C-ITS Message Profiles and Parameters

C-ROADS Platform

Working Group 2 Technical Aspects

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Acronyms

5G-CCH	Channel with 5900 MHz carrier centre frequency
AD	Automated Driving
AG	Amsterdam Group
CA	Cooperative Awareness
CAM	Cooperative Awareness Message
C-ITS	Cooperative ITS
CITSC	C-ITS Corridor
C-ITS-S	Central ITS Station
CRW	Collision Risk Warning
CT	Container
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
DSRC	Dedicated Short Range Communication
F	Facilities Layer
FLS	Facilities Layer Service
GN	Geo Network Layer
GNSS	Global Navigation Satellite System
HF	Header Field
HLN	Hazardous Location Notifications
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). ITS-G5 refers to the approved amendment of the IEEE 802.11 (standard IEEE 802.11p). This technology (possibly others) uses the 5.9 GHz frequency band to support safety- and non-safety ITS applications. In this document ITS-G5 stands for IEEE802.11p/ETSI ITS-G5.
ITS-S	ITS Station
ITSS-VG	Road Operator On Board Unit
IVI	In-Vehicle Information
IVI service	Infrastructure to Vehicle Information (IVI) service
IVIM	Infrastructure to Vehicle Information Message
IVS	In-Vehicle Signage
km	kilometre
m	metre
MAPEM	MAP (topology) Extended Message
ms	millisecond

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MS	Member State
OBU	On Board Unit
OSI	Open Systems Interconnection model
PDU	Protocol Data Unit
R-ITS-S	Roadside ITS Station (the so-called RSU)
RSP	ITS-G5 Roadside System Profile (abbreviated as Roadside System Profile or Infrastructure Profile)
RWW	Roadworks Warning
s	seconds
SAP	Service Access Point
SCT	Sub-Container
SDU	Service Data Unit
SP	Service Primitive
SPATEM	Signal Phase And Timing Extended Message
SREM	Signal Request Extended Message
SSEM	Signal request Status Extended Message
TCC	Traffic Control Centre

N/A	*Not Applicable*

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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Introduction

Cooperative ITS (C-ITS or cooperative systems) encompass a group of ITS technologies and applications that allow data exchange through wireless communication technologies between components and actors of the transport system either between vehicles (vehicle-to-vehicle or V2V) or between vehicle and infrastructure (vehicle-to-infrastructure or V2I).

The deployment of C-ITS is an evolutionary process that will start with less complex ITS-S applications. These are referred to as “Day-1-services”, encompassing messages about for example traffic jams, hazardous locations, roadworks, as well as weather information and speed advice to harmonise traffic.

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

This document defines the common base for the ITS-G5 functional and technical specifications. The specification targets the communication between **roadside units and vehicles**. The communication directions derived from this are also known as **I2V** (Infrastructure-to-Vehicle) and **V2I** (Vehicle-to-Infrastructure) communication. 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)
- Vehicles and vehicles (V2V)

Since this document focuses more on the technical specifications of supported C-ROADS FLS (day-1 services) according to the list of the final C-ITS Platform [3] report, another document (Roadside ITS-G5 System Profile) [4] defines the requirements of the Infrastructure Roadside System Profile (RSP). The Infrastructure Roadside System profile references to this document frequently.

This document is structured into three sections:

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

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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1 Provisions

1.1 Verbal forms for the expression of provisions

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

Shall / Shall not

Recommendations shall be indicated by the verbal forms:

Should / Should not

Permissions shall be indicated by the verbal forms:

May / May not

Possibility and capability shall be indicated by the verbal forms:

Can / Cannot

Inevitability used to describe 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

1.2 Provisions from referenced documents

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

1.3 Multiplicity and Usage

The multiplicity of elements is denoted with mandatory or optional

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 in used). The usage may contain definitions of DE/DF in accordance with corresponding standards. Table 1, Table 3, Table 10, Table 14, Table 15, Table 16 and Table 17 provide general usage information of message sets, while Table 2, Table 6, Table 8 and Table 11 provide details of ITS-S application specific's usage information.

1.4 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 should not be more than one quarter of the width of the carriageway.

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2 System Facilities Layer Services (System FLSs)

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

2.1.1 Introduction

The Coexistence FLS ensures that ITS stations can operate without interfering with CEN DSRC based tolling equipment 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 roadside 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.

2.1.2 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.

2.1.3 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.

2.1.3.1 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 center 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. Table 2 provides detailing of the elements used.

Table 1 Structure of a CAM with Protected Zone elements

Date element / data frame	Data type (No. in CDD [8])
CAM	
header	ItsPduHeader (114)
cam	CoopAwareness
generationDeltaTime	GenerationDeltaTime

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camParameters	CamParameters
basicContainer	BasicContainer
highFrequencyContainer	HighFrequencyContainer
rsuContainerHighFrequency	RSUContainerHighFrequency
protectedCommunicationZonesRSU	ProtectedCommunicationZonesRSU (122)
ProtectedCommunicationZone	ProtectedCommunicationZone (121)
protectedZoneType	ProtectedZoneType (58)
expiryTime	TimestampIts (82)
protectedZoneLatitude	Latitude (41)
protectedZoneLongitude	Longitude (44)
protectedZoneRadius	ProtectedZoneRadius (57)
protectedZoneID	ProtectedZoneID (56)

Table 2 CAM elements specific to the Coexistence ITS-S application

Data element / data frame	M/O*	Usage	Comment
highFrequencyContainer	M	(as specified in [7])	
rsuContainerHighFrequency	M	Note: Mandatory for R-ITS-S	
ProtectedCommunicationZonesRSU	O	Mandatory for Coexistence.	
ProtectedCommunicationZone	M	(as specified in [8])	
protectedZoneType	M	Type of protected zone, ETSI TS 102 792 [6] distinguishes between permanent CEN DSRC tolling (type “0”) and temporary CEN DSRC tolling (type “1”).	
expiryTime	O	(as specified in [8]) The expiry time shall be specified if the end of tolling operation is known.	
protectedZoneLatitude	M	(as specified in [8])	
protectedZoneLongitude	M	(as specified in [8])	
protectedZoneRadius	O	(as specified in [8]) Note: If the radius data element is omitted, the default radius of 55m applies (ETSI TS 102 792 [6]).	
protectedZoneID	O	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 then 67108863, which is not used in the database, shall be used.	
*M/O: Mandatory/Optional according to ETSI TS 102 894-2 [8]			

2.1.3.2 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.

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 Protection Zone CAMs can be received and processed by mobile ITS stations in time by appropriate selection of the dissemination area and the CAM transmission rate.

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2.2 Other system FLSs

There are currently no other system FLSs.

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3 Functional FLSs

3.1 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 3.2 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 EN 302 637-3 [10]),
Infrastructure to 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 3.3 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 applications in the transmitting ITS-S or other connected ITS-S (e.g. a C-ITS-S) and passed to the Facilities layer via service access points. Beyond the payload, these service access points may include further parameters to control the handling and transmission of the payload (service parameters). At the receiving ITS-S, the messages are forwarded to applications or connected ITS-S by forwarding mechanisms.
Once message transmission is triggered, the FLSs may be configured to repeat the transmission, until the applications request its termination or trigger another request to generate an updated message.

3.2 Service definition and message content

3.2.1 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 EN 302 637-3 [10]).

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"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 EN 302 637-3 [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 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 102 894-2 [8].

3.2.1.1 DENM general elements

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

Table 3 DENM elements in general

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

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Table 3 DENM elements in general

Name	M/O	Usage	Comment
		hazardous location starts / is detected at a functional level. **Value:** detectionTime is initially set at the start time of the event (new DENM) then reset for each DENM update. For the DENM termination, this DE shall be the time at which the termination of the event is detected	**Augmented and TCC Triggered RWW, HLN:** detectionTime will be set based on C-ITS-S system time when it receives the event information from the TCC. Will be updated using the DENM update mechanism whenever the event changes according to the TCC.
referenceTime	Mandatory	**Content:** Following the DENM standard, the referenceTime shall be set to the time the DENM message is generated or updated. **Value:** Set automatically	*AT* referenceTime is set by the C-ITS-S or R-ITS-S depending on the use case scenario, for example by the R-ITS-S for Standalone RWW and by the C-ITS for other RWW and HLN use case scenarios.
termination	Optional		
eventPosition	Mandatory	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. The accuracy should be on the level of a lane, but shall at least be on the accuracy level of the carriageway. Altitude and confidence DEs can be used or set to the values corresponding with 'unavailable'. In case of blockages by trailers, it depends on the Member State (MS) whether the blockage is the trailer or a cone.	See ITS-S application specific parts in the following subsections.
relevanceDistance	Optional		See ITS-S application specific parts in the following subsections.
relevanceTrafficDirection	Mandatory	**Content:** This DF indicates for which traffic direction the message is relevant (from the perspective of the eventPosition). **Value:** allTrafficDirections (0), upStreamTraffic (1), downstreamTraffic (2)	See also ITS-S application specific parts in the following subsections.
validityDuration	Mandatory	Events are represented by DEN messages. The duration of a singular DENM is based on the (configurable) value of "validityDuration". As long as an event is valid for the road operator, it will be continuously sent out (using DENM repetition) and updated (using DENM update, renewing "validityDuration", "detectionTime" and "referenceTime" in the process). Message update will be triggered by "validityDuration" falling below a certain (also configurable) threshold. If the event is no longer valid, it is either timing out or being actively cancelled (DENM cancellation).	See also ITS-S application specific parts in the following subsections. *AT, DE* AT is only using DENM repetition and DENM update. DENM update is triggered after half of "validityDuration" has passed. Events no longer valid are no longer updated and therefore timing out. DENM

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Table 3 DENM elements in general

Name	M/O	Usage	Comment
		Content: The DE validityDuration is set to a fixed value. **Value:** Set by application.	cancellation or negation are not used. Default values for "validityDuration" are 20s for Standalone RWW and 720s for all other RWW use case scenarios and HLN.
TransmissionInterval	Optional	Not used	
stationType	Mandatory	**Content:** Fixed value, set to 15 (roadSideUnit). This is true for both fixed R-ITS-S and portable R-ITS-S. Can be 9 for static and towed trailers. For road operator vehicles (static and moving) 10 (specialVehicles) shall be used. For public Transport 6 (bus) or 11 (tram) shall be used. NOTE: 9 is used for towed trailers although the ETSI TS 102 894-2 [8] mentions in an informational note, that 9 should only be used for not towed trailers. In addition, C-ROADS will request the removal of that note. **Value:** Set to 6, 9, 10, 11 or 15.	
Situation Container	Mandatory		
informationQuality	Mandatory	informationQuality expresses the likelihood of occurrence of an event and not the quality of the location information of the event, which is expressed by eventPosition and positionConfidence. Values: Certain (6): verification by a verification system (e. g. detection by loops or radar, accumulation of CAMs) with a 99.9% safety guaranty or manual verification (i. e. by using CCTV or being on site) by road operator agent or other reliable source (e. g. police) Probable (4): multiple sources of automated data in larger quantity per minute alert the event or notification by not verifiable reliable humans Risk of (2): one source of automated data e. g. CAM or a traffic sensor alerting the event or notification by a not verifiable reliable human If (0) is received it should be rejected and if (7) is received it should be considered as Certain.	
eventType	Mandatory	Combination of DE causeCode and DE subCauseCode. See ITS-S application specific parts in the following subsections.	

