5GAA TS S-180175

Technical Specification

5G Automotive Association;
Task Force: Profiles for Cellular Uu-based C-ITS;

C-ITS Communication System Profile Using Cellular Uu Interface

5GAA

5GAA address

5GAA c/o MCI Munich
Neumarkter Str. 21
81673 München – Germany

Internet

http://www.5gaa.org

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Foreword

This Technical Report has been produced by 5GAA.

Introduction

In light of on-going efforts towards a legal framework for the European C-ITS deployment, a minimum set of specifications and configurations is needed for existing ITS standards ensuring the interoperability of C-ITS service among ITS stations using different communication technologies and systems, e.g. short-range and long-range radio communications.

This document specifies the communication system profile for C-ITS implementation using the long-range cellular Uu interface, or Uu Communication System Profile (Uu-CSP). The Uu-CSP ensures the interoperability of C-ITS services among vehicle-, roadside-, personal-, and central-ITS stations, which are defined in the European ITS-Station architecture standard ETSI EN 302 665 [5], when long-range cellular Uu communication is used. The Uu-CSP defines the minimum specification, selected options, and configurations of the existing standards at ITS Application and Facility layers, as well as the existing ITS standards related to security, according to the ETSI ITS station reference architecture [5], as shown in Figure 1. The ITS Network and Transport layer protocols, namely GeoNetworking and BTP, are essential for the Uu-CSP to comply with the C-ITS security and certificate policies based on existing ETSI ITS standards. Considering C-ITS services will be supported using different communication technologies – e.g. short-range and long-range communications and interoperability of C-ITS services can only be achieved by harmonising the upper layer profile and security configurations – this Uu-CSP does not cover the configuration of standards at the lower layers, e.g. the ITS access layer.

The Uu-CSP is aligned to the maximum extent with the roadside system profile developed by the C-ROADS platform for the short-range communication technology [4], to enable interoperability of C-ITS services at ITS Application and Facility layers when using both short- and long-range communication technologies. This document may be subject to changes according to future evolutions of the referenced C-ROADS document [4].

When long-rang communication is used, implementation of C-ITS services, according to this Uu-CSP profile, can be supported by an IP-based communication protocol stack, e.g. UDP/IP, TCP/IP, MQTT/TCP/IP, etc. Using IP-based protocol stacks ensures maximum ‘interworking’ and continuity of C-ITS services, as well as the best support by the existing cellular networks and the evolving cellular technologies. Various IP-based protocol stacks supporting Uu-CSP exist and can interwork with each other, e.g. through respective gateway solutions. The specifications of IP-based protocol stacks supporting this Uu-CSP and related interworking solutions are out of the scope of this Technical Report and will be addressed by other 5GAA documents.[1]

Private data protection in cellular Uu-based C-ITS is also explained in the annex of this document.

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[1] The Uu-CSP is developed for the consideration of the legal framework of European C-ITS deployment. We think the profile referenced in the legal framework of C-ITS deployment shall be limited to the minimum and only cover the essential standards, e.g. at the ITS Facility layer and ITS Security related ones, to enable interoperable and secure C-ITS service deployment using different short- and long-range communication technologies. We do not think the legal framework should include any full system profile (PHY up to APP) of specific technology, as this does not help the interoperability of C-ITS services, which should benefit from technology evolution and from hybrid implementations using different short- and long-range communication technologies.

<table>
<tr><th>Layer</th><th colspan="2">Component</th><th>Tasks</th><th>Com-ponent</th></tr>
<tr><td>ITS Applications</td><td colspan="2">Operational Specifications</td><td>Service definitions and transmission principles and triggering conditions</td><td rowspan="7">ITS Manage ment and Security</td></tr>
<tr><td rowspan="3">ITS Facilities</td><td colspan="2">Positioning & Time (incl. minimum data quality requirements)</td><td>Relevance Checking</td></tr>
<tr><td rowspan="2">Data and Message Content</td><td>DENM</td><td>Vehicle & infrastructure data provider (incl. minimum data quality requirements)</td></tr>
<tr><td>IVIM, SPATEM MAPEM, etc.</td><td>Infrastructure data provider (incl. minimum data quality requirements)</td></tr>
<tr><td rowspan="2">ITS Transport & Network</td><td>ITS Transport</td><td>Basic transport protocol (BTP)</td><td>End-to-end, connection less transport service on top of GeoNetworking</td></tr>
<tr><td>ITS Network</td><td>GeoNetworking (Geo-based addressing and routing)</td><td>Secured ITS packets</td></tr>
</table>

