ID shall be used as protectedZoneID. Otherwise, an ID greater than 67108863, which is not used in the database, shall be used.	
2.2	**basicVehicleC ontainerHighF requency**		Mandatory for potentially mobile units and when using the Infrastructure mobile ITS-G5 System Profile (MSP).	
2.2.1	heading [Heading]	Mandatory	Vehicle's movement with regards to the true north. Heading is defined for a 95% confidence level. If such a level cannot be achieved, HeadingConfidence shall be set to unavailable.	
2.2.2	speed [Speed]	Mandatory	Vehicle's speed. Speed is defined for a 95% confidence level. If such a level cannot be achieved, SpeedConfidence shall be set to unavailable.	
2.2.3	driveDirection [DriveDirection]	Mandatory	If the aftermarket solution has access to additional information besides GNSS (e.g. gearbox information, reverse light), the direction shall be set to forward or backward. Aftermarket GNSS only based solutions cannot accurately detect driveDirection and shall therefore set to unavailable.	
2.2.4	vehicleLength [VehicleLength]	Mandatory	Length of the vehicle and related precision: * the length of the vehicle includes the accessories like a trailer * the precision covers the detection of an accessory like a trailer and the knowledge of its length	
2.2.5	vehicleWidth [VehicleWidth]	Mandatory	Vehicle's overall width (including the side view mirrors).	
2.2.6	longitudinalAcc eleration [LongitudinalAc celeration]	Mandatory	Acceleration is defined for a 95% confidence level. If such a level cannot be achieved, AccelerationConfidence shall be set to unavailable.	
2.2.7	curvature [Curvature]	Mandatory	For aftermarket solutions, curvature shall be calculated based on yawRate.	By experience, yawRate from GNSS only is not of a high quality, but given GNSS only aftermarket devices, it is the only way to calculate curvature.
2.2.8	curvatureCalcu lationMode [CurvatureCalc ulationMode]	Mandatory	Aftermarket solutions can only calculate curvature using yawRate and therefore shall use yawRateUsed(0).	
2.2.9	yawRate [YawRate]	Mandatory	Aftermarket GNSS only based solutions shall calculate the yawRate using the	By experience, yawRate from GNSS only is not of a high quality, but given

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Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
			change of GNSS "Course over Ground" over time. If the aftermarket solution has access to additional information besides GNSS (e.g. gyro, intertial sensor), the yawRate shall be calculated on that basis.	GNSS only aftermarket devices, it is the only available data source.
2.2.10	accelerationControl [AccelerationControl]	Optional	Optional for aftermarket devices, to be used only if available.	
2.2.11	lanePosition [LanePosition]	Optional	Optional for aftermarket devices, to be used only if available.	
2.2.12	steeringWheelAngle [SteeringWheelAngle]	Optional	Optional for aftermarket devices, to be used only if available.	
2.2.13	lateralAcceleration [LateralAcceleration]	Optional	Optional for aftermarket devices, to be used only if available.	
2.2.14	verticalAcceleration [VerticalAcceleration]	Optional	Optional for aftermarket devices, to be used only if available.	
2.2.15	performanceClass [PerformanceClass]	Optional	Optional for aftermarket devices, to be used only if available.	
2.2.16	cenDsrcTollingZone [CenDsrcTollingZone]	Optional	Optional for aftermarket devices, to be used only if available.	
3.0	**LowFrequencyContainer > basicVehicleContainerLowFrequency**	**Optional**	Optional, only used for specific use cases disseminated by potentially mobile units and when using the Infrastructure mobile ITS-G5 System Profile (MSP).	
3.1	vehicleRole [VehicleRole]	Mandatory	**Content:** An emergency vehicle in operation having right of way (typically a "blue flashing light" setting) should result in the vehicle role set to emergency(6) and the usage of the EmergencyContainer. Other special roles indicated by warning lights (e.g. "amber/yellow flashing light") should result in the usage of safetyCar(7) together with the safetyCarContainer or rescue(5) together with the rescueContainer. Details can be found in the "Common C-ITS service and use case definitions". **Value:**	