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Table 3 DENM elements in general

Name	M/O	Usage	Comment
linkedCause	Optional	Possibility to link the current message to a set of causeCode / subCauseCode (similar to eventType) to provide further information	*AT* linkedCause is used for HLN. linkedCause is not used for the RWW ITS-S application because messages belonging together are linked with the more detailed "referenceDenm" data frame from the roadworks container. *DE, BE(Fla), NL, UK* Not used *FR* Used for RWW
eventHistory	Optional	**Content:** This profile optionally uses this DE when the endpoint of the physical blockage can be determined. If so, it describes the start of a blockage to the end of the blockage, or to the start of a new blockage (another DENM). Note that in this context, the eventPoint values are provided without corresponding eventDeltaTime, since the points describe a geospatial extent and not a trajectory. The DE informationQuality inside the eventHistory will be set to the same value as the above specified informationQuality of the whole DENM. The principles of location referencing, defined in 1.4 apply.	*AT* eventHistory in AT is a full history of the event (using equidistant points) from the eventPosition to the end of event. Default point distance is 50m but can increase if events are longer than 1150m due to the restriction of maximum 23 points in the eventHistory. Points are placed in the middle of the carriageway" **Standalone & Augmented RWW, HLN (point events)** Not used. **TCC Triggered RWW, HLN (events with extension)** Used. *DE* Not used for Day 1 *BE(Fla), FR, NL, UK* see InterCor M03 Upgraded Specifications ITS G5 [20]
Location Container	Optional		
eventSpeed	Optional	This DF will not be provided in case of a static event and be provided, when the event is moving, if available.	
eventPositionHeading	Optional	Heading information will only be provided for moving events via eventPositionHeading. Stationary DENM based events will not use this DF	
traces	Mandatory	The first trace point in the message is the point closest to the event position. This point is positioned in the middle	*DE*

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Table 3 DENM elements in general

Name	M/O	Usage	Comment
		of the lane or carriageway upstream from the event position, considering the curvature of the road. This point is coded as an offset delta position about the event position. Additional trace points are defined as offsets or delta positions with respect to their previous trace points. The trace points will be listed in upstream order, thus also defining the event heading. Up to seven traces can be present The principles of location referencing, defined in 1.4 apply.	RWW: Always set by the R-ITS-S on the roadworks trailer. *AT* **TCC Triggered RWW, HLN:** Generated in the TCC via precise map matching of event location information (potentially originating from a trailer) and provided to the C-ITS-S. The data frame shall consist of at least 10 data elements of type pathPoint with a steady distance of 50m. **Augmented RWW** Based on uplink information from R-ITS-S **Standalone RWW** Generated in R-ITS-S or trailer (without any manual interaction; GNSS required). *BE(Fla), FR, NL, UK* **Content:** The last trace point is preferably at least 1.5 km upstream of the event position. Additional trace points are also positioned in the middle of the lane or the carriageway. **Value:** Set by application
roadType	Optional		
Alacarte Container	Optional		
lanePosition	Optional		See ITS-S application specific parts in the following subsections.
impactReduction	Optional	Not used	
externalTemperature	Optional	Not used	
lightBarSirenInUse	Optional	Not used	
roadWorks.closedLanes	Optional		See ITS-S application specific parts in the following subsections.

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Table 3 DENM elements in general

Name	M/O	Usage	Comment
restriction	Optional	Not used.	
speedLimit	Optional	Optional	See ITS-S application specific parts in the following subsections.
incidentIndication	Optional	Not used.	
recommendedPath	Optional		See ITS-S application specific part in the following subsections.
startingPointSpeedLimit	Optional		See ITS-S application specific part in the following subsections.
trafficFlowRule	Optional		See ITS-S application specific part in the following subsections.
referenceDenms	Optional		See ITS-S application specific part in the following subsections.
positioningSolution	Optional	Not used for I2V, but may be used for V2V by road operator vehicles.	
stationaryVehicle	Optional	Not used in Day 1. (Might be used for equipped pre-warners in future)	

Table 4 Service Parameters associated with DEN Basic FLS

Service Parameters			
Name	**Type**	**Layer**	**Value**
repetitionDuration	P	F	Equal to the value of data element ValidityDuration. Note: Shall be discussed with other stakeholders.
repetitionInterval	P	F	See ITS-S application specific part in the following subsections. Note: Shall be discussed with other stakeholders.
itGnLocalAddrConMethod	P	GN	ITS-S application and country specific.
LifeTime	HF	GN	ITS-S application and country specific.
Flags	HF	GN	ITS-S application and country specific.
Country Code	HF	GN	ITS-S application and country specific.
Other parameters	-	All	See the Roadside ITS-G5 System Profile [4].

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Legend: P = Parameter, HF = Header Field, F = Facility Layer, GN = Geo Networking

3.2.1.2 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 application of multiple message types, e.g. IVIM, MAPEM and DENM for complex RWW, are currently not covered.

Table 5 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 6.

Table 6 DENM elements specific to RWW

Name	M/O	Usage	Comment
Situation Container	**Mandatory**		
causeCode	Mandatory	**Value:** Set to 3, 15, 26 or 95	
subCauseCode	Mandatory	Values: 0, 1, 2, 3, 4, 5, 6, 8	

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Table 6 DENM elements specific to RWW

Name	M/O	Usage	Comment
Alacarte Container	**Optional**		
closedLanes	Optional	The lanes are counted from inside border of the road excluding the hard shoulder. This DF consists of drivingLaneStatus and hardShoulderStatus.	*AT, DE* Optional. Its usage depends on the particular use case scenario: **Standalone RWW** Not used. **Augmented (AT: and TCC Triggered) RWW** provided by the TCC as precise as possible if the information is available. *BE(Fla), FR, NL, UK* **Status:** Optional **Content:** In case of a 'plusstrook', an extra narrow lane on the left side, that lane is always included with the correct status set (0=open or 1=closed) in drivingLaneStatus. In case of a hard shoulder temporarily used as a normal lane (also known as 'hard shoulder running'), the hard shoulder shall be included as a regular lane in drivingLaneStatus if it is in use. If this lane is in use, hardShoulderStatus shall, since the hard shoulder as such no longer exists, not be used. If available, it is valid only at the eventPosition.
referenceDenms	Optional	RWW DENMs belonging to the same roadwork situation will be linked in the C-ITS-S by listing all actionIDs belonging together in the referenceDenms data element of each message	*AT* **Moving and Stationary Standalone RWW** Not used. **Augmented and TCC Triggered RWW** Used if the information is available. *BE(Fla), FR, NL, UK* Optional

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Table 7 Service parameters associated with RWW with national choices

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

3.2.1.3 Hazardous Location Notifications (HLN)

The specific usage of DENM data elements and DENM data frames is defined in Table 8. Service parameters are specified in Table 9.

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Table 8 DENM elements specific to Hazardous Location Notifications (HLN)

Name	M/O	Usage	Comment
Management-Container	**Mandatory**		
relevanceTrafficDirection	Mandatory	upstreamTraffic, downstreamTraffic	
Situation Container	**Mandatory**		
eventType	Mandatory	• 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) • causeCode 95 subCauseCode 0, 1 (Emergency vehicle approach) • causeCode 97 subCauseCode 1 (collision risk)	*AT* • causeCode 1 subCauseCode 0 (Traffic condition) • causeCode 2 subCauseCode 0,1,3,4,5 (Accident) • causeCode 6 subCauseCode 4-6 (Adverse weather condition - adhesion) • causeCode 9 subCauseCode 0 (Hazardous location - Surface condition) • causeCode 10 subCauseCode 1,4 (Hazardous location - Obstacle on the road) • causeCode 11-12 subCauseCode 0 (Animal or human presence on the road) • causeCode 13 subCauseCode 0 (Wrong way driving) • causeCode 15 subCauseCode 0 (Rescue and recovery work in progress) • causeCode 17 subCauseCode 1-2 (Adverse weather condition – extreme weather condition) • causeCode 18 subCauseCode 1 (Adverse weather condition - visibility) • causeCode 19 subCauseCode 1 (Adverse weather condition - precipitation) • causeCode 26 subCauseCode 3 (Slow vehicle) • causeCode 94 subCauseCode 2 (Stationary vehicle) • causeCode 99 subCauseCode 0 (Dangerous situation) *ESP* • causeCode 1 subCauseCode 0 (Traffic jam) • causeCode 2 subCauseCode 0, 7 (Accident) • causeCode 6 subCauseCode 0-8 (Adhesion) • causeCode 9 subCauseCode 0, 1, 5 (Surface Condition) • causeCode 10 subCauseCode 0-5 (Obstacle) • causeCode 11 subCauseCode 0, 2, 4 (Animal)

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Table 8 DENM elements specific to Hazardous Location Notifications (HLN)

Name	M/O	Usage	Comment
		• causeCode 99 subCauseCode 0, 1 (dangerous situation)	• causeCode 12 subCauseCode 0-2 (Human presence) • causeCode 17 subCauseCode 1 (Extreme weather condition) • causeCode 18 subCauseCode 0-6 (Visibility) • causeCode 19 subCauseCode 1 (Precipitation) • causeCode 94 subCauseCode 0, 2 (Stationary vehicle) • causeCode 95 subCauseCode 0 (Emergency vehicle approach) • causeCode 99 subCauseCode 1 (Dangerous situation) *FR* • causeCode 2 subCauseCode 0-5, 7 (Unprotected accident area) • causeCode 6 subCauseCode 0-9 (Temporarily slippery road) • causeCode 9 subCauseCode 0, 1, 4, 5, 7 (Unmanaged blockage of a road) • causeCode 10 subCauseCode 4 (Obstacle on the road) • causeCode 11-12 subCauseCode 0 (Animal or person on the road) • causeCode 14 subCauseCode 2 (Wrong way driving) • causeCode 17 subCauseCode 1, 4 or causeCode 19 subCauseCode 1 (Exceptional weather conditions) • causeCode 18 subCauseCode 0, 5 (Reduced visibility) • causeCode 27 subCauseCode 0 (End of queue) • causeCode 94 subCauseCode 0, 2 (Breakdown vehicles) *NL* causeCode set to 97 subCauseCode set to 1
Other DFs / DEs		All other DFs and DEs are the same as specified in the general table (Table 3).	

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Table 9 Service parameters associated with HLN with national choices

Service Parameters					
Name	**Type**	**Layer**	**AT**	**NL**	**FR**
repetitionInterval	P	A or F	1000 milliseconds	Between 250 and 1000 milliseconds.	Between 250 and 500 milliseconds
repetitionDuration	P	A or F	-	Equal to validityDuration	Equal to validityDuration
Life Time	HF	GN	-	-	-
itsGnMaxGeoAreaSize	P	GN	-	Managed (1)	-
Flags	HF	GN	Stationary (0)	This parameter is Stationary (0) for R-ITS-S.	-
Country Code	HF	GN	232	-	-

3.2.2 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 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].

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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 tables Table ***10*** and Table ***11***.

