



C-ITS Roadside ITS-G5 System Profile 2.0.7

C-Roads Platform

Working Group 2 Technical Aspects

Taskforce 3 Infrastructure Communication

15/03/2023

Publication History

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1 Introduction

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

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

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

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

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

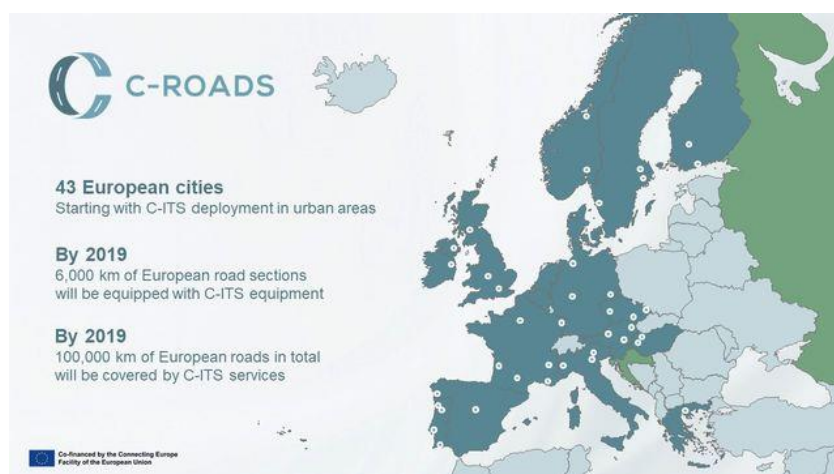


Figure 1 Overview of C-Roads coverage

1.2 Story board C-Roads C-ITS deployment documentation

This document is part of the C-Roads C-ITS Deployment Documentation and Requirements. The complete set of documents is much related to a common project life cycle of a system implementation. As a guide to the C-Roads Documentation, a story board based on such a project life cycle is provided in this section, with emphasis on role of this document *C-ITS Roadside ITS G5 System Profile*. The story board should be read from left to right and shows the different stages of the project life cycle and how each C-Roads Documentation is related to it, thereby can be supportive to road authorities and other stakeholders.

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

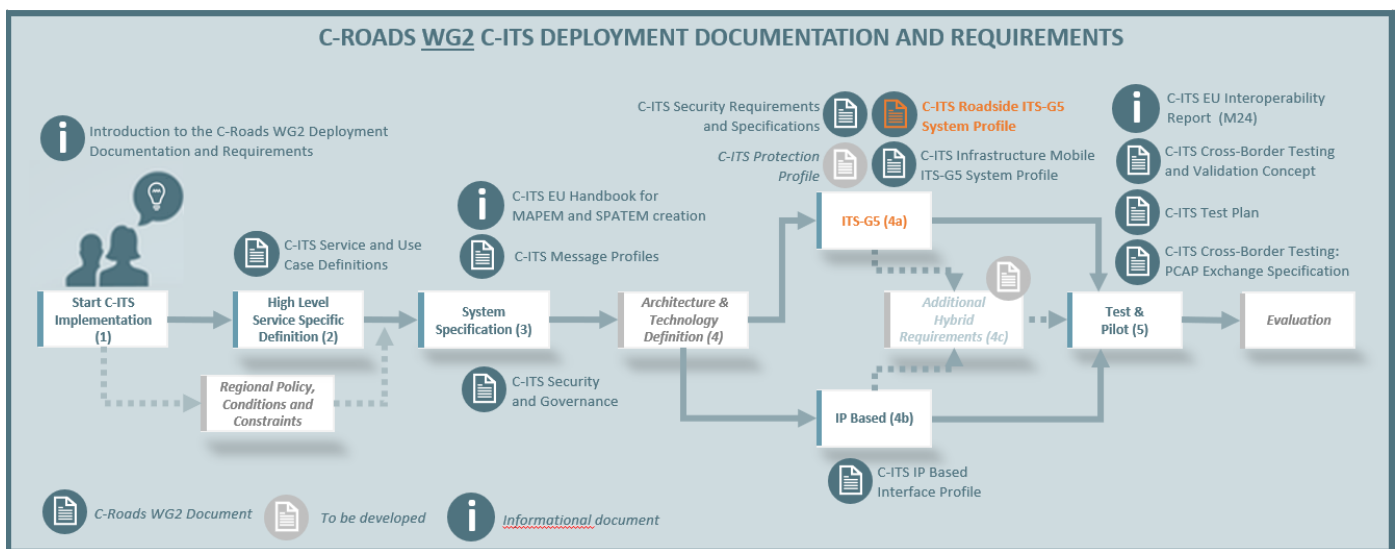


Figure 2 highlight of WG2 document in complete story board

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

1.3 Scope of this document

This document is one of the documents of stage 4 in the C-Roads workflow, as described in section 1.4 of *Introduction to the C-Roads WG2 Deployment Documentation and Requirements*. This workflow reflects how information flows through the C-ITS station architecture. It starts with an application (referred to as “Service”), which is described in the stage 2 documents. In order to perform its function, the application decides to send out messages and in order to do so, it invokes a Service Access Point (SAP) of a Facility Layer Service (FLS). The term SAP is taken from the OSI reference model for the interfaces between layers, many people today would probably rather call it an API. The Facility Layer Service performs its task according to its specification and uses SAPs of underlying layers (transport, network, access) for doing so. The according specifications are not developed in C-Roads, standards are used for this instead, e. g. ETSI EN 302 637-3 [10] and ISO 103 301 [16] for the Facility Layer services.

The present document specifies the requirements and general settings for most layers of the C-ITS system architecture in the case of a Roadside ITS-G5 System, including:

- The Access Layer
- The Network Layer
- The Transport Layer
- The Management Component

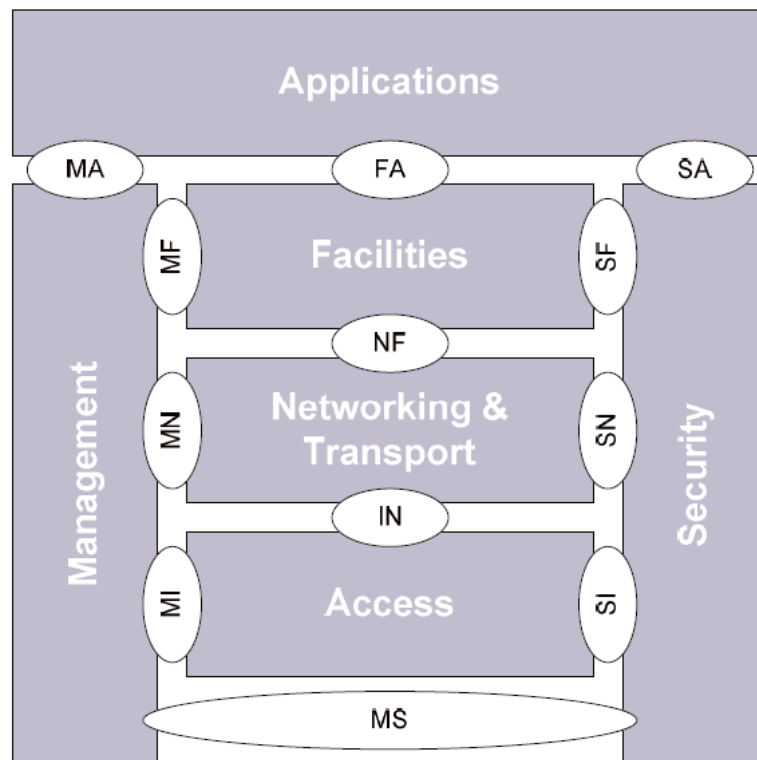


Figure 3 The ITS-Station layered architecture/ITS-S host (ETSI EN 302 665 [12])

The European ITS-Station architecture (Figure 3), outlined in ETSI EN 302 665 [12], defines four ITS sub-systems; vehicle, roadside, personal, and central. Standards are developed in a neutral and open way such that they include different options to allow diversion and future options to extend the standards later. To realize Interoperability among sub-systems many of these options need to be made specific. Profiles therefore describe the selected options and include additional specification when required to ensure the expected interoperability. Herein, the roadside sub-system profile is defined.