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Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
			default(0), publicTransport(1), specialTransport(2), dangerousGoods(3), roadWork(4), rescue(5), emergency(6), safetyCar(7), agriculture(8), commercial(9), military(10), roadOperator(11), taxi(12).	
3.2	exteriorLights [ExteriorLights]	Mandatory	If a vehicle is not equipped with a certain light or if the light switch status information is not available, the corresponding bit shall be set to 0.	If the vehicleRole is used, the status of the exteriorLights is mandatory – which is problematic for aftermarket devices as they do not have information about the light status.
3.3	pathHistory [PathHistory]	Mandatory	Road operators should use design method one as specified in Appendix A.5 to SAE J2945/1. For existing systems, equidistant points may be used instead of design method one. In this case, the default settings are: a maximum of 40 tracking points with a distance of 22.5 m between the points. After a pseudonym change, path history shall be deleted.	
4.0	**SpecialVehicle Container**	**Optional**	It is a choice between the following containers, depending on the type of vehicle and the vehicleRole (between 0 and 7).	
4.1	**publicTransportContainer [PublicTransportContainer]**	**Optional**	**To be used when vehicleRole is publicTransport(1).** **Mandatory only for specific use cases (Public Transport Vehicle Crossing, Public Transport Vehicle at a Stop)** **The mandatory DE listed below are mandatory only when the container is present in the message for these specific use cases**	
4.1.1	embarkationStatus [EmbarkationStatus]	Mandatory	**Content:** Indicates whether the public transport vehicle is under the embarkation process. **Value:** TRUE or FALSE	
4.1.2	ptActivation [PtActivation]	Optional	DE used for various tasks in the public transportation environment, especially for controlling traffic signal systems to prioritize and speed up public transportation in urban area. Currently not used by C-ROADS.	
4.2	**specialTransportContainer [SpecialTransportContainer]**	**Optional**	**To be used when vehicleRole is specialTransport(2).**	

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Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
			Optional for all use cases if a vehicle is carrying goods with heavy load, excess width, excess length or excess height. **The mandatory DE listed below are mandatory only when the container is present in the message for these specific use cases**	
4.2.1	specialTransportType [SpecialTransportType]	Mandatory	Content: Indicates if a vehicle is carrying goods with heavy load, excess width, excess length or excess height Value: BIT STRING (heavyLoad(0), excessWidth(1), excessLength(2), excessHeight(3)). The corresponding bit shall be set to 1 when the special transport applies to the corresponding case. Otherwise, the corresponding bit shall be set to 0.	
4.2.2	lightBarSirenInUse [LightBarSirenInUse]	Mandatory	**Content:** Indicates whether light bar or siren is in use. **Value:** BIT STRING { lightBarActivated (0) and sirenActivated (1)}. The corresponding bit shall be set to 1 if the light bar or the siren is known to be active, otherwise 0.	
4.3	**dangerousGoodsContainer [DangerousGoodsContainer]**	**Optional**	**Currently not used by C-ROADS.**	
4.4	**roadWorksContainerBasic [RoadWorksContainerBasic]**	**Optional**	**Currently not used by C-ROADS.**	
4.5	**rescueContainer [RescueContainer]**	**Optional**	**To be used when vehicleRole is rescue(5).** **Mandatory only for specific use cases (Emergency or Prioritised Vehicle Approaching using blue lights)** **The mandatory DE listed below is mandatory only when the container is present in the message for these specific use cases**	
4.5.1	lightBarSirenInUse [LightBarSirenInUse]	Mandatory	**Content:** Indicates whether light bar or siren is in use. **Value:**	