3.2.2.1 IVIM general elements

Table 10 IVIM elements in general

Name	M/O	Usage	Comment
IVI ManagementContainer	Mandatory		
serviceProviderId	Mandatory	serviceProviderID consists of data elements "countryCode" and "providerIdentifier". countryCode is a bitstring 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]). Together with iviIdentificationNumber, this is the unique identifier for messages for the receiving V-ITS-S.	
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 serviceProvider and can be used by other related messages as a reference.	
timestamp	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.	
validFrom	Optional	See application specific tables.	*UK* Not used
validTo	Mandatory	This DE shall always be used to determine the validity. An update shall be sent before the message times out. Value: set by application Default validity period is defined by road operator.	
connectedIviStructures (1..8)	Optional	See application specific tables.	
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. For concrete values see application specific tables.	*UK* 0,1,2
Geographic Location Container	Mandatory		
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 a gantry, and is the first point of zone definitions for Relevance Zone(s) and Detection Zone(s).	

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Table 10 IVIM elements in general

Name	M/O	Usage	Comment
		The Altitude may be set to unavailable if unknown. If the altitude is provided, it is the altitude of the road. Value: set by application	
referencePositionTime	Optional	Not used.	
referencePositionHeading	Optional	Not used	
referencePositionSpeed	Optional	Not used.	
GlcPart	Mandatory	parts (1..16). Up to 16 parts can be defined in one Geographic Location Container. The GLC contains at least two zones, one for relevance and one for detection. Value: set by application	
zoneId	Mandatory	At least one detection zone and one relevance zone shall be provided for each message.	
laneNumber	Optional	Mandatory if single lanes are described in this location container. Default is absent (no lane information).	*FR, UK* Not used
zoneExtension	Optional	Not used.	
zoneHeading	Mandatory	Effective direction of applicability of the sign at the Reference Position, indicating the traffic direction	
zone	Mandatory	Definition of a zone using the DF zone consisting of the choice DF segment, DF polygonalLine 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).	
IVI Application Container	Mandatory		
detectionZoneIds	Mandatory	List of Identifier(s) of the definition(s) of the Detection Zone(s), using the DE Zid (1..8)	
its-Rrid	Optional	Not used.	
relevanceZoneIds	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)	
direction	Mandatory	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction. Always set to sameDirection(0).	
driverAwarnessZoneIds	Optional	Not used.	
minimumAwarenessTime	Optional	Not used.	
applicableLanes (1..8)	Optional	List of identifiers of the lane(s) using the DE LanePosition (1..8).	

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Table 10 IVIM elements in general

Name	M/O	Usage	Comment
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.	
iviPurpose	Optional	Not used.	
laneStatus	Optional	Indicates the lane status (e.g. open, closed, merge) of the applicableLanes.	
completeVehicle Characteristics	Optional	CompleteVehicleCharacteristics shall contain the definition of the characteristics of the vehicles to which an Application Container is applicable. The component "train", if present shall contain the characteristics applicable to the entire vehicle train.	*UK* Not used
driverVehicleCha racteristics	Optional	Not used.	
layoutId	Optional	Not used.	
preStoredLayoutI d	Optional	Not used.	
roadSignCodes	Mandatory	It shall contain the definition of the road sign code. It allows different options pointing to different pictogram catalogues. This component specifies which road signs are applicable for a Relevance Zone. Road sign codes are dependent on the referenced classification scheme. Additional attributes to the road sign code can be added as provided by the options. List of 1..4 of RSCode NOTE: dangerWarning-9-98 shall be used to describe free text VMS without roadsign while awaiting an update of ISO 19321.	*UK* RSCode - MPH not KPH for particular signs including speed
RSCode	Mandatory	It contains layoutComponentId and a code.	
layoutComponen tId	Optional	This data frame can be used to associate RSCode to the layout component of referenced layout.	
code	Mandatory	For signcoding the ISO/TS 14823 [15] shall be used.	
ISO14823Code	Mandatory	For signcoding the ISO/TS 14823 [15] shall be used. This data frame includes several DFs and DEs. It includes: pictogramCode (countryCode, serviceCategorycode and pictogramCategoryCode) The attributes SET (Section) and NOL (Number of Lane) are not supported because these attributes are providing duplicated information already supported in the Application Container.	
extraText ((1..4),...)	Optional	List of text lines associated to the ordered list of road sign codes. Each piece contains language	

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Table 10 IVIM elements in general

Name	M/O	Usage	Comment
		code plus extra, limited-size text in the selected language using the DF text. Note: This DF can be safely overloaded to include more lines of text.	

3.2.2.2 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 11 describes how respective data elements and data frames are applied.

Table 11 IVIM elements specific to IVS

Name	M/O	Usage	Comment
IVI Management Container	Mandatory		
serviceProviderId	Mandatory	Numbers shall be assigned on national basis. See ISO 3166-1 [13] for registration.	*AT* providerIdentifier will be set to "1" for all AT (ASFINAG) based IVI messages according to http://www.tc278.eu/files/Registries/14816/CS1registerAT.pdf. *BE(Fla), FR, NL, UK* providerIdentifier: A value between 0 and 16383
validFrom	Optional	This component may hold the start time of the validity period of the message. If start time is not relevant or unknown to the system, validFrom is not present or equal to timestamp.	*UK* Not used.
connectedIviStructures (1..8)	Optional	Not used.	
iviStatus	Mandatory	New, Update, Cancellation: used. Negation: not used Value: set by application	*AT* Supported iviStatus: new, update. iviStatus cancellation or negation will not be used
Geographic Location Cont.	Mandatory		
GlcPart			
IVI Application Container	Mandatory		
applicableLanes (1..8)	Optional	If applicable to all lanes on a carriageway this DE may be absent. Otherwise used if lane specific. Value: set by application	*AT* All lanes to which the iviStatus and/or laneStatus applies.
extraText ((1..4),...)	Optional	Can be used to send a message for clarification or additional information.	*FR*

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Table 11 IVIM elements specific to IVS

Name	M/O	Usage	Comment
		Due to an error in the currently published version of (ISO/TS 19321) [12], the layoutComponentId data element is mandatory at the moment, even if no layoutContainer (lac) is present. It will be statically set to "1" until an update of (ISO/TS 19321) [12] which rectifies this error is available. The language data element 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 textContent data element. Value: set by application	Coding of sub-roadsign panel is coded between "//" (example : //25km//) in the first container of extraText. If well interpreted, it will be displayed properly on HMI. If not, users may understand it well enough. So that it is a solution respecting standard constraints, without any interoperability issue generated.
Other DFs / DEs		All other DFs and DEs in the IVI standard are not used.	

3.2.2.3 Automated Driving (AD)

The Automated Driving (AD) 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).

There is only one implementation making use of the IVI standard (ISO 19321) [12], Table 12 describes how respective data elements and data frames are applied.

Table 12 IVIM elements specific to AD

Name	M/O	Usage	Comment
IVI Management Container	Mandatory		
validFrom	Optional	Not used.	
connectedIviStructures (1..8)	Optional	This component holds a list of other iviIdentificationNumbers identifying other IVI messages containing clearance information for other connected subsegments (i.e. preceding and following subsegment)	
iviStatus	Mandatory	New, Update, Cancellation: used. Negation: not used	
Automated Vehicle Container	Mandatory	Automated Vehicle Container may contain 1-16 or more AvcParts.	
detectionZoneIds	Mandatory	List of Identifier(s) of the definition(s) of the Detection Zone(s), using the DE Zid (1..8)	
relevanceZoneIds	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)	

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Table 12 IVIM elements specific to AD

Name	M/O	Usage	Comment
direction	Mandatory	Direction of Relevance in relation to the direction (implicitly) defined by the zone using the DE direction.	
applicableLanes	Optional	List of identifiers of the lane(s) to which the automated vehicle container applies using the DE LanePosition (1..8).	
vehicleCharacteristics	Optional	VehicleCharacteristics shall contain the definition of the characteristics of the vehicles to which an Application Container is applicable. The component "train", if present shall contain the characteristics applicable to the entire vehicle train.	
automatedVehicleRules		The list of rules applying to single automated vehicles. AutomatedVehicleRules container may contain up to 5 rules. Mandatory for SAE Level Clearance, otherwise not used.	
priority	Mandatory	Level of priority of the information. 0 is lowest, 2 is highest. The value 2 is reserved for future use.	
allowedSaeAutomationLevels	Mandatory	The list of automation levels according to SAE J3016 that are allowed to be operated by single vehicles.	
minGapBetweenVehicles	Optional	Not used.	
recGapBetweenVehicles	Optional	Not used.	
automatedVehicleMaxSpeedLimit	Optional	Maximum Speed limit applicable to all automated vehicles of the listed types, in km/h.	
automatedVehicleMinSpeedLimit	Optional	Minimum Speed limit applicable to all automated vehicles of the listed types, in km/h.	
roadSignCodes	Optional	It shall contain the definition of the road sign code using the Ref. [ISO 14823] catalogue and associated attributes.	
extraText	Optional	List of text lines associated to the ordered list of road sign codes. Each piece contains language code plus extra, limited-size text in the selected language using the DF text The “language” data element uses a bitstring representing the language according to [ISO 639-1], e.g. German text is encoded as “DE” (D (10010) and E (10000) → 1001010000 according to [ISO 14816]). The actual text can be found in the “textContent” data element.	
platooningRules		The list of rules applying to automated vehicles forming a platoon.	

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Table 12 IVIM elements specific to AD

Name	M/O	Usage	Comment
		PlatooningRules container may contain up to 5 rules. Mandatory for Platoon support, otherwise not used.	
priority	Mandatory	Level of priority of the information. 0 is lowest, 2 is highest. The value 2 is reserved for future use.	
allowedSaeAutomationLevels	Mandatory	A list of automation levels according to SAE J3016 that are allowed to be operated by the platoon followers, i.e. the platoon participants that are not the leader.	
maxNoOfVehicles	Optional	The maximum allowed number of vehicles in the platoon including the platoon leader.	
maxLenghtOfPlatoon	Optional	The maximum length of the platoon in units of 10 meters.	
minGapBetweenVehicles	Optional	The minimum distance between vehicles in a platoon, measured from the rear bumper of the preceding vehicle to the front bumper of the next following vehicle, in meters.	
platoonMaxSpeedLimit	Optional	Maximum speed limit applicable to the platoon, in km /h.	
platoonMinSpeedLimit	Optional	Minimum speed limit applicable to the platoon, in km/h.	
platoonSpeedRecommendation	Optional	Speed recommendation applicable to the platoon, in km/h.	
roadSignCodes	Optional	It shall contain the definition of the road sign code using the Ref. [ISO 14823] catalogue and associated attributes. Several instances of RSCode can be used for the following scenarios: • Lane clearance: layoutComponentId and ISO14823Attributes are not used. Example Values: trafficSignPictogram (12 regulatory), nature (7), serialNumber (13 Direction to be followed – straight forward) • Maximum speed limit: layoutComponentId is not used. Example Values: trafficSignPictogram (12 regulatory), nature (5), serialNumber (57 Maximum Speed Limit), ISO14823Attributes (spe), spm (80), unit (km/h)	

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Table 12 IVIM elements specific to AD

Name	M/O	Usage	Comment
		• Minimum speed limit: layoutComponentId is not used. Example Values: Example Values: trafficSignPictogram (12 regulatory), nature (7), serialNumber (95 Minimum Speed Limit), ISO14823Attributes (spe), mns (60), unit (km/h) • Minimum gap between vehicles: layoutComponentId is not used. Example Values: Example Values: trafficSignPictogram (13 guide), nature (5), serialNumber (15 Driving of Vehicles less than XX m apart prohibited), ISO14823Attributes (dbv), value (60), unit (3 - meter) • Recommended speed: layoutComponentId is not used. Example Values: trafficSignPictogram (13 guide), nature (8), serialNumber (87 Advisory speed), ISO14823Attributes (spe), spm (60), unit (km/h)	
extraText	Optional	List of text lines associated to the ordered list of road sign codes. Each piece contains language code plus extra, limited-size text in the selected language using the DF text The “language” data element uses a bitstring representing the language according to [ISO 639-1], e.g. German text is encoded as “DE” (D (10010) and E (10000) → 1001010000 according to [ISO 14816]). The actual text can be found in the “textContent” data element. An Example of a German text could be “Autonomes Fahren Level X”	

3.2.2.4 Road Works Warning (RWW)

The Road Works Warning (RWW) ITS-S application in the Extensive Workzone use case is implemented using In-Vehicle Information (IVI) messages according to (ISO 19321) [12].