The Infrastructure Roadside ITS-G5 System Profile, referred as Roadside System Profile (RSP), defines a common base for the ITS-G5 communication between roadside and vehicle. The communication directions derived from this are also known as I2V (Infrastructure-to-Vehicle) and V2I (Vehicle-to-Infrastructure).

The profile provides descriptions, definitions and rules for all layers (Applications, Facilities, Networking & Transport and Access) of the ETSI ITS station reference architecture/ITS-S host. Management is included, but Security is out of scope. The understanding of the core infrastructure roadside system components is depicted in Table 1:

Table 1 Infrastructure roadside system components

Layer	Component		Tasks	Com- ponent
Applications	Operational Specifications		Service definitions, and transmission principles, and triggering conditions	Management & Security
Facilities	Positioning & Time (incl. minimum data quality requirements)		Relevance Checking (C2C-CC White Paper on Positioning and Timing [20])	
	Data and Message Content	CAM & DENM	Vehicle & infrastructure data provider (incl. minimum data quality requirements)	
		IVIM, SPATEM, MAPEM, etc.	Infrastructure data provider (incl. minimum data quality requirements)	
Transport & Network	Transport	Basic transport protocol (BTP)	End-to-end, connection-less transport service	
	Network	Geo-Based Addressing	Source and destination specification, handling of geographic relevance	
		Geo-Routing Protocol	multihop-forwarding and message dissemination	
Access	ETSI ITS-G5 European Profile Standard		Physical layer, media access and congestion control	
IEEE 802.11p				

This infrastructure system is a Roadside ITS sub-system enabling a set of “Day-1 services” (listed in Table 2 in section 3.2).

Since the requirements of the ITS sub-systems are very similar, this Infrastructure Roadside ITS-G5 System Profile uses the C2C-CC BSP [2] as a basis from content- and structure point of view.

This system profile specifies a minimum set of standards and fills the missing gaps necessary for the realisation of an interoperable roadside ITS-Station as defined in the Communication Architecture ETSI EN 302 665 [12]. The profile only includes the interoperability requirements leaving open any additional requirements, it therefore does not describe the full functionality of the roadside ITS-Station.

The current version of this system profile enables the deployment of the “Day-1 services”, as selected by C-Roads for this release. It may also support other services but these other services may require extensions of this system profile in next releases.

An infrastructure roadside system shall at least realize the requirements as specified here to realize European interoperability with the aim to increase road traffic safety and at improving the overall traffic efficiency.

The current document considers requirements such as information quality, the efficient use of the spectrum in the 5.9 GHz range and the coexistence with the tolling frequency band 5.8 GHz.

It does not consider the communication between roadside and centre (R2C and C2R) or roadside and web service (R2W and W2R) as well as vehicle and vehicle (V2V) are out of scope.

Security related requirements are also out of scope for this document, as they are covered by a dedicated document.

Mobile R-ITS-S are also not covered in this document.

The infrastructure roadside system profile contributes to the realisation of the objective of the C-ROADS Platform to develop, share, and publish common communication profiles.

The current document covers the Intra-C-ITS information exchange between infrastructure and vehicles, and not for intra-sub-system interoperability.

1.4 Acronyms and Definitions

1.4.1 Acronyms

BSP	Basic System Profile
BTP	Basic Transport Protocol
C-ITS	Cooperative Intelligent Transport Systems
C2C-CC	Car2Car Communication Consortium
CA	Cooperative Awareness
CAM	Cooperative Awareness Message
CCH	Control Channel; Channel with 5900 MHz carrier centre frequency (IEEE channel 180) also known as Service Channel 0 (SCH0)
CPM	Collective perception message (ETSI TR 103 562 [35])
CRW	Collision Risk Warning
DCC	Decentralised Congestion Control
DENM	Decentralized Environmental Notification Message
DP	DCC profile
DPID	DCC profile identifier
DSRC	Dedicated Short Range Communications
FLS	Facility Layer Service
GBC	Geo Broadcast
GN	Geo Networking
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HST	Header Sub-Type
HT	Header Type
ITS	Intelligent Transport Systems
ITS-G5	ITS-G5 is a European standard for ad-hoc short-range communication of vehicles among each other (V2V) and with Road ITS Stations (V2I). The ITS-G5 Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band is given in ETSI EN 302 663. ITS-G5 is a profile of the amendmend IEEE 802.11p, which has been incorporated into the main IEEE 802.11 standard and an IEEE 802.2 LLC. It uses the 5.9 GHz frequency band to support safety- and non-safety ITS applications.
ITS-S	Intelligent Transport Systems Station

IVI	Infrastructure to Vehicle Information
IVIM	Infrastructure to Vehicle Information Message
IVS	In-Vehicle Signage
LLC	Logical Link Control
LT	Lifetime
MAP	Geometric information for the intersection
MAPEM	MAP (topology) Extended Message
MHP	Maximum Hop limit
MS	Member State
NDL	Network Design Limits
NH	Next Hop
NTP	Network Time Protocol
HLN	Hazardous Location Notification
R-ITS-S	Static Roadside ITS Station (RSU or ITS-S R in the French Terminology); also called infrastructure roadside system in this document
RLT	Road Lane Topology
RSP	Roadside ITS-G5 System Profile (short also Roadside System Profile)
RWW	Roadworks Warning
s	Seconds
SCF	Store Carry Forward
SCH 1	Safety related channel with the carrier centre frequency of 5 880 MHz (IEEE channel 176) (for CPM)
SCH 2	Service channel with the carrier centre frequency of 5890 MHz (IEEE channel 178) (for IVIM using the automated vehicle container)
SCH 5	Service channel with the carrier centre frequency of 5910 MHz (IEEE channel 182) (extension channel)
SCH 6	Service channel with the carrier centre frequency of 5920 MHz (IEEE channel 184) (extension channel); urban rail has priority on this channel
SHB	Single-Hop Broadcast
SPAT	Signal Phase and Timing
SPATEM	Signal Phase and Timing Extended Message
TAI	Temps Atomique International, engl. International Atomic Time
TC	Traffic Class
TCC	Traffic Control Centre
TLM	Traffic Light Manoeuvre
time base	ITS-S time
V-ITS-S	Vehicle ITS station
WiFi	Technology for radio wireless local area networking of devices based on the IEEE 802.11 standards

WGS	World Geodetic System
N/A	<i>Not Applicable</i>
TBC	<i>To Be Checked, with MS or associated partner</i>

1.4.2 Definitions

Term	Definition
<i>ITS-S Application</i>	Uses one or more FLSs with different parameters, depending on the situation, to provide an ITS service to the user. ETSI TR 102 638 [34] e.g. RWW, IVS and CRW. Also known as C-ITS Service in C_ROADS_WG2_TF2_Service Description [37].
<i>Use case scenario</i>	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.
<i>Facilities Layer Service</i>	In this document, the term service is derived from the term ITS-S service as defined in ETSI EN 302 665 [12]. It describes a communication functionality offered by an ITS-S to an ITS-S application.
<i>C-ITS time</i>	The number of elapsed International Atomic Time (TAI) milliseconds since 2004-01-01 00:00:00.000 Coordinated Universal Time (UTC)+0 as defined in ETSI EN 302 636-4-1 [7]. Timestamps as defined in [15] [15] follow this time format. (Copied as it is from RS_BSP_193)
<i>Station clock</i>	A clock representing C-ITS time in a mobile C-ITS station. (Copied as it is from RS_BSP_430)
<i>Confidence interval</i>	The estimated value plus/minus the confidence value. (Copied as it is from RS_BSP_500)
<i>Confidence area</i>	For the horizontal position, a confidence area is used instead of a single confidence interval. The confidence area is specified by an ellipse (centred at the estimated horizontal position) described via a major axis, minor axis and orientation of the major axis relative to the north of the reference coordinate system. (Copied as it is from RS_BSP_200)

2 Provisions

2.1 Verbal forms of the expression of provisions

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

Shall / Shall not

Recommendations shall be indicated by the verbal forms:

Should / Should not

Permissions shall be indicated by the verbal forms:

May / May not

Possibility and capability shall be indicated by the verbal forms:

Can / Cannot

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

Will / Will not

Facts shall be indicated by the verbal forms:

Is / Is not

2.2 Provisions from referenced documents

Unless otherwise specified in the present document, the 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 document or generally by the SDO (standardisation organisation) or the organisation providing them. For example, normative requirements in ETSI documents are indicated by the verbal form “shall”.