Figure 1 Overview of components in Uu-CSP

1 Scope

This document defines the communication system profile that identifies a minimum set of specifications and standards to ensure interoperability of C-ITS services among ITS stations using long-range communication technologies, including the cellular Uu interface, and short-range communication technologies. Similar to [3], the supported C-ITS services are intended for 'Day-1' deployment on the European market with focus on communication between vehicles and the infrastructure.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1]. C-ROADS Platform, Working Group 2 Technical Aspects, Taskforce 2 Service Harmonisation, Common C-ITS Service Definitions, Version 1.2, June 12, 2018

[2]. European Commission, COM (2016) 766, A European Strategy on Cooperative Intelligent Transport Systems, a Milestone Towards Cooperative, Connected and Automated Mobility, Dec. 2016

[3]. C-ROADS Platform, Working Group 2 Technical Aspects, Taskforce 3 Infrastructure Communication, C-ITS Infrastructure Functions and Specifications, June 12, 2018

[4]. C-ROADS Platform, Working Group 2 Technical Aspects, Taskforce 3 Infrastructure Communication, Roadside ITS G5 System Profile, June 12, 2018.

[5]. ETSI EN 302 665 V1.1.1 (2010-09) Intelligent Transport System, Communication Architecture

[6]. ETSI, ETSI Drafting Rules, Version adopted by the Director-General (1 June 2015)

[7]. Directive 2010/40/EU on the Framework for the Deployment of Intelligent Transport Systems in the Field of Road Transport and for Interfaces with Other Modes of Transport

[8]. 5G Automotive Association; Task Force: Profiles for Cellular Uu-based C-ITS; 5GAA Technical Report; Suggested Changes on C-ROADS Common C-ITS Service Definitions Version 1.2

[9]. 5G Automotive Association; Task Force: Profiles for Cellular Uu-based C-ITS; 5GAA Delta Specifications of ITS Message Content and Trigger Condition

[10]. ETSI TS 102 894-2, Intelligent Transport Systems (ITS); Users and Applications Requirements; Part 2: Applications and Facilities Layer Common Data Dictionary, V1.3.1, 2018-06

[11]. ETSI EN 302 637-3 V1.3.1 (2018-06) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralised Environmental Notification Basic Service

[12]. ETSI TS 103 301 V1.1.1 (2018-06) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities Layer Protocols and Communication Requirements for Infrastructure Services

[13]. ISO/TS 19321:2015 (2015-04-15); Intelligent Transport Systems, Cooperative ITS – Dictionary of In-vehicle Information (IVI) Data Structures

[14]. ETSI TS 103 097 V1.3.1. Intelligent Transport Systems (ITS) Security; Security Header and certificate formats

[15]. ETSI TS 102 940: Intelligent Transport Systems (ITS); Security; ITS Communications Security Architecture and Security Management
[16]. ETSI TS 102 941: Intelligent Transport Systems (ITS); Security; Trust and Privacy Management
[17]. ETSI EN 302 636-4-1 Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical Addressing and Forwarding for Point-to-Point and Point-to-Multipoint Communications; Sub-part 1: Media-Independent Functionality
[18]. ETSI EN 302 636-5-1 Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol
[19]. ETSI EN 302 931 Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition
[20]. ETSI TS 103 248 Intelligent Transport Systems (ITS); GeoNetworking; Port Numbers for the Basic Transport Protocol (BTP)
[21]. C-ITS Platform Phase II, Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS), Rel 1, 2017
[22]. Security Policy and Governance Framework for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS), Rel 1, 2017
[23]. ETSI TR 102 962 Intelligent Transport Systems (ITS); Framework for Public Mobile Networks in Cooperative ITS (C-ITS)
[24]. 5G Automotive Association; Working Group Standards and Spectrum; Initial C-V2X System Profile (ICSP) – Amendments to C-ROADS Roadside System Profile (Draft), Aug. 2018

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purpose of the present document, the following definitions apply:

central ITS station: ITS station in a central ITS sub-system, as defined in [5]

central ITS sub-system: ITS sub-system in the context of an ITS centre, as defined in [5], which interfaces with the backend ITS central system, e.g. traffic authority cloud and automotive OEM cloud