IVI messages are used for the long-term Road Works application in Austria (C-ITS for Automated Driving - SWP1.2 - Functional Specification v01.00).

There is only one implementation making use of the IVI standard (ISO 19321) [12], Table 13 describes how respective data elements and data frames are applied.

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Table 13 IVIM elements specific to RWW

Name	M/O	Usage	Comment
IVI Management Container	Mandatory		
validFrom	Optional	Not used.	
connectedIviStructures (1..8)	Optional	Not used.	
iviStatus	Mandatory	New, Update, Cancellation: used. Negation: not used	
connectedDenms	Optional	List of ids of DENMs which are semantically connected to the IVI, using the DF ConnectedDenms.	
IVI Application Container	Mandatory	This is the General IVI Application Container has to be included once and contains general information.	
applicableLanes (1..8)	Optional	Not used.	
laneStatus	Optional	Not used.	
vehicleCharacteristics	Optional	Not used.	
RSCode	Mandatory	Can be used to provide maximum speed limit, recommended speed and road works warning information.	
layoutComponentId	Optional	Not used.	
ISO14823Code	Optional	Not used for road works warning information, otherwise mandatory.	
IVI Application Container	Mandatory	This Container can be included multiple times, if needed and it is used for lane specific information	
applicableLanes (1..8)	Mandatory	List of identifiers of the lane(s) using the DE LanePosition (1..8). Used for all lanes to which the same information applies.	
laneStatus	Mandatory	Indicates the lane status (e.g. open, closed, merge) of the applicableLanes.	
vehicleCharacteristics	Optional	Not used.	
RSCode	Mandatory	Can be used to provide maximum speed limit, recommended speed, vehicle width limitation and lane status information.	
layoutComponentId	Optional	Not used.	
ISO14823Code	Optional	Not used for lane status information, otherwise mandatory.	

3.2.3 Traffic Light Manoeuvre (TLM) and Road and Lane Topology (RLT) Service (TLS 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,

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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 maneuvers 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. In future enhancements, the digital map will include additional topology-descriptions like traffic roundabouts. Examples for describing topology with the data structures offered by MAPEM are provided in Annex G of ISO TS 19091 [26].

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 14 to 14.6 and Table 15 to 15.5. 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 1 and in Figure 2 for the relationship of the SPATEM tables.

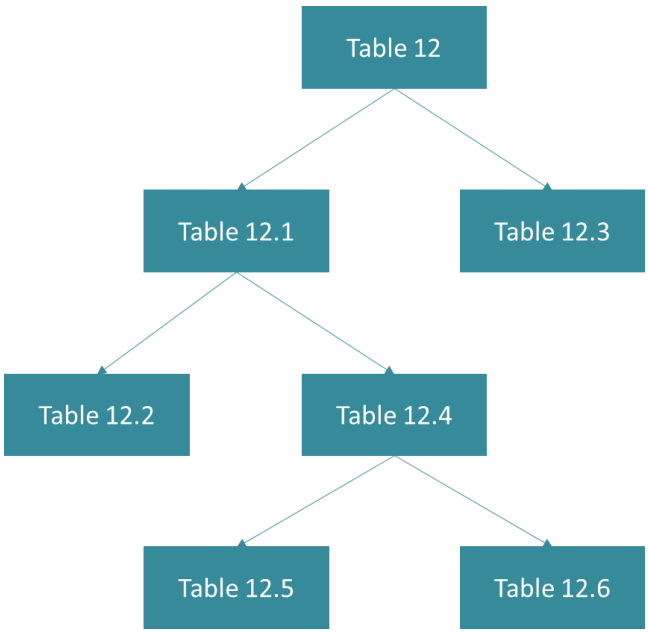

Figure 1 relationship of MAPEM data element tables

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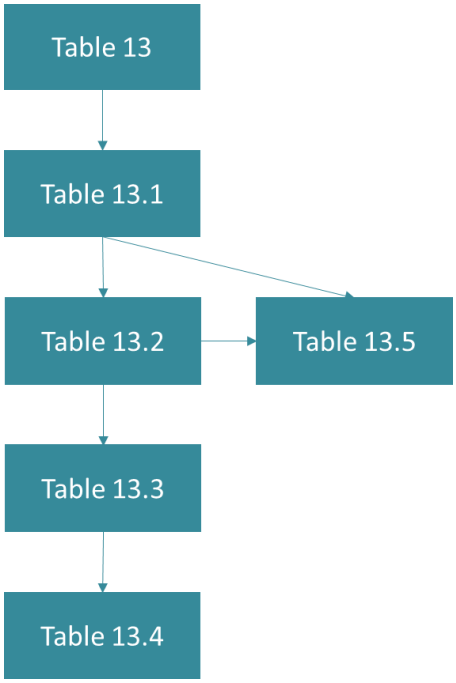

Figure 2 relationship of SPATEM data element tables

3.2.3.1 Parameter settings

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

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
tMapCompleteTransmission	1	s	Time duration within the whole MAP including all fragments shall be transmitted	--	--	--
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	--	--	--
*pLateralNodeOffset*AD	1	m	Maximum lateral offset to the center of the lane for the node points within a MAP if automated driving shall be supported	--	--	--
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	--	--	--
pMinLaneWidth	2.6	m	Minimum 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	--	--	--

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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	--	--	--
tSubSystemClockAccuracy	200	ms	Accuracy of the system clock of the subsystem responsible for the generation of time change details	--	--	--
tIntraSystemClockAccuracy	500	ms	Maximum deviation between the different system clocks	--	--	--
pSpatUpdateDelay	100	ms	Maximum period between SPaTEM update in content and its transmission	--	--	--
fSpatTransmissionFreqMax	10	Hz	Maximum transmission frequency for SPaT messages	--	--	--
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	--	--	--
tTimeChangeInterval	1.5	S	Interval to be used for the calculation of the likely time confidence	--	--	--
tDelayFailureTransmission	200	ms	Maximum allowed delay between the instant the traffic light controller goes into failure until the information is being transmitted	--	--	--

3.2.3.2 MAPEM general elements

Table 14 MAPEM data elements

Level	Name	Type	M/O	Usage	Comment
*	mapData	DF	Mandatory		
**	timeStamp	DE	Optional	Not used.	
**	msgIssueRevision	DE	Mandatory	Set to 0. As defined in ISO TS19091.	
**	layerType	DE	Optional	Not used.	
**	layerID	DE	Optional	As defined in ISO TS19091.	
**	intersections (1..32)	DF	Mandatory	IntersectionGeometryList ::= SEQUENCE (SIZE(1..32)) OF IntersectionGeometry (see table 14.1)	

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Table 14 MAPEM data elements

Level	Name	Type	M/O	Usage	Comment
				Mandatory for TLM/RLT ITS-S applications.	
**	roadSegments (1..32)	DF	Optional	Not used. Data elements within are not further profiled.	
**	dataParameters	DF	Optional		
***	processMethod	DE	Optional	Not used.	
***	processAgency	DE	Optional		
***	lastCheckedDate	DE	Optional	as: yyyy-mm-dd	
***	geoidUsed	DE	Optional	Not used.	
**	restrictionList (1..32)	DF	Optional	RestrictionClassList ::= SEQUENCE (SIZE(1..254)) OF RestrictionClassAssignment (see table 14.3).	
**	regional	DE	Optional	REGION.Reg-MapData. Not used.	
***	signalHeadLocations	DF	Optional	SignalHeadLocationList ::= SEQUENCE (SIZE(1..64)) OF SignalHeadLocation (see table XXX) Not used.	

Table 14.x SignalHeadLocationList → SignalHeadLocation

Level	Name	Type	M/O	Usage	Comment
*	SignalHeadLocation	DF	Optional		
**	nodeXY	DF	Mandatory		
**	nodeZ	DE	Mandatory		
**	signalGroupID	DE	Mandatory		

Table 14.1 IntersectionGeometryList → IntersectionGeometry

Level	Name	Type	M/O	Usage	Comment
*	intersectionGeometry	DF	Mandatory	Mandatory if 'intersections' is used.	

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Table 14.1 IntersectionGeometryList → IntersectionGeometry

Level	Name	Type	M/O	Usage	Comment
**	name	DE	Optional	Typically human readable and recognizable by road authority.	
**	id	DF	Mandatory	(IntersectionReferenceID) Must be the same as in the SPATEM. The combination of region and id must be unique within a country.	
***	region	DE	Mandatory		RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs t intersections. C2CC: RS_ARSM_11: The data field 'id' (DF_IntersectionReferenceID) shall consist of bo 'region' (DE_RoadRegulatoryID) and 'id' (DE_IndersectionID)
***	id	DE	Mandatory	The id shall be unique within a radius of 5 km around each intersection.	C2CC: RS_ARSM_12: The id shall be unique within a radius of 5 km around each intersection
**	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 TS19091.	
**	refPoint	DF	Mandatory		
***	lat	DE	Mandatory		
***	long	DE	Mandatory		
***	elevation	DE	Optional	Not used. Replaced by regional Reg-Position3D.	
***	regional	DF	Optional	REGION.Reg-Position3D-addGrpC. Optional. When given provides altitude.	
****	altitude	DF	Mandatory	Consists of altitudeValue and altitudeConfidence	
*****	altitudeValue	DE	Mandatory		

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Table 14.1 IntersectionGeometryList → IntersectionGeometry

Level	Name	Type	M/O	Usage	Comment
*****	altitudeConfidence	DE	Mandatory	When not available set to (15) = unavailable.	
**	laneWidth	DE	Mandatory	Any significant lane width difference of at least 0.3 meters to the basic width, shall be expressed by the DE dWidth	
**	speedLimits (1..9)	DF	Optional	SpeedLimitList ::= SEQUENCE (SIZE(1..9)) OF RegulatorySpeedLimit (see table 14.2).	
**	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 LaneList ::= SEQUENCE (SIZE(1..255)) OF GenericLane (see table 14.4).	C2CC: RS_ARSM_15: 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)).
**	preemptPriorityData (1..32)	DF	Optional	Not used. Data elements within are not further profiled.	
**	regional	DF	Mandatory	REGION.Reg-IntersectionGeometry-addGrpC. Used to provide the countryCode of origin linked to the RoadRegulatorID	
***	countryCode	DE	Mandatory	Country code of the region (RoadRegulatorID) of the IntersectionReferenceID.	This regional extension enables global uniqueness of IntersectionReferenceIDs, assuming that: RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs to intersections. -