2.3 Notation used to identify requirements

Interoperability between C2C-CC (Car-2-Car Communication Consortium) and C-Roads Platform is a key aspect for the RSP (Roadside ITS G5 System Profile) requirements. Thus, the requirements follow the following formalism:

Req_ID	<i>UniqueRequirementID (RequirementVersion)</i>
Requirement	Content of the requirement. Principal verb like “shall” or “should” are written in bold .
Origin	<i>BSPCopyPaste</i>
Interop issue	<i>InteroperabilityComment</i>

With:

- *UniqueRequirementID*

Initiated with RS_RSP_001 for the first requirement and incremented for each additional requirement. Each requirement has a unique ID.

- *RequirementVersion*

Initiated with the value 1.

If the requirement evolves, *RequirementVersion* is incremented. To limit versioning, the version only evolves when the document is in a release: for draft and non-official releases, revision marks are sufficient.

- *BSPCopyPaste*

The BSP requirement that may have inspired the RSP requirement. The possible values are:

- “RS_BSP_XXX as it is” if the requirement originates from the BSP and is exactly copied.
- “RS_BSP_XXX with modification” if the BSP requirement is not exactly copied.
- “N/A” if the RSP requirement is not inspired from the BSP

- *InteroperabilityComment*

Summarises the conclusion on the interoperability reflexions with the BSP. The possible values are:

- “N/A” if the requirement is equivalent to the BSP one.
- Otherwise, write a short description of the deviation from C2C and an analysis of the impact on interoperability.

2.4 Standards evolution

The standards chosen as specifications in this deliverable are evolving standards. This document selects specific versions of the underlying existing standards for concrete implementation.

2.5 Terms from Definitions

Predefined terms listed in chapter 1.4.2 Definitions are put in [] and italic, e.g. *[ITS-S Application]*

3 FEATURES OF THE ROADSIDE SYSTEM PROFILE (RSP)

3.1 Introduction

The standards profile distinguishes between two types of interoperability:

- Inter-sub-system interoperability (interoperability of different ITS subsystems), i.e. sub-systems implementing the standards profile can communicate/understand each other,
- Intra-sub-system interoperability (interoperability of components within one ITS subsystem), i.e., the sub-system consists of completely interchangeable components.

Each type of interoperability provides benefits for the system but comes with a certain effort to achieve this interoperability.

Inter-sub-system interoperability requires a precise definition of the external interfaces but can leave room for different implementations within the sub-system, which encourages innovation and competitive differentiation.

Intra-sub-system interoperability requires a much higher degree of standardisation within the sub-system and allows customers to select among the best suppliers for each individual component within the sub-system.

The infrastructure roadside system standard profile contributes to the realisation of the objective of the C-ROADS Platform to develop, share, and publish common communication profiles. This standard profile aims for inter-sub-system interoperability between infrastructure and vehicles, and not for intra-sub-system interoperability.

3.2 Set of supported applications

The main purpose of the Roadside System Profile (RSP) document is to ensure interoperability between roadside ITS-Stations and vehicle ITS-Stations for safety and efficiency related functions. This document focuses on specifying the infrastructure roadside system on the roadside ITS-Station transmitting side. Moreover, this profile document shall be oriented towards ensuring the fulfilment of the requirements of the FLSs from the safety and efficiency domains as specified in Table 2.

Table 2 'Day-1' Infrastructure-to-Vehicle ITS-S applications incl. mapping to FLSs

ITS-S Application	Facility Layer Service (FLS)
Roadworks Warning (RWW)	Decentralized Environmental Notification (DEN) Basic Service (DEN Basic FLS)
Hazardous Location Notifications (HLN)	
Probe Vehicle Data (PVD) – Event Data Collection	
In-Vehicle Signage (IVS) Automated Vehicle Guidance (AVG) HD Topology (HDT)	Infrastructure to Vehicle Information (IVI) Service (IVI FLS)
Signalized Intersections (SI)	Traffic Light Maneuvers (TLM) Service & Road and Lane Topology (RLT) Service (TLM FLS and RLT FLS)
	Traffic Light Control (TLC FLS)
Coexistence (ITS-G5 – CEN-DSRC)	Cooperative Awareness (CA) Basic Service (CA Basic FLS)
Probe Vehicle Data (PVD) – Vehicle Data Collection	

Coexistence differentiates itself from the other ITS-S applications. It is used to ensure the stable operation of the roadside system and is therefore called a system ITS-S application. The other ITS-S applications are of functional nature.

3.3 Channel usage

The Roadside System Profile supports the use of multiple channels. The ITS-G5 control channel hosts essential safety-related services and has a coordination function. It serves the initial Day-1 use cases, such as the cooperative awareness basic service, hazardous location notifications and road works warning.

Service channels are used for services which have a special scope and performance characteristics. The use of service channels is communicated by a service announcement (cf. RS_RSP_116) on the control channel, so that receiving ITS stations can specifically listen to those channels.

As an example, the cooperative perception service (CPS) is ideally served by a service channel, because of the following reasons: First, the exchange of sensor perceptions can create a high load that should not lead to an overloading of the control channel. Second, CPS is an independent service, and vehicles that need this service could specifically listen to this channel. Furthermore, the repeated exchange of sensor data in CPMs might carry partially redundant information, which might allow operation under high channel load, while whereas overloading the control channel would be detrimental for the overall system.

A further example is the special scope of the automated vehicle guidance use cases, which are only of interest for automated vehicles and do not need to be distributed on the control channel. This way, the offloading of messages, which could disperse use cases across channels, is not required (cf. RS_RSP_042).

The overall aim of the multichannel concept is to distribute channel load in order to ensure that safety-related messages have a very high predictability to be received by other ITS stations.

	ITS-G5 Service Channel 4	ITS-G5 Service Channel 3	ITS-G5 Service Channel 1	ITS-G5 Service Channel 2	ITS-G5 Control Channel	ITS-G5 Service Channel 5	ITS-G5 Service Channel 6
Abbreviation:	SCH 4	SCH 3	SCH 1	SCH 2	CCH / SCH 0	SCH 5	SCH 6
Centre frequency:	5860 MHz	5870 MHz	5880 MHz	5890 MHz	5900 MHz	5910 MHz	5920 MHz
IEEE channel number:	172	174	176	178	180	182	184
Designation:	Non safety ITS		Safety-related ITS				Priority for Urban Rail ITS
	5855 MHz	5875 MHz				5915 MHz	5925 MHz

4 Infrastructure roadside system requirements

This section defines the interoperable characteristics of the infrastructure roadside system. The roadside system shall be supported by R-ITS-Ss (Roadside ITS stations) that implement the infrastructure roadside system profile as identified in 4.

4.1 Positioning and timing

4.1.1 General

The requirements specified in this subsection considers the assumptions and motivation introduced and explained in the C2C-CC white Paper “Positioning and Timing” [20].

A R-ITS-S state estimation shall include confidence values according to the definition in [RS_RSP_004](#), for position, heading and velocity, as a standardised description of the estimation accuracy.

NOTE: Any numeric values (except the confidence level of 95%) provided in this and further sub-sections are reflecting the current possibilities as provided by the GNSS sub-system. Values provided here have to be seen as targeted values. Hence, these values should be deemed as suggestions and are subject to change.

Objective

An infrastructure roadside system (R-ITS-S) is in a static situation (fixed station) and therefore able to determine its own position with high accuracy.

In case the R-ITS-S is placed on a moving vehicle the same accuracy and confidence shall apply as defined by the vehicle Mobile ITS G5 System Profile (MSP) [38] for messages generated by the ITS-S itself or messages based on information generated by the ITS-S itself.