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Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
			BIT STRING {lightBarActivated (0), sirenActivated (1)}. The corresponding bit shall be set to 1 if the light bar or the siren is known to be active, otherwise 0.	
4.6	**emergencyContainer [EmergencyContainer]**	**Optional**	**To be used when vehicleRole is emergency(6).** **Mandatory only for specific use cases (e.g. Emergency or Prioritised Vehicle Approaching using blue lights)** **The mandatory DE listed below are mandatory only when the container is present in the message for these specific use cases**	
4.6.1	lightBarSirenInUse [LightBarSirenInUse]	Mandatory	**Content:** Indicates whether light bar or siren is in use. **Value:** BIT STRING { lightBarActivated (0), sirenActivated (1)}. The corresponding bit shall be set to 1 if the light bar or the siren is known to be active, otherwise 0.	
4.6.2	incidentIndication [CauseCode]	Mandatory	**Content:** In case of incident, the CauseCode and subCauseCode associated to the event and described in DENM message profile shall be provided. **Value:** Use case dependent, causeCodes 15/1 and 95/1 are currently used in C-ROADS use cases. Find details in the individual use case description in the “Common C-ITS service and use case definitions”	
4.6.3	emergencyPriority [EmergencyPriority]	Optional	**Content:** Indicates a vehicle’s necessity for priority. **Value:** 0 for requestForRightOfWay and 1 for requestForFreeCrossingAtATrafficLight.	
4.7	**safetyCarContainer [SafetyCarContainer]**	**Optional**	**To be used when vehicleRole is safetyCar(7).** **Mandatory only for specific use cases (e.g. Special Vehicles using yellow lights).** **The mandatory DE listed below are mandatory only when the container is present in the message for these specific use cases**	
4.7.1	lightBarSirenInUse	Mandatory	**Content:** Indicates whether light bar or siren is in use.	

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Table 20 camParameters DF

Level	Name	M/O	Usage	Comment
	[LightBarSirenInUse]		**Value:** BIT STRING {lightBarActivated (0), sirenActivated (1)}. The corresponding bit shall be set to 1 if the light bar or the siren is known to be active, otherwise 0.	
4.7.2	incidentIndication [CauseCode]	Mandatory	**Content:** In case of incident, the CauseCode and subCauseCode associated to the event and described in DENM message profile shall be provided. **Value:** Use case dependent, causeCodes 15/0 and 95/2 are currently used in C-ROADS use cases. Find details in the individual use case description in the "Common C-ITS service and use case definitions"	
4.7.3	trafficRule [TrafficRule]	Optional	**Content:** It indicates traffic rules that apply to vehicles at a certain position. It includes the following information: • If overtaking is prohibited for all vehicles, the DE shall be set to 0. • If overtaking is prohibited for trucks, the DE shall be set to 1. • If vehicles should pass to the right lane, the DE shall be set to 2. • If vehicles should pass to the left lane, the DE shall be set to 3. **Value:** Is 0, 1, 2 or 3.	
4.7.4	speedLimit [SpeedLimit]	Optional	The speed limit is given between 1 and 255. The unity to be used is kilometers per hour.	

4.3 Operational Specifications / Triggering Conditions

This section describes the information management DENM and IVIM. CAM, SPATEM, MAPEM, SREM, SSEM will be investigated for a later release. Note, that different triggering conditions do not cause interoperability issues. If the information enclosed in the messages is interoperable, different update or cancellation mechanisms do not cause semantic problems. However, the following principles shall be applied to all messages:

1. Messages shall be updated within the validity duration or before the validity time runs out.
2. To render a message invalid either a cancellation for the rest of the remaining validity duration shall be sent or the validity shall be let run out.
3. Negation shall never be used.

4.4 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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4.5 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.

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 FLSs can and will be detailed by Task Force 1 (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/IEC 27001 [24] 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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5 Geonetworking settings

The Geonet destination area (as defined by GeoAreaPos and Distance in the GBC packet header) shall be set in a way that it at least includes the eventPosition / referencePosition, traces / detectionZones and eventZone / relevanceZones of the message. The destination area shall have a maximum size of 80 km2 (RS_BSP_255 max size of geonet destination area in BSP).
Note: The centre of the destination area does not need to be on the eventPosition / referencePosition.

For short-range communication, the GeoAdhoc router reference position within the SO PV (source position vector) in the GBC packet header should be set to the position of the transmitting RSU to enable forwarding within the Geonet destination area.

For long-range communication, the GeoAdhoc router reference position within the SO PV (source position vector) in the GBC packet header should be set at an offset of the eventPosition / referencePosition to enable forwarding within the Geonet destination area on short-range communication.

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6 References

All normative references within a standard referenced here are automatically included and will not be listed separately. Only if a normative reference is out of date because a newer version of the reference standard is supported, the newer reference is listed and marked accordingly.