Table 14.2 SpeedLimitList → RegulatorySpeedLimit

Level	Name	Type	M/O	Usage	Comment
*	regulatorySpeedLimit	DF	Mandatory	Mandatory if 'speedLimits' is used.	
**	type	DE	Mandatory		
**	speed	DE	Mandatory		

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Table 14.3 ResdtrictionClassList → RestrictionClassAssignment

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

Table 14.4 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
*	genericLane	DF	Mandatory	Mandatory if 'laneSet' is used	Minor side-roads along the ingress lanes should not be described or interrupt the lane, while non-right-of-way merging lanes shall start at the diverge/merge point. ~~Egress lane shall have a minimum length of 5 meters and should have a maximum length of 10 meters.~~ C2CC: RS_ARSM_40: For each ingress approach at least one ingress lane of type vehicle shall be at least *pMinLaneIngressLength* long following the priority road. C2CC: RS_ARSM_43: At intersections with higher speed limits allowed (> pSpeedLimitHigh) the ingress lanes shall be minimum pMinIngressLaneLengthHighSpeed long. C2CC: RS_ARSM_47: Vehicle egress lanes shall have a minimum length of *pMinEgressLaneLength*. C2CC: RS_ARSM_44: The ingress lanes shall

Table 14.4 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
					follow the main road with priority towards the intersection. Note: If a non-priority road shall be included into the ingress structure, all lanes of the non-priority roads shall be grouped into one or several separate approaches that only represent these non-priority roads. C2CC: RS_ARSM_41: If an adjacent intersection is closer than *pMinIngressLaneLength*, ingress lanes shall be shortened to the first egress point of the adjacent intersection. 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.
**	laneID	DE	Mandatory		
**	name	DE	Optional		
**	ingressApproach	DE	Optional/Mandatory (see usage)	Each lane must have the applicable ApproachID set. Ingress and egress approaches of the same arm have the same ApproachID. For unidirectional lanes, exactly one of the data elements 'ingressApproach' and 'egressApproach' (of type DE_ApproachID) shall be present and used. For bidirectional lanes that cross both the ingress- and egress approach of an intersection arm (e.g. bike lanes or 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. 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	C2CC_RS_ARMS_16: For unidirectional lanes, exactly one of the data elements 'ingressApproach' and 'egressApproach' (of type DE_ApproachID) shall be present and used. C2CC_RS_ARSM_17: For bidirectional lanes that cross both the ingress- and egress approach of an intersection arm (e.g. bike lanes or 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. C2CC_RS_ARSM_18: 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.

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Table 14.4 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
				attribute.	
**	egressApproach	DE	Optional/Mandatory (see usage)	Each lane must have the applicable ApproachID set. Ingress and egress approaches of the same arm have the same ApproachID. For unidirectional lanes, exactly one of the data elements 'ingressApproach' and 'egressApproach' (of type DE_ApproachID) shall be present and used. For bidirectional lanes that cross both the ingress- and egress approach of an intersection arm (e.g. bike lanes or 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.	C2CC_RS_ARMS_16: For unidirectional lanes, exactly one of the data elements 'ingressApproach' and 'egressApproach' (of type DE_ApproachID) shall be present and used. C2CC_RS_ARSM_17: For bidirectional lanes that cross both the ingress- and egress approach of an intersection arm (e.g. bike lanes or 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.
**	laneAttributes	DF	Mandatory		
***	directionalUse	DE	Mandatory		

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Table 14.4 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
***	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)	
***	laneType	DF	Mandatory	Mandatory. Used in this profile: - vehicle - crosswalk - bikeLane - trackedVehicle -- see ISO TS19091 for pedestrian crossing examples.	
****	Vehicle	DE	Optional	(choice)	
****	crosswalk	DE	Optional	(choice)	
****	bikeLane	DE	Optional	(choice)	
****	sidewalk	DE	Optional	(choice)	
****	median	DE	Optional	Not used.	
****	striping	DE	Optional	Not used.	
****	trackedVehicle	DE	Optional	(choice)	
****	parking	DE	Optional	Not used.	
***	regional	DF	Optional	Reg- LaneAttributes-addGrpC. Not used.	
****	maxVehicleHeight	DE	Optional		
****	maxVehicleWeight	DE	Optional		
**	maneuvers	DE	Optional	The data element ‘maneuvers’ (of type DE_AllowedManeuvers) shall not be present in any instance of a ‘generic lane’	C2CC:_RS_ARSM_117: The data element ‘maneuvers’ (of type DE_AllowedManeuvers) shall not be present in any instance of a ‘generic lane’ within a MAPEM.

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Table 14.4 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
				within a MAPEM.	
**	nodeList	DF	Mandatory		Definition: 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].
***	nodes (2..63)	DF	Mandatory	NodeSetXY ::= SEQUENCE (SIZE(2..63)) OF NodeXY (see table 14.5) 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. The first node of any vehicle lane shall be the node of the lane which is closest to the centre of the intersection. 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. If the number of nodes of a lane exceeds pMaxNoOfNodesPerLane to keep the perpendicular distance between the linear connection of two node points and the center of the lane lower than pMaxPerpendDistLaneCenter, the ingress lane might be shorter than 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.	C2CC: RS_ARSM_118: For all lanes represented in MAPEM within the data element nodeListXY (of type DF_NodeListXY) the data element nodes (a list of DF_NodeSetXY) shall be used. C2CC: RS_ARSM_25: The first node of any vehicle lane shall be the node of the lane which is closest to the centre of the intersection. C2CC: RS_ARSM_35: The number of node points shall be limited to *pMaxNoOfNodesPerLane* nodes per lane (for both ingress and egress lanes). C2CC: RS_ARSM_94: the angle between the linear connection of two node points and the corresponding tangent to the lane center shall not be greater than pLaneAngleDeviation. Requirement RS_ARSM_34 The perpendicular distance between the linear connection of two node points and the center of the lane shall be less than pMaxPerpendDistLaneCenter. C2CC: RS_ARSM_42: If the number of nodes of a lane exceeds pMaxNoOfNodesPerLane (see RS_ARSM_35) to fulfil RS_ARSM_34, the ingress lane might be shorter than pMinIngressLaneLength.

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Table 14.4 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
***	computed	DF	Optional	Not used.	C2CC: RS_ARSM_118: The data element computed (of type DF_ComputedLane) shall not be used.
**	connectsTo (1..16)	DF	Optional	ConnectsToList ::= SEQUENCE (SIZE(1..16)) OF Connection (see table 14.6). The data element 'connectsTo' (of type DF_ConnectsToList) shall be present at least for every ingress lane of the intersection that is controlled by a traffic light. The data field 'connectsTo' shall include every possible connection between ingress and egress lanes of one intersection – u-turns includedoptional if they are allowed by traffic rules. The contained connections shall however not include those requiring lane changes in the conflict area (if applicable). There shall be no duplicate connections indicated via 'connectsTo' between the same ingress and egress lanes for the same direction.	C2CC: RS_ARSM_119: The data element 'connectsTo' (of type DF_ConnectsToList) shall be present at least for every ingress lane of the intersection that is controlled by a traffic light. C2CC: RS_ARSM_19: The data field 'connectsTo' (DF_ConnectsToList) shall include every possible connection between ingress and egress lanes of one intersection – u-turns includedoptional if they are allowed by traffic rules. The contained connections shall however not include those requiring lane changes in the conflict area (if applicable). C2CC: RS_ARSM_20: There shall be no duplicate connections indicated via 'connectsTo' between the same ingress and egress lanes for the same direction.
**	overlays	DF	Optional	Not used.	
**	regional	DF	Optional	REGION-Reg-GenericLane. To provide ConnectionTrajectory-addGrpC. Relevant for use case scenario safe intersection manoeuvre.	
***	nodes	DF	Mandatory		

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Table 14.4 LaneList → GenericLane

Level	Name	Type	M/O	Usage	Comment
***	connectionID	DE	Mandatory		

Table 14.5 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
*	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.	C2CC: RS_ARSM_32: The absolute lateral offset of node points to the center of the lane shall be less than pLateralNodeOffset. C2CC: RS_ARSM_94: Let $\overline{a}$ be the vector representing the linear connection of two node points, and $\overline{p}$ be the vector representing the shortest distance of vector $\overline{a}$ to the center of the lane (that is, $\overline{p}$ is perpendicular to the tangent of the center line of the lane at the foot of the dropped perpendicular). Then for $\lvert\overline{p}\rvert > 0$ it shall always hold that $\cos^{-1}\left(1 - \frac{\overline{a}*\overline{p}}{\lvert\overline{a}\rvert*\lvert\overline{p}\rvert}\right) \leq$ *pLaneAngleDeviation*. For $\lvert\overline{p}\rvert = 0$ (i.e. $\overline{a}$ crosses the lane center) the angle α between $\overline{a}$ and the tangent to the lane center at the intersection point with the lane center shall be less than *pLaneAngleDeviation*. Note: in less formal wording this means that the angle between the linear connection of two node points and the corresponding tangent to the lane center shall not be greater than pLaneAngleDeviation.
**	delta	DF	Mandatory		
***	node-XY1	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
***	node-XY2	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
***	node-XY3	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
***	node-XY4	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
***	node-XY5	DF	Optional	(choice) DF composed with X and Y, both mandatory.	

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Table 14.5 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
***	node-XY6	DF	Optional	(choice) DF composed with X and Y, both mandatory.	
***	node-LatLon	DF	Optional	Not used for intersections. Used for e.g. motorways is acceptable.	
***	regional	DF	Optional	REGION.Reg-NodeOffsetPointXY. Not used.	
**	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'.
***	localNode (1..8)	DF	Optional/Mandatory (see usage)	NodeAttributeXYList ::= SEQUENCE (SIZE(1..8)) OF NodeAttributeXY Node attributes Stopline, mergePoint and divergePoint are mandatory whenapplicable. 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 indicated that actual stop line, i.e. typically at the first node of the lane, and in this case where the do-not-block section starts. In addition, the doNotBlock segment-attribute shall be appropriately enabled/disabled to indicated the do-not-block area. C2CC: RS_ARSM_26: 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). 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. C2CC: RS_ARSM_27: In the MAPEM an additional attribute "stop line" exists. This shall be used for additional upstream "do not block" lines (e.g. in Germany: "bei Rot hier halten"). C2CC: RS_ARSM_36: Each diverge or merge point (of type DF_NodeXY) shall be explicitly marked with corresponding node attribute (DF_NoteAttributeSetXY) "divergePoint" or "mergePoint". Note: For further details see [ISO/TS 19091 2019-06] 'localNode'. C2CC: RS_ARSM_37: For diverging / merging lanes one node shall be defined as diverge /

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Table 14.5 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
					merge point according to RS_ARSM_36. This node shall be present with the same position in the ongoing lane and as first / last node in the diverging / merging lane.
****	nodeAttributeXY	DE	Mandatory	Mandatory if localNode is used.	
***	disabled (1..8)	DF	Optional/Mandatory (see usage)	SegmentAttributeXYList ::= SEQUENCE (SIZE(1..8)) OF SegmentAttributeXY Optional. 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 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. If 'taperToLeft' or 'taperToRight' is present in the 'enabled' list of a previous node, a SegmentAttributeXY of same value shall be present in the ´disabled´ list at the first node where the diverging lane has reached a width of at least pMinLaneWidth. If 'taperToLeft' or 'taperToRight' is present in the 'enabled' list of a previous node, a SegmentAttributeXY of same value shall be present in the ´disabled´ list at the last node of the merging lane.	C2CC: RS_ARSM_30: A SegmentAttributeXY of value 'doNotBlock' shall be present in the 'disabled' list at the first node of the lane thereafter (see RS_ARSM_29), which may again be blocked by a vehicle. C2CC: RS_ARSM_112: If 'taperToLeft' or 'taperToRight' is present in the 'enabled' list of a previous node (as described in RS_ARSM_38), a SegmentAttributeXY of same value shall be present in the ´disabled´ list at the first node where the diverging lane has reached a width of at least pMinLaneWidth. C2CC: RS_ARSM_114: If 'taperToLeft' or 'taperToRight' is present in the 'enabled' list of a previous node (as described in RS_ARSM_113), a SegmentAttributeXY of same value shall be present in the ´disabled´ list at the last node of the merging lane.
****	segmentAttributeXY	DE	Mandatory	Mandatory if disabled is used.	
***	enabled (1..8)	DF	Optional/Mandatory (see usage)	SegmentAttributeXYList ::= SEQUENCE (SIZE(1..8)) OF SegmentAttributeXY It is encouraged to use at least the segment attributes from the	C2CC: RS_ARSM_29: 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.