A R-ITS-S state estimation shall include confidence values according to the definition in [RS_RSP_004](#), for position, heading and velocity, as a standardised description of the estimation accuracy.

<i>Req_ID</i>	RS_RSP_001(1)
<i>Requirement</i>	<i>[C-ITS time]</i> (time base) is the number of elapsed TAI milliseconds since 2004-01-01 00:00:00.000 UTC as defined in ETSI EN 302 636-4-1 [7]. Timestamps (as defined in ETSI TS 102 894-2 [15]) follow this time format. NOTE: "TAI milliseconds" denote the true number of milliseconds counted and not altered by leap seconds after 1.1.2004.
<i>Origin</i>	RS_BSP_193
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_002(1)
<i>Requirement</i>	Timestamps in messages generated by static roadside ITS stations shall be based on the <i>[Station clock]</i> . NOTE: This includes the C-ITS payload and the Geo Networking layer.
<i>Origin</i>	RS_BSP_432 as it is
<i>Interop issue</i>	N/A

4.1.2 Confidence validation

<i>Req_ID</i>	RS_RSP_003(1)
<i>Requirement</i>	<p>The accuracy estimations shall yield valid 95 % confidence information. This means that the true value is inside the [Confidence interval] or [Confidence area] for at least 95 % of the data points in a given statistical population.</p> <p>Note: Some GNSS chips do not provide the area, wherein 95% of the sampling values are, but CEP (50%). Then a conversion is necessary. If the values are normally distributed, the conversion factor from 50% to 95% is 2.1 – this means, the major and minor axis of 50% need to be multiplied by 2.1 to get the axis length for the area of 95%.</p>
<i>Origin</i>	RS_BSP_431 with modification
<i>Interop issue</i>	N/A

4.1.3 Position, Velocity and Heading confidence values

<i>Req_ID</i>	RS_RSP_004(1)
<i>Requirement</i>	<p>For a stationary mounted R-ITS-S the position shall be accurately measured and set permanently. This avoids GPS jitter in position accuracy and raise the confidence close to 100%.</p> <p>The confidence values shall be equal to or lower than the following values in at least 95% of 3D position data points in datasets:</p> <ul style="list-style-type: none">• horizontal (latitude, longitude) position confidence of 5 m• altitude position confidence of 20 m <p>This requirement ensures the usefulness of information sent.</p>
<i>Origin</i>	RS_BSP_205
<i>Interop issue</i>	N/A

4.1.4 Timing accuracy

<i>Req_ID</i>	RS_RSP_006(1)
<i>Requirement</i>	<p>The maximum difference of station clock time - C-ITS time should not exceed 20 ms, but shall be less than 200 ms. The ITS-S shall not transmit messages if the [Station clock] differs more than 200 ms.</p> <p>NOTE 1: A precise timestamp is needed not only for time synchronisation but is also an indicator that the system works properly.</p> <p>NOTE 2: The information for time synchronisation can be obtained from GNSS receiver or from an NTP service.</p> <p>NOTE 3: V-ITS-S will implement the maximum time difference of 20 ms.</p>
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

4.1.5 Confidence requirements dependent on ITS-S applications and use case scenarios

The position confidence depends on the ITS-S application and use case scenario. Some ITS-S applications are GNSS/trailer based others use map projections from the road operator system. Further information will be provided in future releases.

4.2 System behaviour

<i>Req_ID</i>	RS_RSP_007(1)
<i>Requirement</i>	The R-ITS-S shall be able to generate and transmit CAM (to support certificate requests) and those infrastructure messages (e.g. DENM, SPATEM, MAPEM, IVIM, SSEM) for the use cases it is intended to support.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_115(1)
<i>Requirement</i>	<p>The R-ITS-S shall be able to receive all C-ITS messages without crashing.</p> <p>Note: This is to ensure that the R-ITS-S will not crash when it receives message that are not intended to be processed by it.</p>
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_099(1)
<i>Requirement</i>	The R-ITS-S shall be able to receive, decode and process DENM, CAM as defined in the C2C-CC BSP [2].
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

5 LIST OF RELEVANT STANDARDS AND REFERENCE DOCUMENTS

This chapter lists the set of documents essential for specifying the infrastructure roadside system. Most of these documents are published (or under the publishing process) at ETSI, CEN, or ISO. The document C-ROADS C-ITS Message Profiles and Parameters [4] is essential to achieve interoperability between the various implementations of the infrastructure roadside systems as it fills gaps currently not addressed by CEN and ETSI.

5.1 Access Layer

5.1.1 General

The access layer comprises of the two lowest layers in the protocol stack; physical (PHY) and data link layers, where the latter is further subdivided into medium access control (MAC) and logical link control (LLC). All of them are specified in ETSI EN 302 663 [11]. PHY and MAC are derived from IEEE 802.11-2016 [24] with the MIB parameter **dot11OCBActivated** set to true enabling a new capability namely “communicating outside the context of a basic service set (BSS)”. ETSI EN 302 663 [11] mandates the use of IEEE 802.2 LLC with the mode of operation set to Type 1 – unacknowledged connectionless. Further, ETSI EN 302 663 [11] requires decentralised congestion control (DCC) methods to avoid unstable network behaviour and channel congestion. ETSI TS 102 792 [14] specifies requirements to ensure interoperability with CEN DSRC (European electronic toll collection at 5.8 GHz). ETSI EN 302 571 [21] specifies the frequency channels for radio equipment in the 5 855 MHz to 5 925 MHz frequency band. Further, it specifies output power for the different frequency channels and spectrum masks.

5.1.2 List of relevant documents

Table 3 Relevant documents for the access layer

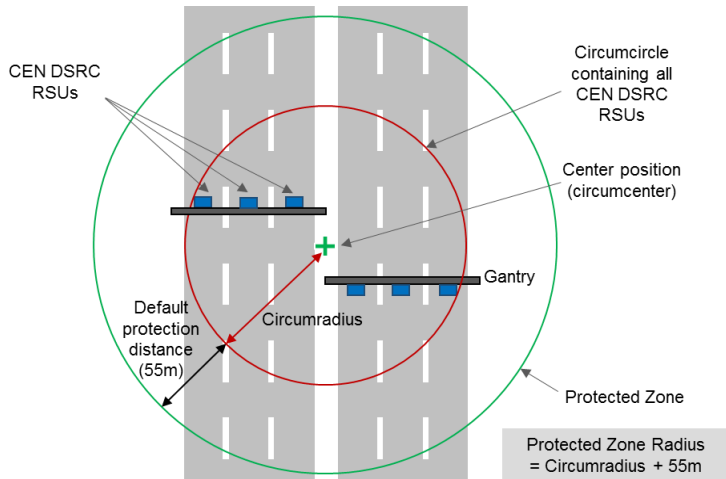
Document	Title	Short Description
ETSI EN 302 571 [21]	Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU	Specification of frequency channels for 5 855 MHz to 5 925 MHz, with corresponding spectrum mask and output power.
ETSI EN 302 663 [11]	Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band	Specifies the whole access layer with PHY, MAC, and LLC, for 5 855 MHz to 5 925 MHz. Requirements on DCC [17] and co-existence with CEN DSRC.
ETSI TS 102 792 [14]	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.	Specifies requirements to ensure coexistence between ITS stations using the frequency bands ITS-G5A/B/D and CEN DSRC using the TTT band.
ETSI TS 102 687 [17]	Decentralized Congestion Control Mechanisms for Intelligent Transport	Specifies the DCC operation responsible for maintaining network stability, throughput efficiency and

	Systems operating in the 5 GHz range; Access layer part	fair resource allocation to ITS-S using ITS-G5 access technology.
IEEE 802.11	Wireless LAN	Set of media access control and physical layer specifications for implementing wireless local area network (WLAN) communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands.