ITS station: functional entity specified by the ITS station (ITS-S) reference architecture, as defined in [5]

ITS sub-system: sub-system of ITS with ITSC components for a specific context, as defined in [5]

personal ITS station: ITS station in a personal ITS sub-system, as defined in [5]

personal ITS sub-system: ITS sub-system in the context of a portable device for ITS, as defined in [5]

roadside ITS station: ITS station in a roadside ITS sub-system, as defined in [5]

roadside ITS sub-system: ITS sub-system in the context of roadside ITS equipment, as defined in [5]

vehicle ITS station: ITS station in a vehicular ITS sub-system, as defined in [5]

vehicle ITS sub-system: ITS sub-system in the context of an ITS equipment used in a vehicle, as defined in [5]

3.2 Symbols

For the purpose of the present document, the following symbols apply:

<symbol> <Explanation>

3.3 Abbreviations

For the purpose of the present document, the following abbreviations apply:

BSP	Basic System Profile
BTP	Basic Transport Protocol
C-ITS	Cooperative ITS
CDD	Common Data Dictionary
DENM	Decentralised Environmental Notification Message
ETSI	European Telecommunications Standards Institute
GBC	GeoBroadcast
HLN	Hazardous Location Notifications
IP	Internet Protocol
ITS	Intelligent Transport Systems
ITSC	ITS Communication
IVIM	Infrastructure to Vehicle Information Message
IVS	In-Vehicle Signage
MAPEM	MAP (topology) Extended Message
MQTT	Message Queuing Telemetry Transport
OEM	Original Equipment Manufacturer
RSP	Roadside System Profile
RWW	Roadworks Warning
SHB	Single Hop Broadcast
SI	Signalised Intersections
SPATEM	Signal Phase And Timing Extended Message
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
Uu-CSP	Uu Communication System Profile
VRU	Vulnerable Road User

4 Provisions

4.1 Verbal forms for the expression of provisions

The verbal forms used in this document for the expression of provisions follow clause 3.2 of ETSI Drafting Rules [6].

Note: The verbal form used in this document is aligned with [4].

4.2 Provisions from referenced documents

This document follows the convention of provisions from referenced documents as in section 1.2 of [4].

4.3 Notation used to identify requirements

This document uses the C-ROADS Roadside System Profile (RSP) as a basis for content and structure. Some requirements were directly copied, to ensure the interoperability of C-ITS services using different communication technologies. Those have the identifier of the referenced RSP requirement in brackets after the Uu-CSP identifier, e.g. RS_Uu_CSP_001 (RS_RSP_001).

Other requirements have been adopted from the RSP. They are also marked by the Uu-CSP identifier with the key word ‘based on’, e.g. RS_Uu-CSP_007 (based on RS_RSP_007).

Requirements without any reference to an RSP requirement are new and only apply to the long-range communication-based system.

4.4 Standards evolution

The standards chosen as specifications in this deliverable are evolving. For reference to standard with specific version information, only the cited version applies. For references to standards without specific version information, the latest version of the referenced document applies.

4.5 Terminologies

This document adopts the following terminologies defined in EN 302 665 [5]: **ITS station**, **vehicle ITS station**, **personal ITS station**, **roadside ITS station**, and **central ITS station**.

Note: the terminology *roadside ITS Station* used in this document is interchangeable with the terminology *Infrastructure Roadside System* used in the C-ROADS Roadside System Profile [4].

5 Features of Uu communication system profile (Uu-CSP) for C-ITS

5.1 General

In the European Commission ITS Directive 2010/40/EU, delivering interoperability is one of the principles for specifications and deployment of ITS [7]:

> "***Deliver interoperability** – ensure that systems and the underlying business processes have the capacity to exchange data and to share information and knowledge to enable effective ITS service delivery*"

To ensure interoperability, the implementation of each ITS station shall follow the system profile, which is a specific configuration of standards defining the implementation of various options in the standards.

This Uu-Communication System Profile (Uu-CSP) is the minimum set of configurations and requirements of the ITS Application layer, facility layer, and security related standards for ITS stations using long-range cellular Uu communication and considering the interoperability of C-ITS services with ITS stations using other communication technologies, e.g. short-range technologies.