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Table 14.5 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
				following categories, for which guidelines are provided in ISO TS 19091: - General items - Porous lane states and mering - Bike lane needs - Lane geometry details - doNotBlock - taperToLeft - taperToRight 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. A SegmentAttributeXY of value "taperToLeft" or "taperToRight" shall be present in the 'enabled' list of the first node of the diverging lane, if the lane width of the diverging lane is below pMinLaneWidth at the first node after the diverge point (i.e. more than two nodes are used to describe the tapering part of the diverging lane, e.g. for accuracy reasons). A SegmentAttributeXY of value "taperToLeft" or "taperToRight" shall be present in the 'enabled' list of the last node of the merging lane, for which the merging lane has a lane width of at least pMinLaneWidth, if the lane width of the merging lane is below pMinLaneWidth at the last node before the merge point (i.e. more than two nodes are used to describe the tapering part of the merging, e.g. for accuracy reasons).	C2CC: RS_ARSM_38: A SegmentAttributeXY of value "taperToLeft" or "taperToRight" shall be present in the 'enabled' list of the first node of the diverging lane, if the lane width of the diverging lane is below pMinLaneWidth at the first node after the diverge point (i.e. more than two nodes are used to describe the tapering part of the diverging lane, e.g. for accuracy reasons). C2CC: RS_ARSM_113: A SegmentAttributeXY of value "taperToLeft" or "taperToRight" shall be present in the 'enabled' list of the last node of the merging lane, for which the merging lane has a lane width of at least pMinLaneWidth, if the lane width of the merging lane is below pMinLaneWidth at the last node before the merge point (i.e. more than two nodes are used to describe the tapering part of the merging, e.g. for accuracy reasons).
****	segmentAttributeXY	DE	Mandatory	Mandatory if enabled is used.	
***	data	DF	Optional		

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Table 14.5 NodeSetXY → NodeXY

Level	Name	Type	M/O	Usage	Comment
****	pathEndPointAngle	DE	Optional	Not used.	
****	pathEndPointAngle	DE	Optional	Not used.	
****	laneCrownPointCenter	DE	Optional	Not used.	
****	laneCrownPointLeft	DE	Optional	Not used.	
****	laneCrownPointRight	DE	Optional	Not used.	
****	laneAngle	DE	Optional	Not used.	
****	speedLimits (1..9)	DE	Optional	SpeedLimitList ::= SEQUENCE (SIZE(1..9)) OF RegulatorySpeedLimit (see table 14.2). (choice)	
****	regional	DF	Optional	REGION.Reg-LaneDataAttribute. Not used.	
***	dWidth	DE	Optional	Any significant lane width difference of at least 0.3 meters to the basic width, shall be expressed.	
***	dElevation	DE	Optional		
***	regional	DF	Optional	REGION.Reg-NodeAttributeSet-addGrpC. Not used.	
****	ptvRequest	DE	Optional		
****	nodeLink	DF	Optional	NodeLink ::= SEQUENCE SIZE (1..5) OF Node (see table XXX)	

Table 14.6 NodeLink → Node

Level	Name	Type	M/O	Usage	Comment
*	Node	DE	Optional		
**	id	DE	Mandatory		

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**	lane	DE	Optional		
**	connectionID	DE	Optional		
**	intersectionID	DF	Optional		

Table 14.6 ConnectsToList → Connection

Level	Name	Type	M/O	Usage	Comment
*	connection	DF	Optional	Mandatory if 'connectsTo' is used.	
**	connectingLane	DF	Mandatory		
***	lane	DE	Mandatory		
***	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. 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. C2CC: RS_ARSM_21: For every 'connectingLane' (inside an instance of DF_Connection) the data element 'maneuver' shall be present. C2CC: RS_ARSM_23: The information in the data element 'maneuver' in 'connectingLane' shall be based on the lane marking arrows on the lane itself (if present). 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 intersection. C2CC: RS_ARSM_22: 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. & C2CC: RS_ARSM_24:The maneuver indication "maneuverleft-/maneuverRightTurnonRedAllowed" and "maneuverLaneChangeAllowed" shall not be used. Note: All other bits of the DE_AllowedManeuvers, which are not covered by this requirement or RS_ARSM_22 may be set but will not be used by current vehicle implementations.
**	remoteIntersection	DF	Optional	Only used if the referenced intersection is part of the same MAPEM.	
***	region	DE	Optional		

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***	id	DE	Mandatory		
**	signalGroup	DE	Optional/Mandatory (see usage)	Optional as not all connections may have a signalgroup related to it. However, shall be given for every connection that is signalised with a traffic light.for connections which are controlled by a traffic light the signalgroup must be set. 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.	C2CC: RS_ARSM_48: The data element 'signalGroup' (DE_SignalGroupID) shall be given for every connection that is signalized with at least one operational traffic light (see also RS_ARSM_74, RS_ARSM_109). C2CC: RS_ARSM_49: Every given 'signalGroup' / 'intersectionReferenceID' tuple in the MAPEM shall also be found in the SPATEM.
**	userClass	DE	Optional		
**	connectionID	DE	Mandatory		

3.2.3.3 SPATEM general elements

Table 15 SPATEM data elements

Level	Name	Type	M/O	Usage	Comment
*	Spat	DF	Mandatory		
**	timeStamp	DE	Optional	Not used	
**	name	DE	Optional	Not used	
**	Intersections (1..32)	DF	Mandatory	IntersectionStateList ::= SEQUENCE (SIZE(1..32)) OF IntersectionState (see table 15.1).	
**	regional (1..4)	DF	Optional	REGION.Reg-SPAT. Not used.	

Table 15.1 IntersectionStateList → IntersectionState

Level	Name	Type	M/O	Usage	Comment
*	intersectionState	DF	Mandatory		
**	name	DE	Optional	Used, but kept optional Based on a numbering scheme used by the road authority.	
**	id	DF	Mandatory	(IntersectionReferenceID) Must be the same as in the MAPEM. The combination of region and id must	C2CC: RS_ARSM_68: The data field 'id' (DF_IntersectionReferenceID) shall be identical to the appropriate id tuple of the corresponding MAPEM 'intersectionState'IntersectionGeometry'.

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Table 15.1 IntersectionStateList → IntersectionState

Level	Name	Type	M/O	Usage	Comment
				be unique within a country.	
***	region	DE	Mandatory		~~Preferably, region is used to distinguish from other regions, at least nationally or regionally. Since a uniform approach is missing, the DE remains optional.~~ RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs to intersections.
***	id	DE	Mandatory		
**	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 TS19091.	
**	status	DE	Mandatory	Typically used based on EN 12675 are: • manualControlIsEnabled (0), • fixedTimeOperation (5), • trafficDependentOperation (6), • standbyOperation (7), • failureMode (8), • off (9). Exactly one of the status bits shall be set to 1.	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. C2CC: RS_ARSM_69: For the data element 'status' (of type IntersectionStatusObject) only the status bits "fixedTimeOperation" (5), "trafficDependentOperation" (6), "standbyOperation" (7), "failureMode" (8) or "off" (9) shall be used. All other bits shall always be set to zero. Note: Vehicles will mostly rely on MovementPhaseState without consideration of the IntersectionStatusObject. C2CC: RS_ARSM_70: Exactly one of the status bits referred to in RS_ARSM_69 shall be set to 1. C2CC: RS_ARSM_80: If a failure of the

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Table 15.1 IntersectionStateList → IntersectionState

Level	Name	Type	M/O	Usage	Comment
					traffic light controller is detected (i.e. the IntersectionStatusObject indicates 'failureMode'), either a SPaTEM with the eventState "0" (unavailable) should be sent or SPATEM transmissions deactivated completely within less than tDelayFailureTransmission after the traffic light goes into failure mode.
**	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.	C2CC requirement RS_ARSM_52: 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.
**	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.	C2CC: RS_ARSM_53: If the data element 'timeStamp' (DE_DSecond) in IntersectionState is present, it shall be set to the time of information generation, i.e. the time when the 'timeChangeDetails' are determined.
**	enabledLa ne s	DF	Optional	Mandatory if the revocableLane bit is used in any of the lane descriptions, otherwise not used.	
**	states (1..16)	DF	Mandatory	MovementList ::= SEQUENCE (SIZE(1..255)) OF MovementState (see table 15.2). 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). 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.	C2CC: RS_ARSM_71: The 'states' (DF_MovementList) shall be given at least for all connections through the intersection area with operational traffic lights (see definition of 'operational' RS_ARSM_109), if the intersection status is either "fixedTimeOperation" (5) or "trafficDependentOperation" (6) (see RS_ARSM_69). C2CC: RS_ARSM_89: 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. Therefore this requirement is only stated as "should". 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.
**	maneuver	DF	Optional	ManeuverAssistList ::= SEQUENCE	

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Table 15.1 IntersectionStateList → IntersectionState

Level	Name	Type	M/O	Usage	Comment
	As sistList (1..16)			(SIZE(1..16)) OF ConnectionManeuverAssist (see table 15.5). Not used, therefore not further profiled on this level.	
**	regional (1..4)	DF	Mandatory	REGION.Reg-IntersectionState-addGrpC. Used to provide the countryCode of origin linked to the RoadRegulatorID, and to ensure interoperability with existing public transport prioritisation systems.	
***	activePrioritizations	DF	Optional	PrioritizationResponseList ::= SEQUENCE SIZE(1..10) OF PrioritizationResponse (see table XXX)	
***	countryCode	DE	Mandatory	Country code of the region (RoadRegulatorID) of the IntersectionReferenceID.	This regional extension enables global uniqueness of IntersectionReferenceIDs, assuming that: RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs to intersections. -

Table 15.2 PrioritizationResponseList → PrioritizationResponse

Level	Name	Type	M/O	Usage	Comment
*	Prioritization Response	DF	Optional		
**	stationID	DE	Mandatory		
**	priorState	DE	Mandatory		
**	signalGroup	DE	Mandatory		