5.1.3 ETSI EN 302 571

5.1.3.1 Infrastructure Profile Settings of ETSI EN 302 571

<i>Req_ID</i>	RS_RSP_072(1)
<i>Requirement</i>	The roadside ITS-S access layer shall be compliant with the ETSI EN 302 571 [21].
<i>Origin</i>	RS_BSP_433
<i>Interop issue</i>	N/A

Req_ID	RS_RSP_100(1)
Requirement	<p>A Protected Zone shall be defined as follows: If a tolling location only consists of a single CEN-DSRC RSU, then a Protection Zone with the default radius of 55m shall be defined, having the location of the CEN-DSRC RSU as centre position. In case there are multiple CEN-DSRC RSUs nearby, overlaps of Protected Zones should be avoided as much as possible through combined Protected Zones. A combined Protected Zone shall use the geographical centre (circumcentre) of all contained DSRC RSUs as a centre position; the radius shall be given by the circumradius + 55 m (See Figure 2). In any case, the maximum radius of 255 m shall not be exceeded.</p> <p>NOTE: Due to the maximum radius of 255 m, overlaps can not always be avoided.</p>  <p>Figure 4 combined protected zone</p>
Origin	RS_BSP_433
Interop issue	N/A

Control Channel

Req_ID	RS_RSP_011(1)
Requirement	ITS-G5 radio equipment of the R-ITS-S shall use the ITS-G5 control channel (G5-CCH) [21] to transmit C-ITS messages (DENM, IVIM if the automated vehicle container is not used, SPATEM, MAPEM, CAM, SSEM) to other ITS-G5 ITS-Ss
Origin	RS_BSP_225
Interop issue	N/A

Service Channels

<i>Req_ID</i>	RS_RSP_112(1)
<i>Requirement</i>	ITS-G5 radio equipment of the R-ITS-S shall use the ITS-G5 service channel 2 (G5-SCH2) to transmit the IVIM containing the automated vehicle container to other ITS-G5 ITS-Ss. NOTE: This is relevant for the automated vehicle guidance use cases.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_113(1)
<i>Requirement</i>	TS-G5 radio equipment of the R-ITS-S shall use the ITS-G5 service channel 1 (G5-SCH1) to transmit the Collective Perception Message (CPM) [35] to other ITS-G5 ITS-Ss.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

Service Announcement

<i>Req_ID</i>	RS_RSP_116(1)
<i>Requirement</i>	If any ITS-G5 service channel is used, the radio equipment should announce the availability of the service/s on the service channel (e. g. CPS and/or IVIM AVG services) using the service announcement service according to ETSI EN 302 890-1 [36].
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

Security Channel

No additional requirements.

RF Output Power

<i>Req_ID</i>	RS_RSP_012(1)
<i>Requirement</i>	The nominal RF output power shall be within the range of 17 dBm (e.i.r.p) to 33 dBm (e.i.r.p). The target nominal RF output power is 23 dBm (e.i.r.p). RF output power of the roadside equipment (e.g. R-ITS-S) depends on the relevance area for the specific message sent and shall be adjustable such that the communication performance specified to comply to the minimum communication performance as achieved but shall not exceed the maximum set in the ETSI EN 302 571 [21].
<i>Origin</i>	RS_BSP_226
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_017(1)
<i>Requirement</i>	The power spectral density shall not exceed 23 dBm/MHz.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

5.1.4 ETSI EN 302 663

5.1.4.1 Infrastructure Profile Settings of ETSI EN 302 663

<i>Req_ID</i>	RS_RSP_018(1)
<i>Requirement</i>	The roadside system shall use a transfer rate of 6Mbit/s (QPSK 1/2) for the transfer of messages in requirement RS_RSP_011 on CCH. The transfer rate of 6 Mbit/s is recommended as default for the service channels. For CPM a higher transfer rate of 12 Mbit/s may be used.
<i>Origin</i>	RS_BSP_228
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_073(1)
<i>Requirement</i>	Roadside equipment's (e.g. R-ITS-S's) access layer shall be compliant with ETSI EN 302 663 [11].
<i>Origin</i>	RS_BSP_434
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_074(1)
<i>Requirement</i>	Roadside equipment (e. g. R-ITS-S) shall implement the DCC State Machine in such a way that the parameters in Table 4 can be modified in later releases. Table 4 lists the parameters that may be subject to change (i.e., through optimization) in future revisions of the DCC Mechanism.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

Table 4 DCC parameter settings for Day One

Parameter	Description	Default
PTx	Transmission power	There is no default value set in this document. For each system the default TX power will depend on what is needed to fulfill the minimum

		communication range requirement
PToll	Transmission power across all states and DPs when in <i>toll communication mode</i> (see NOTE 3 in [25])	$PToll = 10 \text{ dBm}$
Tup	Time of sustained channel load that triggers transition to a more restrictive state	$Tup = 5 \text{ s}$ $Tup = \text{NDL_timeUp}$ in ETSI TS 102 687 [17]
Tdown	Time of sustained channel load that triggers transition to a less restrictive state	$Tdown = 1 \text{ s}$ $Tdown = \text{NDL_timeDown}$ in ETSI TS 102 687 [17]
TTX_MAX	Maximum transmission interval for all states	$TTX_MAX = 460 \text{ ms}$
TTX_MIN	Minimum transmission interval for DP1-DP3 NOTE: minimum transmission interval for DP0 is 50 ms	$TTX_MIN = 60 \text{ ms}$
RBurst	Maximum message rate of message bursts (additionally to rate of Dp1-DP3)	$RBurst = 20 \text{ messages per second}$
TBurst	Time period over which message burst is measured TBurst seconds is allowed very TWaitBurst seconds.	$TBurst = 1 \text{ second}$
TBurstPeriod	Time period in which one burst is allowed.	$TBurstPeriod = 10 \text{ seconds}$
Rmax_relaxed	Maximum message rate in relaxed state	$Rmax_relaxed = 36,7 \text{ messages/second}$
Rmax_active,k	Maximum message rate in active sub-states	The inverse of the transmission interval for each CI value. $k=1..n$
Rmax_restrictive	Maximum message rate in restrictive sub-states	See ETSI TS 102 687 [17].
CLmax	Transition threshold between active and restrictive states	$CLmax = 59\%$
CLmin	Transition threshold between relaxed and active states	$CLmin = 19\%$

CLactive_k k=1...n	Transition threshold between active states	CLactive_k , k= 1...n
tj , j=1..m	relaxed (sub-)states transmission interval values as per Table 8	m = 1, see ETSI TS 102 687 [17]
tk , k=1..n	active (sub-)states transmission interval values as per Table 8	n = 5, see ETSI TS 102 687 [17]
tl , l=1..q	restrictive (sub-)states transmission interval values as per Table 8	q = 1, see ETSI TS 102 687 [17]
n	Number of active sub- states	n=5
q	Number of restrictive (sub-)states	n=1
m	Number of relaxed (sub-)states	m=1
MCS	Modulation and Coding Scheme	6 Mbps QPSK ½ as per ETSI EN 302 571 [21] for all states and DP values in Table 8
α, β, γ	Channel Load smoothing parameters	Default values are $\alpha=\beta=0.5$, $\gamma=0$ see section 1.3 of [25].
Sth, Np, Tm , Tp	Channel Load estimation parameters	Default values are Tm= 100 ms, Tp = 8 μ s, Np= 12 500, and Sth = -85 dBm see section 1.3 of [25].