Table 21 Table of normative key references

#	Reference
[5]	ETSI EN 302 571 V2.1.1 (2017-02) - 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
[11]	ETSI TS 103 301 V2.1.1 (2021-03) - Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services

Table 22 Table of additional normative references

#	Reference
[1]	ETSI TR 102 638 V1.1.1 (2009-06) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions
[2]	ETSI EN 302 665 V1.1.1 (2010-09) Intelligent Transport Systems (ITS); Communications Architecture
[4]	C-ROADS, Roadside ITS G5 System Profile
[6]	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
[7]	ETSI EN 302 637-2 V1.4.1 (2019-01) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service
[8]	ETSI TS 102 894-2 V2.1.1 (2022-11) Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary; Release 2
[9]	C-ROADS, C-ITS Service and Use Case Definitions
[10]	ETSI TS 103 831 V2.1.1 (2022-11) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Decentralized Environmental Notification Service; Release 2
[12]	ISO/TS 19321:2020 (2020-09) - Intelligent transport systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structures

[13]	ISO 3166-1:2013 Codes for the representation of names of countries and their subdivisions -- Part 1: Country codes
[14]	ISO 14816:2005 Road transport and traffic telematics; Automatic vehicle and equipment identification; Numbering and data structure.
[15]	ISO/TS 14823:2017. Intelligent transport systems -- Graphic data dictionary
[16]	ECo-AT_SWP2.1_InVehicleInformation_v04.00
[17]	DUTCH C-ITS Corridor Profile, Version 3.0
[18]	ISO 639-1 Codes for the representation of names of languages - Part 1: Alpha-2 code
[19]	ISO/IEC 27001:2017 Information technology -- Security techniques -- Information security management systems -- Requirements
[21]	ISO/TS 19091:2019 Intelligent transport systems — Cooperative ITS — Using V2I and I2V communications for applications related to signalized intersections
[22]	SAE J2735:2016, Dedicated Short Range Communications (DSRC) Message Set Dictionary
[23]	C-ITS for Automated Driving - SWP1.2 - Functional Specification v01.00
[24]	C-ROADS, Mobile ITS G5 System Profile
[25]	C-Roads, C-ITS European Handbook for MAPEM and SPATEM Creation
[26]	SAE J2945:2016, On-Board System Requirements for V2V Safety Communications
[27]	Automotive Requirements for the Infrastructure to Vehicle Information (IVI) Service 1.6.3, CAR 2 CAR Communication Consortium

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7 Informative Annex I

Legacy implementations exist, which implement functionality similar to the TLC FLS by using CAM. They can be used for testing purposes, but need to migrate to the specified solution in 4.2.4 according to the migration path and are not fully supported by C-ROADS. Table 23 Shows the usage of CAM elements for this purpose.

Table 23 CAM elements specific for the TLC functionality

Level	Name	Type	M/O	Usage	Comments
0.0	**CAM**	**DF**	**Mandatory**		
0.1	generationDeltaTime	DE	Mandatory	Timestamp belonging to the referencePosition.	
1.0	**Basic Container**	**DF**	**Mandatory**		
1.1	stationType	DE	Mandatory	Type of broadcast source – bus / tram	
1.2	referencePosition	DE	Mandatory	Vehicle location	
2.0	**High Frequency Container**	**DF**	**Mandatory**		
2.1	speed	DE	Mandatory	Vehicle speed	
2.2	heading	DE	Mandatory	Vehicle direction	
2.3	longitudinalAcceleration	DE	Mandatory	Vehicle acceleration	
2.4	driveDirection	DE	Mandatory	Drive direction	
2.5	vehicleLength	DE	Mandatory	Length of the vehicle	
3.0	**Low Frequency Container**	DF	Optional		
3.1	vehicleRole	DE	Mandatory	Vehicle role – publicTransport / emergency	
3.2	exteriorLights	DE	Mandatory	Activated headlights	
4.0	**Public Transport Container**	DF	Optional		
4.1	embarkationStatus	DE	Optional	State of passenger doors	
4.2	ptActivation	DF	Optional	Information about PT vehicle (e.g. priority request information, public transport line number)	
5.0	**Emergency Container**	DF	Optional		
5.1	emergencyPriority	DE	Optional	Priority request	

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