Table 15.2 MovementList → MovementState

Level	Name	Type	M/O	Usage	Comment
*	movementState	DF	Mandatory	Mandatory if 'states' is used.	
**	movementName	DE	Optional		
**	signalGroup	DE	Mandatory		C2CC Requirement RS_ARSM_75: Every given 'signalGroup' / 'intersectionReferenceID' tuple in the SPATEM shall be found in the MAPEM and vice versa.
**	state-time-speed	DF	Mandatory	MovementEventList ::= SEQUENCE (SIZE(1..16)) OF MovementEvent Mandatory (1-16). (see table 15.3).	Definition: 'Phase' is a general term denoting all the movement phase states strictly allowing or prohibiting to proceed

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Table 15.2 MovementList → MovementState

Level	Name	Type	M/O	Usage	Comment
				All events in 'state-time-speed' shall be sorted in chronological order with respect to tAbsMinEndTime. At least MovementEvent instances for the current and next phase and all transitions in between shall be included in 'state-time-speed' (DF_MovementEventList). Additional MovementEvent instances may be included. Note: This means that the current and the next phase have to be included. If there is a transition in-between, three MovementEvent instances in total have to be included in the SPATEM.	into an intersection (so the "Reds" and "Greens" as summarized in SAE J2735). Definition: 'Transition' is a general term denoting all the movement phase states which are not covered by the term phase (so the "Yellows / Ambers" as summarized in SAE J2735). C2CC: RS_ARSM_78: All events in 'state-time-speed' shall be sorted in chronological order with respect to tAbsMinEndTime. C2CC: RS_ARSM_79: At least MovementEvent instances for the current and next phase and all transitions in between shall be included in 'state-time-speed' (DF_MovementEventList). Additional MovementEvent instances may be included. Note: This means that the current and the next phase have to be included. If there is a transition in-between, three MovementEvent instances in total have to be included in the SPATEM.
**	maneuverAssistList (1..16)	DF	Optional	ManeuverAssistList ::= SEQUENCE (SIZE(1..16)) OF ConnectionManeuverAssist (see table 15.5).	
**	regional (1..4)	DF	Optional	REGION.Reg-MovementState. Not used.	

Table 15.3 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
*	movementEvent	DF	Mandatory	Mandatory if 'state-time-speed' is used. In case of multiple signals applying to one connection (e.g. for right turns) one singular virtual signal group with corresponding MovementState shall be transmitted, which reflects the combined MovementPhaseState of all applicable signals.	C2CC: RS_ARSM_74: In case of multiple signals applying to one connection (e.g. for right turns) one singular virtual signal group with corresponding MovementState shall be transmitted, which reflects the combined MovementPhaseState of all applicable signals. C2CC: RS_ARSM_80: If a failure of the traffic light controller is detected (i.e. the IntersectionStatusObject indicates 'failureMode'), either a SPaTEM with the eventState "0" (unavailable) should be sent or SPATEM transmissions deactivated completely within less than tDelayFailureTransmission after the traffic light goes into failure mode.

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Table 15.3 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
**	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 rules and not the physical representation / color of the physical traffic lights. Defined as follows: (0) unavailable (unknown or error) (1) dark shall not be used ~~(e.g. when some lights are amber blinking and others are off).~~ (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 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	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. C2CC: RS_ARSM_76: 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 (see also RS_ARSM_71 and RS_ARSM_74). Note: The cars needs to know the applicable rules and not the physical representation / color of the physical traffic lights. C2CC: RS_ARSM_77: The data element 'eventState' shall be set to the applicable value considering the distinction between protected and permissive movements. C2CC: RS_ARSM_72: The MovementPhaseState "dark" shall not be used. Note 1: For the vehicle the applicable traffic rules are of relevance – not the physical representation. If no information can be given, "unavailable" shall be used rather than "dark". Note 2: According to the other requirements on MovementPhaseState (i.e. RS_ARSM_74 and RS_ARSM_76), there is no situation left in which "dark" needs to be used. C2CC: RS_ARSM_103: The MovementPhaseState "stop-And-Remain" shall be used when vehicles on corresponding lanes are not allowed to enter the conflict zone. Note: In most cases, this corresponds to the traffic light showing "red". C2CC: RS_ARSM_104: The MovementPhaseState "pre-Movement" shall be used for transitions that directly precede the phase "permissive-Movement-Allowed" or "protected-Movement-Allowed". Note: For example in Germany, this corresponds to the traffic light showing "red-yellow". C2CC: RS_ARSM_105:

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Table 15.3 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				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 (e.g. Amber light blinking; Proceed with caution, Conflicting traffic may be present in the intersection conflict area).	The MovementPhaseState "permissive-Movement-Allowed" shall be used when vehicles on corresponding lanes are allowed to enter the conflict zone but there still might occur conflicting traffic which they have to pay attention for. Note: This applies for example in some right-turn situations when the driver needs to pay attention to pedestrians which might cross the street because they also are allowed to enter the conflict zone. C2CC: RS_ARSM_106: The MovementPhaseState "protected-Movement-Allowed" shall be used 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. Note: This applies for example in some left-turn situations when only lanes having a left-turn connections are in a "Movement-Allowed" state but no other conflicting traffic. C2CC: RS_ARSM_107: The MovementPhaseState "permissive-Clearance" shall be used 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. Note: In Germany this corresponds to the traffic light showing "yellow". C2CC: RS_ARSM_110 The MovementPhaseState "protected-Clearance" shall be used 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. Note: In Germany this corresponds to the traffic light showing "yellow". C2CC: RS_ARSM_108: The MovementPhaseStates "caution-Conflicting-Traffic" shall be used for signalGroups belonging to lanes of minor roads if none of the aforementioned MovementPhaseStates are applicable

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Table 15.3 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
					(e.g. if the traffic light controller is in standby mode). It shall indicate that vehicles are allowed to proceed but have to give way to conflicting traffic. Note: In Germany this corresponds to the traffic light showing “flashing yellow”.
**	timing	DF	Optional /Mandatory (see usage)	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	C2CC: RS_ARSM_120: 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). Note: See also RS_ARSM_79. C2CC: RS_ARSM_61: For traffic signal controllers operating fixed time, where the time of change is known, ‘minEndTime‘, ‘likelyTime’ and ‘maxEndTime’ shall be equal, if they

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Table 15.3 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				probability which can be used interchangeably subject to availability.	are present.
***	startTime	DE	Optional	Not used.	
***	minEndTime	DE	Mandatory	Pre-configured or calculated value with high probability, but sometimes not available (36001). In case of e.g. fixed time control identical to maxEndTime and likelyTime which indicates high probability. 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. The data element 'minEndTime' shall have a value between pTimeMarkMin and pTimeMarkOutOfRange. Note: This means that the value pTimeMarkUnknown (unknown) shall not be used. 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	C2CC Requirement RS_ARSM_55: 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. C2CC: RS_ARSM_56: The data element 'minEndTime' shall have a value between pTimeMarkMin and pTimeMarkOutOfRange. Note: This means that the value pTimeMarkUnknown (unknown) shall not be used. C2CC Requirement RS_ARSM_91: 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. C2CC: Requirement RS_ARSM_62 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. [Note: For tests the electrical controller output to the lights may be measured.]

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Table 15.3 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				light within tTimeOfChangeAccuracy.	
***	maxEndTime	DE	Mandatory	Pre-configured or calculated value with high probability, but sometimes not available (36001). In case of e.g. fixed time control identical to minEndTime and likelyTime which indicates high probability. The data element 'maxEndTime' (DE_TimeMark) shall be set to the latest time possible at which the phase state could change. 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.	C2CC: RS_ARSM_57: The data element 'maxEndTime' (DE_TimeMark) shall be present for actuated traffic light operation. C2CC RS_ARSM_58: The data element 'maxEndTime' (DE_TimeMark) shall be set to the latest time possible at which the phase state could change. C2CC: RS_ARSM_59: 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. C2CC: RS_ARSM_60: For 'maxEndTime' the value pTimeMarkUnknown (unknown) shall not be used. C2CC RS_ARSM_90: 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.
***	likelyTime	DE	Mandatory	In case of e.g. fixed time control identical to minEndTime and maxEndTime which indicates high probability. For the data element 'likelyTime' the value pTimeMarkUnknown (unknown) shall not be used.	C2CC: RS_ARSM_64: The data element likelyTime (DE_TimeMark) shall be present for actuated traffic light operation. Note: The confidence for the likelyTime is given in the DE "confidence" (DE_TimeIntervalConfidence). C2CC RS_ARSM_66: For the data element 'likelyTime' the value pTimeMarkUnknown (unknown) shall not be used.
***	confidence	DE	Optional/Mandatory	Mandatory if likelyTime is provided. Confidence shall be interpreted as probability that the real phase change occurs within ± *tTimeChangeInterval* of the indicated likelyTime.	Definition: Information provided with a 'confidence level' of 95 % means that the true value is inside the confidence interval or the confidence area for at least 95 % of the data points in a given statistical base.

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Table 15.3 MovementEventList → MovementEvent

Level	Name	Type	M/O	Usage	Comment
				Note 1: This means that the probability for likelyTime – tTimeChangeInterval <= phase change time <= likelyTime + tTimeChangeInterval shall be indicated. ~~For example, assuming normal distribution, a likelyTime 30 seconds ahead in time and a standard deviation of 3,6 seconds, the following applies:~~ ~~• The likelyTime is within 26 and 34 seconds (1 sigma) with 68,27% probability.~~ ~~• The likelyTime is within 22 and 38 seconds (2 sigma) with 95,44% probability.~~ ~~• The likelyTime is within 18 and 42 seconds (3 sigma) with 99,73% probability.~~ If no prediction is available, the confidence of 'likelyTime' shall be disseminated with the value "0".	C2CC: RS_ARSM_115: If the data element 'likelyTime' is present, the confidence of 'likelyTime' shall be present as well. C2CC: RS_ARSM_102: The data element TimeIntervalConfidence shall be used as defined in SAE J2735. Confidence shall be interpreted as probability that the real phase change occurs within ± *tTimeChangeInterval* of the indicated likelyTime. Note 1: This means that the probability for likelyTime – *tTimeChangeInterval* <= phase change time <= likelyTime + *tTimeChangeInterval* shall be indicated. Note 2: 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. C2CC: RS_ARSM_67: If no prediction is available, the confidence of 'likelyTime' shall be disseminated with the value "0".
***	nextTime	DE	Optional		
**	speeds (1..16)	DF	Optional	AdvisorySpeedList ::= SEQUENCE (SIZE(1..16)) OF AdvisorySpeed (see table 15.4).	
**	regional (1..4)	DF	Optional	REGION.Reg-MovementEvent-addGrpC,	
***	stateChangeReason	DE	Optional		

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Table 15.4 AdvisorySpeedList → AdvisorySpeed

Level	Name	Type	M/O	Usage	Comment
*	advisorySpeed	DF	Mandatory	Mandatory if 'speeds' is used.	
**	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.	
**	speed	DE	Optional		
**	confidence	DE	Optional	Not used.	
**	distance	DE	Optional	Not used for greenwave (1). In other cases, distance is specified upstream from the stop bar along the ingressing lane.	
**	class	DE	Optional		
**	regional (1..4)	DF	Optional	REGION.Reg-AdvisorySpeed . Not used.	