<i>Req_ID</i>	RS_RSP_076(1)
<i>Requirement</i>	<p>Roadside equipment (e.g. R-ITS-S) should manage its limited hardware and software resources at its disposal. The Roadside equipment may implement a filtering of received messages that also affects GeoBroadcast forwarding in situations of high message loads.</p> <p>NOTE: Traffic shaping is especially relevant for relayed DENM messages sent on DP3, as it is anticipated that in some situations – such as severe traffic congestion or other extreme vehicular network scenarios – the DENM load might increase abruptly. In such cases, Roadside equipment (e.g. R-ITS-S) are explicitly allowed to forgo the forwarding of foreign DENM messages.</p>
<i>Origin</i>	RS_BSP_241
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_078(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall , at a minimum, be able to generate and transmit the number of messages as determined by the value of the highest CAM generation rate (i.e. 10 Hz) and, if detection algorithms are used, then increased by the minimum required DENM generation rate derived from those triggering conditions.
<i>Origin</i>	RS_BSP_243
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_021(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall support the broadcast mode as defined in ETSI EN 302 663 [11].
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

5.1.5 ETSI TS 102 792

5.1.5.1 Infrastructure Profile Settings of ETSI TS 102 792

<i>Req_ID</i>	RS_RSP_022(1)
<i>Requirement</i>	In case the R-ITS-S is located in close distance (at least inside the protection radius) of CEN DSRC based tolling equipment, this R-ITS-S shall apply mitigation techniques as defined in ETSI TS 102 792 [14].
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_024(1)
<i>Requirement</i>	<p>In case the R-ITS-S is used to indicate the presence of one or several tolling station, this R-ITS-S shall transmit CAMs including protected zones in line with the technique defined in ETSI TS 102 792 [14] and in line with the CA message format as specified in the ETSI EN 302 637-2 [9]. CAM Termination shall not be used.</p> <p>NOTE 1: The data elements specific for the Coexistence <i>[ITS-S Application]</i> are located in the highFrequencyContainer and the data frame rsuContainerHighFrequency.</p> <p>NOTE 2: A CAM may as well contain other data elements not related to Coexistence.</p> <p>NOTE 3: In case the R-ITS-S is used to indicate the presence of a tolling station, roadside equipment (e.g. R-ITS-S) shall transmit CAM including protected zone information in such a way, that vehicles can receive it before entering the protected zone.</p>
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

5.1.6 ETSI TS 102 687

5.1.6.1 Infrastructure Profile Settings

<i>Req_ID</i>	RS_RSP_027(1)
<i>Requirement</i>	DCC techniques shall be applied according with ETSI TS 102 687 [17].
<i>Origin</i>	RS_BSP_436
<i>Interop issue</i>	N/A

5.2 Network and Transport Layer

5.2.1 General

The relevant standards are listed in Table 5 below. The specification of the Geo Networking protocol is split into two parts, media-independent and media-dependent. Purpose of the split was to allow for more than one access technology other than ITS-G5. However, so far, a specification for another access technology-specific extension other than ITS-G5 does not exist. Roadside equipment (e.g. R-ITS-S) does not include the features specified in the media dependent standard. Transport layer requirements are considered in this section.

5.2.2 List of relevant documents

Table 5 Relevant documents for the network and transport layer

Document	Title	Short Description
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ETSI EN 302 636-4-1 [7]	Vehicular Communication; Geonetworking; Part 4 Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality	Defines common media-independent functionality of Geo Networking
ETSI EN 302 636-5-1 [8]	Vehicular Communication; Geonetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocols	Defines the Basic Transport Protocol (what data is to be provided by higher layer to networking layer)
ETSI EN 302 931 [6]	Vehicular Communications; Geographical Area Definition	Defines geographical areas so that different shapes can be used as destinations for the messages from higher layers.

5.2.3 ETSI EN 302 636-4-1 Geo Networking media-independent

5.2.3.1 Infrastructure Profile Settings of ETSI EN 302 636-4-1

<i>Req_ID</i>	RS_RSP_030(1)
<i>Requirement</i>	GeoNetworking (GN) shall be applied as networking protocol according to ETSI EN 302 636-4-1 [7] by roadside equipment (e.g. R-ITS-S).
<i>Origin</i>	RS_BSP_437
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_031(1)
<i>Requirement</i>	The R-ITS-S radio equipment parameter values and default constants that are not set in the current document shall be set as specified in the Annex H of ETSI EN 302 636-4-1 [7].
<i>Origin</i>	RS_BSP_250
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_114(1)
<i>Requirement</i>	R-ITS-Ss within the GeoNet destination area (as defined by GeoAreaPos and Distance in the GBC packet header) shall send out the message. R-ITS-Ss outside the destination area with a maximum distance of 6km towards the extremities of the trace / detectionZone may send out the message.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_083(1)
<i>Requirement</i>	Packet repetition shall not be performed by GN and the corresponding steps in the packet handling procedures in ETSI EN 302 636-4-1 [7] (clause 10.3) shall not be executed. The parameter 'Maximum repetition time' of the service primitive GN-DATA.request is not applicable. Also, the GN protocol constant itsGnMinPacketRepetitionInterval is not applicable.
<i>Origin</i>	RS_BSP_416
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_033(1)
<i>Requirement</i>	“Anonymous address” may be chosen for GN address configuration (itsGnLocalAddrConfMethod set to ANONYMOUS (2)) by roadside equipment (e.g. R-ITS-S).
<i>Origin</i>	RS_BSP_252 with modifications
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_117(1)
<i>Requirement</i>	Roadside equipment shall use the following GeoNetworking packet header types as defined in ETSI EN 302 636-4-1 [7]: <ul style="list-style-type: none"> - SHB on all CAM it generates. - GBC on all DENM, IVIM, SPATEM, MAPEM, SREM, SSEM it generates.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_035(1)
<i>Requirement</i>	GN shall be used with itsGnIfType set to ITS-G5 (1) by roadside equipment (e.g. R-ITS-S).
<i>Origin</i>	RS_BSP_414
<i>Interop issue</i>	N/A

Basic Header Fields

<i>Req_ID</i>	RS_RSP_038(1)
<i>Requirement</i>	The LifeTime (LT) field of all SHB packets shall be set to 1 second.
<i>Origin</i>	RS_BSP_258
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_039(1)
<i>Requirement</i>	The LifeTime (LT) field of all GBC packets shall be set to the minimum of ValidityDuration and RepetitionInterval in case of DENM Dissemination. The value of the LifeTime field shall not exceed the itsGnMaxPacketLifetime parameter, specified in Annex G of ETSI EN 302 636-4-1 [7].
<i>Origin</i>	RS_BSP_259
<i>Interop issue</i>	N/A

Common Header Fields

<i>Req_ID</i>	RS_RSP_040(1)
<i>Requirement</i>	SCF is not recommended. The vehicle C-ITS station shall set the store-carry-forward (SCF) bit of the TC field of GBC packets to pGnGbcScf. NOTE: The SCF mechanism of ETSI EN 302 636-4-1 [7] is considered to have some undesirable side effects. An activation of the feature might be evaluated if the standard ETSI EN 302 636-4-1 [7] is revised accordingly.
<i>Origin</i>	RS_BSP_260 as it is
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_042(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) is not required to offload packets to another channel. Consequently, the channel offload bit of the TC (Traffic Class) field should be set to 0 for all message types.
<i>Origin</i>	RS_BSP_262
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_044(1)
<i>Requirement</i>	Stationary roadside equipment (e.g. R-ITS-S) shall set the itsGnIsMobile bit of the Flags field to 0.
<i>Origin</i>	RS_BSP_264
<i>Interop issue</i>	N/A

Multi-Hop support

<i>Req_ID</i>	RS_RSP_046(1)
<i>Requirement</i>	The multi-hop operation mode shall be supported by the R-ITS-S by implementing the forwarding algorithm specified in the Annexes D, E.3 and F.3 of ETSI EN 302 636-4-1 [7]. NOTE: Multi-hop support is for R-ITS-S for incoming GN packets, with multi-hop request. Currently, the multi hop support by R-ITS-S is under discussion. It has to be tested if it is viable at low penetrations. The “network” of R-ITS-S is first and foremost built for I2V services, not as multi-hop network.
<i>Origin</i>	RS_BSP_266
<i>Interop issue</i>	N/A

Duplicate Packet Detection

<i>Req_ID</i>	RS_RSP_048(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall use duplicate packet detection on the networking and transport layer. For the detection of duplicated packets, the algorithm specified in Annex A.2 of the ETSI EN 302 636-4-1 [7] shall be used.
<i>Origin</i>	RS_BSP_268
<i>Interop issue</i>	N/A

Beaconing Support

<i>Req_ID</i>	RS_RSP_049(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) may only send beacons with the Position Accuracy Indicator (PAI) set to 1.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

Ethertype

<i>Req_ID</i>	RS_RSP_050(1)
<i>Requirement</i>	GeoNetworking Frames sent by roadside equipment (e.g. R-ITS-S) shall use the EtherType value 0x8947 as listed by the IEEE Registration Authority at http://standards.ieee.org/develop/regauth/ethertype/eth.txt .
<i>Origin</i>	RS_BSP_270
<i>Interop issue</i>	N/A

5.2.4 ETSI EN 302 636-5-1 Basic Transport Protocol

5.2.4.1 Infrastructure Profile Settings of ETSI EN 302 636-5-1

<i>Req_ID</i>	RS_RSP_051(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall implement the Basic Transport Protocol ETSI EN 302 636-5-1 [8] and the following definitions in this section.
<i>Origin</i>	RS_BSP_438
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_052(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall employ BTP-B headers. Consequently, the GeoNetworking common header shall use a value of 2 for the NH field.
<i>Origin</i>	RS_BSP_273
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_053(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall set the destination port info field to the value 0.
<i>Origin</i>	RS_BSP_274
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_054(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall set the destination port depending on the message set as specified in the ETSI TS 103 248 [22].
<i>Origin</i>	RS_BSP_275 & RS_BSP_276
<i>Interop issue</i>	N/A

5.2.5 ETSI EN 302 931 Geographical area definition

5.2.5.1 Infrastructure Profile Settings of ETSI EN 302 931

<i>Req_ID</i>	RS_RSP_056(1)
<i>Requirement</i>	The roadside system shall at least support circular, rectangular and ellipsoidal geographical areas as defined in the ETSI EN 302 931 [6]. Each <i>[ITS-S Application]</i> shall specify one of the above geographical area types and indicated through the GeoNetworking header as specified in ETSI EN 302 636-4-1 [7].
<i>Origin</i>	RS_BSP_279
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_057(1)
<i>Requirement</i>	<p>When roadside equipment (e.g. R-ITS-S) calculates the distance between two positions using GNSS coordinates (e.g. for PathDeltaPoints or in case of circular relevance area), it is recommended that the great-circle or orthodromic distance method is used. Thereby, care shall be taken to avoid large rounding errors on low-precision floating point systems; these can be avoided, e.g., with the haversine formula.</p> <p>In case the relevance area is an ellipse or a rectangle, then the cartesian coordinates of the area centre and of the current position need to be calculated for assessing whether to hop the packet as specified in ETSI EN 302 636-4-1 [7]; for this purpose, it is recommended to use the Local Tangent Plane method, or another method delivering the same accuracy.</p>
<i>Origin</i>	RS_BSP_280
<i>Interop issue</i>	N/A

5.3 Facility Layer

5.3.1 List of relevant documents

The relevant standards for the facility layer are listed in Table 6 below.

Table 6 Relevant documents for the facility layer

Document	Title	Short Description
ETSI EN 302 637-3 [10]	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3 Specifications of Decentralized Environmental Notification Basic Service	Defines event/triggered DEN message as second core message for many ITS-S applications
ETSI TS 102 894-2 [15]	Intelligent Transport Systems (ITS); Users and applications requirements; Applications and facilities layer common data dictionary	Definition and specifications on the common data container at the applications and facility layer. The common data container includes the definition, syntax and semantic specifications of all the data elements/data frames used in the applications and facilities layer messages
ETSI TS 103 301 [16]	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services	It provides specifications of infrastructure related ITS services to support communication between infrastructure ITS equipment and traffic participants using ITS equipment (e.g. vehicles, pedestrians).
C-ROADS C-ITS Message Profiles and Parameters [4]	C-ITS Message Profiles and Parameters	Functional and operational specifications of infrastructure day-1 ITS-S applications
VSC-A [1]	Vehicle Safety Communications – Applications; VSC-A; Final Report: Appendix B-2; Path History Reference Design and Test Results	Path History methods, constant and variables
ISO 8855 [28]	Road vehicles – Vehicle dynamics and road-holding ability - Vocabulary	Reference Coordinates System
EN 302 637-2 [9]	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service	Defines CAM as core message for many ITS-S applications, plus sending rules

5.3.2 ETSI EN 302 637-3 Decentralized Environmental Notification Basic Service

5.3.2.1 Infrastructure Profile Settings of ETSI EN 302 637-3

<i>Req_ID</i>	RS_RSP_085(1)
<i>Requirement</i>	Roadside equipment's (e.g. R-ITS-S's) DEN basic FLS shall be compliant to ETSI EN 302 637-3 [10].
<i>Origin</i>	RS_BSP_440
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_058(1)
<i>Requirement</i>	Roadside equipment (e.g. R-ITS-S) shall implement the DENM repetition as specified in the DEN basic FLS specification ETSI EN 302 637-3 [10].
<i>Origin</i>	RS_BSP_301
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_069(1)
<i>Requirement</i>	The following service parameters shall be used.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

Service Parameters associated with DEN Basic FLS

Service Parameters			
Name	Type	Layer	Value
repetitionDuration	P	F	Equal to the value of data element ValidityDuration unless specified differently in the use case specification
repetitionInterval	P	F	See ITS-S application specific part in the following subsections.
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.

Service parameters associated with RWW with national choices

Service Parameters			
Name	Type	Layer	Value
repetitionInterval	P	A or F	200 ms – 1000 ms
repetitionDuration	P	A or F	Equal to validityDuration
Life Time	HF	GN	Shall not exceed validityDuration
Flags	HF	GN	Mobile (1) Stationary (0)

Service parameters associated with HLN with national choices

Service Parameters			
Name	Type	Layer	Value
repetitionInterval	P	A or F	200 ms – 1000 ms
repetitionDuration	P	A or F	Equal to validityDuration
Life Time	HF	GN	
Flags	HF	GN	Stationary (0)

Req_ID	RS_RSP_060(1)
Requirement	In the case roadside equipment (e.g. R-ITS-S) sends a DENM, the Traces shall be described as a list of geographical locations leading from the event position back to the first path point.
Origin	RS_BSP_304
Interop issue	N/A

Req_ID	RS_RSP_062(1)
Requirement	Additional PathHistory elements may be present in the DENM traces. However, unlike the first element, these shall describe alternative routes to the event location. These routes may or may not be available at the time of detecting the event. PathPoints shall be position-ordered and shall not include the PathDeltaTime.
Origin	RS_BSP_308
Interop issue	N/A

Req_ID	RS_RSP_063(1)
Requirement	For roadside equipment (e. g. R-ITS-S) the traffic class value for message sets shall be set as defined in Table 7.
Origin	N/A
Interop issue	N/A

Table 7 Mapping of ITS-S applications to Traffic Class values

ITS-S applications	Message Sets	Traffic Class Values
HLN + RWW	DENM	1
IVI-Traffic Signs (IVI-TS)	IVIM	1
IVI Free Text (IVI-FT)	IVIM	3
IVI automated vehicle guidance (IVI-AVG)	IVIM	3

All applications	SPATEM / MAPEM	3
All applications	SREM/SSEM	2

5.3.3 ETSI TS 103 301 Facility layer protocols and communication requirements for infrastructure services

5.3.3.1 Infrastructure Profile Settings of ETSI TS 103 301

<i>Req_ID</i>	RS_RSP_101(1)
<i>Requirement</i>	For the transmission of messages by roadside systems the facilities layer protocol and communication profile setting CPS_001 shall be used as specified by ETSI TS 103 301 [16] with the exception of traffic class (TC), which are defined in RS_RSP_063 .
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