Table 15.5 ManeuverAssistList → ConnectionManeuverAssist

Level	Name	Type	M/O	Usage	Comment
*	connectionManeuverAssist	DF	Mandatory	Mandatory if 'maneuverAssistList' is used.	
**	connectionID	DE	Mandatory		
**	queueLength	DE	Optional		
**	availableStorageLength	DE	Optional	Not used.	
**	waitOnStop	DE	Optional	Not used.	
**	pedBicycleDetect	DE	Optional	Not used.	
**	regional (1..4)	DF	Optional	REGION.Reg-ConnectionManeuverAssist-addGrpC Not used.	
***	itsStationPosition	DF	Optional	ItsStationPositionList ::= SEQUENCE SIZE(1..5) OF ItsStationPosition (see table XXX)	

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Table 15.5 ItsStationPositionList → ItsStationPosition

Level	Name	Type	M/O	Usage	Comment
*	ItsStationPosition	DF	Optional		
**	stationdID	DE	Mandatory		
**	laneID	DE	Optional		
**	nodeXY	DF	Optional		
**	timeReference	DE	Optional		

3.2.4 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 16 and Table 17. 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 3 and in Figure 4 for the relationship of the SSEM tables.

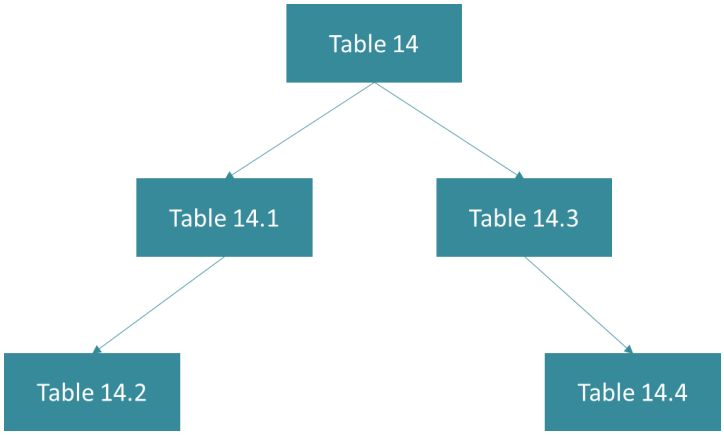

Figure 3 relationship of SREM data element tables

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Figure 4 relationship of SSEM data element tables

3.2.4.1 SREM general elements

Table 16 SREM general elements

Level	Name	Type	M/O	Usage	Comment
*	SREM	DF	Mandatory		
**	timeStamp	DE	Mandatory		
**	second	DE	Mandatory		
**	sequenceNumber	DE	Mandatory		
**	requests	DE	Mandatory	SignalRequestList ::= SEQUENCE (SIZE(1..32)) OF SignalRequestPackage (see table 16.1).	
**	requestor	DF	Mandatory	See table 16.3.	
**	regional	DF	Optional	REGION.Reg-SignalRequestMessage Not used.	

Table 16.1

Level	Name	Type	M/O	Usage	Comment
*	signalRequestPackage	DF	Mandatory	Continues 'requests'	
**	request	DF	Mandatory	See table 16.2.	
**	minute	DE	Optional		
**	second	DE	Optional		
**	duration	DE	Optional	Not used.	

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Table 16.1

**	regional	DF	Optional	REGION.Reg-SignalRequestPackage	

Table 16.2

Level	Name	Type	M/O	Usage	Comment
*	signalRequest	DF	Mandatory	Continues 'request'	
**	id	DE	Mandatory		
***	region	DE	Optional		
***	id	DE	Mandatory		
**	requestID	DE	Mandatory		
**	requestType	DE	Mandatory		
**	inBoundlane	DF	Mandatory		
***	lane	DE	Optional	(choice)	
***	approach	DE	Optional	(choice)	
***	connection	DE	Optional	(choice)	
**	outBoundLane	DF	Optional		
***	lane	DE	Optional	(choice)	
***	approach	DE	Optional	(choice)	
***	connection	DE	Optional	(choice)	
**	regional	DE	Mandatory	REGION.Reg-SignalRequest-addGrpC Used to provide the countryCode of origin linked to the RoadRegulatorID.	
***	countryCode	DE	Mandatory	Country code of the region (RoadRegulatorID) of the IntersectionReferenceID.	This regional extension enables global uniqueness of IntersectionReferenceIDs, assuming that: RoadRegulatorIDs are

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Table 16.2

Level	Name	Type	M/O	Usage	Comment
					managed and assigned nationally, and each road regulator assigns IDs to intersections.

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Table 16.3

Level	Name	Type	M/O	Usage	Comment
*	requestorDescription	DF	Mandatory	Continues 'requestor'	
**	id	DF	Mandatory		
***	entityID	DE	Optional	Not used.	
***	stationID	DE	Mandatory	Identical to the stationID of the CAM message and may not change during pending SREM.	
**	type	DF	Optional	See table 16.4	
**	position	DF	Optional	Not used.	
***	position	DE	Optional	Not used as parent DF is not used.	
****	lat	DE	Optional	Not used as parent DF is not used.	
****	long	DE	Optional	Not used as parent DF is not used.	
****	elevation	DE	Optional	Not used as parent DF is not used.	
****	regional	DF	Optional	REGION.Reg-Position3D Not used as parent DF is not used.	
***	heading	DE	Optional	Not used.	
***	speed	DF	Optional	Not used.	
****	transmission	DE	Optional	Not used as parent DF is not used.	
****	speed	DE	Optional	Not used as parent DF is not used.	
**	name	DE	Optional		
**	routeName	DE	Optional		
**	transitStatus	DE	Optional		
**	transitOccupancy	DE	Optional	Not used.	
**	transitSchedule	DE	Optional		

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**	regional	DE	Optional	REGION.Reg-Requestor-Description-addGrpC. Not used.	
***	fuel				
***	batteryStatus				

Table 16.4

Level	Name	Type	M/O	Usage	Comment
*	requestorType	DF	Mandatory	Continues 'type'	
**	role	DE	Mandatory		
**	subrole	DE	Optional		
**	request	DE	Optional		
**	iso3833	DE	Optional	Not used.	
**	hpmsType	DE	Optional	Not used.	
**	regional	DE	Optional	REGION.Reg-RequestorType Not used.	

3.2.4.2 SSEM general elements

Table 17 SSEM general elements

Level	Name	Type	M/O	Usage	Comment
*	SSEM	DF	Mandatory		
**	timeStamp	DE	Mandatory		
**	second	DE	Mandatory		
**	status	DF	Mandatory	SignalStatusList ::= SEQUENCE (SIZE(1..32)) OF SignalStatus See table 17.1.	
**	regional	DF	Optional	REGION.Reg-SignalStatus-Message Not used.	

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Table 17.1

Level	Name	Type	M/O	Usage	Comment
*	signalStatus	DF	Mandatory	Continues 'status'.	
**	sequenceNumber	DE	Mandatory		
**	id	DF	Mandatory		
***	region	DE	Optional		
***	id	DE	Mandatory		
**	sigStatus	DF	Mandatory	SignalStatusPackageList ::= SEQUENCE (SIZE(1..32)) OF SignalStatusPackage See table 17.2.	
**	regional	DF	Mandatory	REGION.Reg-SignalStatus-addGrpC. Used to provide the countryCode of origin linked to the RoadRegulatorID.	
***	countryCode	DE	Mandatory	Country code of the region (RoadRegulatorID) of the IntersectionReferenceID.	This regional extension enables global uniqueness of IntersectionReferenceIDs, assuming that: RoadRegulatorIDs are managed and assigned nationally, and each road regulator assigns IDs to intersections.

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Table 17.2

Level	Name	Type	M/O	Usage	Comment
*	signalStatusPackage	DF	Mandatory	Continues 'sigStatus'	
**	requestor	DF	Mandatory		
***	id	DE	Mandatory		
****	entityID	DE	Optional	Choice: not used.	
****	stationID	DE	Mandatory	Choice	
***	request	DE	Mandatory		
***	sequenceNumber	DE	Mandatory		
***	role	DE	Optional	Not used.	
***	typeData	DE	Mandatory		
****	role	DE	Mandatory		
****	subrole	DE	Optional		
****	request	DE	Optional	Not used.	
****	iso3833	DE	Optional	Not used.	
****	hpmsType	DE	Optional	Not used.	
****	regional	DF	Optional	REGION.Reg-RequestorType Not used.	
**	inBoundlane	DF	Mandatory		
***	lane	DE	Optional	(choice)	
***	approach	DE	Optional	(choice)	
***	connection	DE	Optional	(choice)	
**	outBoundLane	DF	Optional		
***	lane	DE	Optional	(choice)	
***	approach	DE	Optional	(choice)	

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***	connection	DE	Optional	(choice)	
**	minutes	DE	Mandatory		
**	second	DE	Mandatory		
**	duration	DE	Mandatory		
**	status	DE	Mandatory		
**	regional	DF	Optional	REGION.Reg-SignalStatus-Package-addGrpC Not used.	
***	synchToSchedule		Optional		
***	rejectedReason		Optional		

3.3 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 will be applied to all messages:

1. Messages will be updated within the validity duration or before the validity time runs out.
2. The mechanism to make a message invalid is by either sending a cancellation for the rest of the remaining validity duration or letting the validity run out.
3. Negation is never used.

3.4 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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3.5 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 [19] or other standards available.

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

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4 References

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 18

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 V1.3.1 (2020-02) - Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services

Table 19 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
[3]	C-ITS Platform Final report, January 2016
[4]	C-ROADS, Roadside ITS G5 System Profile, Release 1.7 (2020-06)
[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 V1.3.1 (2018-08) Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and Facilities layer common data dictionary
[9]	C_ROADS_WG2_TF2_Service Descriptions v1.7

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[10]	ETSI EN 302 637-3 v1.3.1 (2019-04) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service
[12]	ISO/TS 19321:2020 (2020-??-??) - 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
[20]	InterCor_M03-Upgraded-Specifications-ITS-G5_v1.1.pdf
[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]	ECo-AT C-ITS for Automated Driving - SWP1.2 - Functional Specification v01.00

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5 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 3.2.4 according to the migration path and are not fully supported by C-ROADS. Table 20 Shows the usage of CAM elements for this purpose.

Table 20 CAM elements specific for the TLC functionality

Name	Type	M/O	Usage	Comments
CAM	DF	Mandatory		
generationDeltaTime	DE	Mandatory	Timestamp belonging to the referencePosition.	
Basic Container	DF	Mandatory		
stationType	DE	Mandatory	Type of broadcast source – bus / tram	
referencePosition	DE	Mandatory	Vehicle location	
High Frequency Container	DF	Mandatory		
speed	DE	Mandatory	Vehicle speed	
heading	DE	Mandatory	Vehicle direction	
longitudinalAcceleration	DE	Mandatory	Vehicle acceleration	
driveDirection	DE	Mandatory	Drive direction	
vehicleLenght	DE	Mandatory	Length of the vehicle	
Low Frequency Container	DF	Optional		
vehicleRole	DE	Mandatory	Vehicle role – publicTransport / emergency	
exteriorLights	DE	Mandatory	Activated headlights	
Public Transport Container	DF	Optional		
embarkationStatus	DE	Optional	State of passenger doors	
ptActivation	DF	Optional	Information about PT vehicle (e.g. priority request information, public transport line number)	
Emergency Container	DF	Optional		
emergencyPriority	DE	Optional	Priority request	

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