5.3.4 ETSI EN 302 637-2 [9]

5.3.4.1 Infrastructure Profile Settings of ETSI EN 302 637-2 [9]

<i>Req_ID</i>	RS_RSP_104(1)
<i>Requirement</i>	The Protected Zone data provided in a CAM sent by an R-ITS-S shall not conflict with the Protected Zone information provided in the respective database. If the same zone is defined in the European Protected Zone database, the same ID shall be used as protectedZoneID. Otherwise, an ID greater than 67108863, which is not used in the database, shall be used.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_106(1)
<i>Requirement</i>	The antenna of a Roadside ITS Station (R-ITS-S) intended to disseminate Protected Zone data shall be placed such that Protection Zone CAM's can be received in time before entering the Protected Zone. NOTE: The realisation of this requirement must consider the processing time the road user equipment requires to process the information received. According to the ETSI TS 101 539-1 [29] a time of 300 ms should be used as reference.
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_107(1)
<i>Requirement</i>	<p>Roadside ITS Stations (R-ITS-S) intended to disseminate Protected Zone data shall transmit CAMs containing Protected Zone data with a transmit rate that ensures that mobile ITS stations are able to identify the presence of Protected Zones in time.</p> <p>EXAMPLE: Assuming a packet reception rate of 80% within 300m radius around an R-ITS-S, and a vehicle speed of 130 km/h, a CAM transmit rate of 1 Hz results in 13 expected CAM receptions by the vehicle ITS station.</p>
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_108(1)
<i>Requirement</i>	A Roadside ITS Station (R-ITS-S) intended to disseminate Protected Zone data shall be installed outside Protected Zones or configured in accordance to ETSI TS 102 792 [14].
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_067(1)
<i>Requirement</i>	If the Coexistence (ITS-G5 – CEN-DSRC) FLS is used, it shall be applied according to ETSI EN 302 637-2 [9] and as specified in ETSI TS 102 792 [14].
<i>Origin</i>	RS_BSP_439
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_091(1)
<i>Requirement</i>	<p>The CA basic FLS shall be active as long as the roadside equipment (e.g. R-ITS-S) is in the safety-related context. As long as the CA basic FLS is active, CAMs shall be generated according to the generation rules defined in ETSI EN 302 637-2 [9].</p> <p>NOTE: By default, a roadside equipment shall be considered to be within the safety-related context, as long as the roadside equipment is participating in public traffic under normal driving conditions.</p>
<i>Origin</i>	RS_BSP_214
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_092(1)
<i>Requirement</i>	A roadside equipment (e.g. R-ITS-S) shall transmit CAMs as long as position and time information are available and within the specified limits in RS_RSP_004 .
<i>Origin</i>	RS_BSP_291
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_094(1)
<i>Requirement</i>	The parameter T_GenCam_Dcc (see ETSI EN 302 637-2 [9]) shall be set to the value of the transmission interval, TTX, as given by the DCC Mechanism (see Table 4).
<i>Origin</i>	RS_BSP_293
<i>Interop issue</i>	N/A

<i>Req_ID</i>	RS_RSP_098(1)
<i>Requirement</i>	The adjustable N_GenCam parameter (see ETSI EN 302 637-2 [9]) specified in the CAM Generation Frequency Management shall be set to 0 for the roadside equipment (e.g. R-ITS-S), unless it is intended to disseminate Protected Zone data as defined in RS_RSP_105 .
<i>Origin</i>	RS_BSP_297
<i>Interop issue</i>	N/A

5.4 Management

5.4.1 List of relevant documents

Table 8 Relevant management standards

Document	Title	Short Description
ETSI TS 103 175 [3]	Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium	Specify the functionality of the decentralized congestion control (DCC) entity residing in the management plane for the ITS-G5A, ITS-G5B, and ITS-G5D radio interfaces, collectively known as the 5 GHz ITS frequency band

5.4.2 ETSI TS 103 175

5.4.2.1 C-Roads Profile Settings of ETSI TS 103 175

<i>Req_ID</i>	RS_RSP_070(1)
<i>Requirement</i>	A roadside system implementing ITS-G5 functionalities shall implement a management layer including a DCC_CROSS entity as specified in ETSI TS 103 175 [3].
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

5.5 Security

Not all specified security services are required to be implemented. Additionally, for some services, the implementation is defined internally by the operator.

<i>Req_ID</i>	RS_RSP_111(1)
<i>Requirement</i>	A roadside system shall be compliant to ETSI TS 102 965 [30], ETSI TS 102 940 [31], ETSI TS 102 941 [32] and ETSI TS 103 097 [33].
<i>Origin</i>	N/A
<i>Interop issue</i>	N/A

6 References

All normative references within a standard referenced here are automatically included and will not be listed separately.

Only if a normative reference is out of date because a newer version of the reference standard is supported, the newer reference is listed and marked accordingly.

Table 9 Table of normative key references

#	Reference
[16]	ETSI TS 103 301 V2.1.1 (2021-03) - Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services
[17] ¹	ETSI TS 102 687 V1.2.1 (2018-04) - Intelligent Transport Systems (ITS); Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part
[21] ²	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
[30]	ETSI TS 102 965 v1.5.1 (2020-01) - Intelligent Transport Systems (ITS); Application Object Identifier (ITS-AID); Registration
[31]	ETSI TS 102 940 v2.1.1 (2021-07) - Intelligent Transport Systems (ITS); Security; ITS communications security architecture and security management
[32]	ETSI TS 102 941 v2.1.1 (2021-10) - Intelligent Transport Systems (ITS); Security; Trust and Privacy Management
[33]	ETSI TS 103 097 v2.1.1 (2021-10) - Intelligent Transport Systems (ITS); Security; Security header and certificate formats
[2]	C2C-CC Basic System Standards Profile Version 1.6.1
[7]	ETSI EN 302 636-4-1 V1.4.1 (2020-01) Intelligent Transport Systems (ITS); Vehicular Communication; Geonetworking; Part 4 Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality
[8]	ETSI EN 302 636-5-1 V2.2.1 (2019-05) Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol
[11]	ETSI EN 302 663 V1.3.1 (2020-01) Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band

¹ Old reference in ETSI EN 302 663 [11]

² Old reference in ETSI EN 302 663 [11]

Table 10 Table of additional normative references

#	Reference
[1]	VSC-A Final Report, [Online]. Available: http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2011/811492B.pdf .
[3]	ETSI TS 103 175 V1.1.1 (2015-06) - Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium
[4]	C-ROADS (2022-05) C-ITS Message Profiles_2.0.4
[5]	Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC Text with EEA relevance
[6]	ETSI EN 302 931 V1.1.1 (2011-07) Vehicular Communications; Geographical Area Definition.
[9]	ETSI EN 302 637-2 V1.4.1 (2019-04) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service
[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]	ETSI EN 302 665 V1.1.1 (2010-09) Intelligent Transport Systems (ITS); Communications Architecture
[14]	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 rang.
[15]	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
[18]	ISO/TS 19321:2020 (2020-09) - Intelligent transport systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structures
[20]	C2C-CC White Paper on Positioning and Timing
[22]	ETSI TS 103 248 V1.3.1 (2019-04) - Intelligent Transport Systems (ITS); GeoNetworking; Port Numbers for the Basic Transport Protocol (BTP)
[24]	IEEE Std. 802.11-2016. IEEE Standard for Information technology — Telecommunications and information exchange between systems, local and metropolitan area networks — Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
[25]	C2C-CC White Paper Decentralized Congestion Control (DCC) for Day One

[26]	ETSI TS 102 636-4-2 V1.1.1 (2013-10) Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 2: Media-dependent functionalities for ITS-G5
[27]	ISO/TS 19091:2019 Intelligent transport systems -- Cooperative ITS -- Using V2I and I2V communications for applications related to signalized intersections
[28]	ISO 8855:2011 Road vehicles -- Vehicle dynamics and road-holding ability -- Vocabulary
[29]	ETSI TS 101 539-1 V1.1.1 (2013-08) - Intelligent Transport Systems (ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification
[34]	ETSI TR 102 638 V1.1.1 (2009-06) - Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions
[35]	ETSI TR 103 562 V2.1.1 (2019-12) - Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Analysis of the Collective Perception Service (CPS); Release 2
[36]	ETSI EN 302 890-1 V1.2.1 (2019-07) - Intelligent Transport Systems (ITS); Facilities layer function; Part 1: Services Announcement (SA) specification
[37]	C_ROADS_WG2_TF2_Service Descriptions v2.0.4 (2022-06)
[38]	C-ROADS, Mobile ITS G5 System Profile v2.0.3 (2022-03)