Interoperability of C-ITS services among ITS stations using different communication technologies, e.g. short-range and long-range communications, are addressed by harmonising the corresponding system profiles at the ITS Application and facility layer as covered in this document and [24] from 5GAA, the RSP from C-ROADS, and the BSP from C2C-CC, as well as through conformance with the common C-ITS security and certificate policies [22] [21].

5.2 Set of supported applications

This profile document fulfils the road safety and efficiency requirements as specified in the domains in Table 1. The definition of the services and respective use cases are given in [8].

Table 1 Services supported by the Uu Communication System Profile

Services
Roadworks Warning (RWW)
Hazardous Location Notifications (HLN)
In-Vehicle Signage (IVS)
Signalised Intersections (SI)

5.3 System requirements for ITS stations using the Uu interface

5.3.1 General

This section defines the interoperable characteristics of ITS stations using the long-range cellular Uu communication, whose implementation follows the Uu-CSP specified in this document.

5.3.2 Security

All ITS stations, when transmitting ETSI ITS messages, shall comply with the European C-ITS security policy [22] and certificate policy [21].

5.3.3 Positioning and timing

Following is a summary of the requirements on positioning and timing:

General	
RS_Uu_CSP_g01 (RS_RSP_001)	*The basis for the ITS-S time (time base) shall be TAI (Temps Atomique International, International Atomic Time), a high-precision atomic coordinate time standard. Timestamps shall be counted in milliseconds with epoch set to 1.1.2004, 00:00 UTC (ETSI TS 102 894-2 [10]).*[4]
RS_Uu_CSP_g02 (RS_RSP_002)	*The ITS-S time shall be the reference for all time stamps for all the ITS-S based transmitted messages.* *NOTE: This implies that timestamps in GeoNetworking header use the same clock and time base as timestamps in, e.g. DENM/IVIM payloads.* [4]
Confidence validation	
RS_Uu_CSP_g03 (RS_RSP_003)	*The accuracy estimation shall yield valid 95% confidence values, according to the following definition:* *A system providing 'state' information with a 95% confidence level shall be interpreted as meaning that 'the true state value' (e.g. the position of a reference measurement system) is the range specified by the estimated state value plus/minus the confidence value in 95% of the datasets in a given statistic base.* *NOTE: This section is concerned with the positional accuracy of the ITS-S itself. This position is used for GN-Networking and may be used for other purposes in future use cases. To be evaluated with suppliers.* [4]
RS_Uu_CSP_g04 (RS_RSP_004)	*The confidence values shall be equal to or lower than the following values in at least 95% of datasets:* *• horizontal position confidence of 5 m* *• vertical position confidence of 15 m* *This requirement ensures the usefulness of information sent.* *NOTE 1: Altitude Accuracy will be quantized quite roughly for DENM, e.g. within 1/2/5/10/20/50/100/200 m.* *NOTE 2: To be evaluated with suppliers.* [4]
Timing accuracy	

RS_Uu_CSP_g05 (RS_RSP_005)	*The clock representing the time base in an ITS-S shall be called the Station clock. The Station clock shall be within 200 ms of the time base (see RS_Uu_CSP_001), i.e. Delta t = |Station clock time - time base| < 200 ms. Timestamps in messages shall be based on the Station clock.* [4]
RS_Uu_CSP_g06 (RS_RSP_006)	*The difference between Station clock and time base shall be estimated. If the maximum difference of |Station clock time - time base| = >200 ms, the ITS system should not send out messages originated by itself.* *NOTE: A precise timestamp is needed not only for time synchronisation but also implies that system states are valid at precisely that point in time, i.e., that the vehicle states stay consistent.* [4]

5.3.4 System behaviour

The following is a summary of the requirements on system behaviour:

General	
RS_Uu_CSP_g07 (based on RS_RSP_007)	As long as a vehicle or a pedestrian is part of 'public traffic' under normal driving conditions, as the default mode, the vehicle or personal ITS station shall be considered to be within the safety-related context. The safety-related context may be deactivated for the vehicle ITS station in some specific situations under deactivation conditions. These conditions shall be verified by a vehicle occupant or an in-vehicle system. Roadside ITS stations and central ITS stations are considered to be in 'safety-related context' when the ITS station fulfils all requirements specified in this Uu-CSP.
RS_Uu_CSP_g08 (based on RS_RSP_008)	Vehicle ITS stations and pedestrian ITS stations supporting long-range cellular Uu communication shall transmit DENM when in a safety-related context. Roadside ITS stations and central ITS stations supporting long-range communication shall transmit DENM, IVIM, SPATEM and MAPEM when in a safety-related context.
RS_Uu_CSP g09 (based on RS_RSP_009)	Traces and path history data shall only be generated when 'position confidence' and ITS time information are available as specified in sub-section 5.3.3.
RS_Uu_CSP_g10 (based on RS_RSP_010)	Following the Uu_CSP, the moment in time when the ITS station sends a message on the communication channel, minus the moment in time when the information in the message was obtained, shall be in the range of 0 milliseconds to +160 milliseconds. *This requirement handles the processing time up until information or a message is sent.* *NOTE 1: A measurement of the moment in time when a message is sent and the time-stamp inside the message will not always refer to the same clock (typically ITS Time and time base, respectively), which needs to be taken into account when the time difference is determined.* *NOTE 2: This requirement should be tested with applications, where the fulfilment of the triggering conditions is not dependent on timers or durations.* *NOTE 3: The timestamps inside the messages are represented in SPATEM, MAPEM and IVIM by timestamp and in a DENM by DetectionTime.*

	NOTE 4: The 160 ms come together from (100 + 60) ms: *In normal operation up to 10 messages/second can be generated, 10 messages/second. That means that the system as a whole must guarantee a traversal time lower than 100 ms in order to support this generation rate, otherwise overlaps and message drops will occur.* *In order to be aligned with the system behaviour requirement of ITS-G5 system, i.e. RS_RSP_010 in [4], 60 ms added for the possible channel access delay.* *NOTE 5: The information of a DENM is obtained, when the last necessary trigger applies and is evaluated to be valid.* [4]

6 List of relevant standards and reference documents

6.1 General

This chapter lists the set of documents essential for specifying the ITS station using long-range cellular Uu communication. Most of these documents are published (or under the publishing process) at ETSI, CEN, IETF, or ISO. The document [9] is essential to achieve interoperability between the various implementations of the ITS stations using long-range cellular Uu communication as it fills gaps currently not addressed by CEN and ETSI.

6.2 ITS Facility layer and application layer

6.2.1 List of relevant documents

Table 2 provides the list of relevant documents for the ITS Facility and Application layer.

Table 2 Relevant documents for the ITS Facility layer

Document	Title	Short Description
ETSI EN 302 637-3 [11]	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3 Specifications of Decentralised Environmental Notification Basic Service.	Defines event/triggered DEN message as core message for many use cases.
ETSI TS 103 301 [12]	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).

Note: ETSI TS 102 894-2 [10] for Common Data Dictionary (CDD) is normatively referenced in ETSI EN 302 637-3 [11] and ETSI TS 103 301 [12].

Note: ISO / TS 19321 [13] Dictionary of in-vehicle-information (IVI) data structure is normatively referenced in ETSI TS 103 301 [12].

6.2.2 ETSI EN 302 637-3 Decentralised Environmental Notification Basic Service

<u>Title</u>

Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service. [11]

<u>Purpose</u>

Specifications of the Decentralised Environmental Notification basic service in support of ‘Day-1’ use cases.

<u>Status</u>

ETSI EN 302 637-3 [11] is available.

6.2.2.1 Main specifications of ETSI EN 302 637-3

ETSI EN 302 637-3 specifies:

Syntax and semantic of Decentralised Environmental Notification Message (DENM)

6.2.2.2 Uu-CSP settings of ETSI EN 302 637-3

<table>
<tr><td colspan="2">EN 302 637-3 Decentralised Environmental Notification Message</td></tr>
<tr><td>RS_Uu_CSP_f01 (based on RS_RSP_058 and RS_RSP_068)</td><td>The DENM repetition shall follow the DEN specification in ETSI EN 302 637-3 [11].</td></tr>
<tr><td>RS_Uu_CSP_f02 (RS_RSP_059)</td><td>The ‘traces’ in the DENMs shall cover at most 1000 m from the first to the last point.</td></tr>
<tr><td>RS_Uu_CSP_f03 (based on RS_RSP_060)</td><td>The ITS stations shall use the DENM traces as follows:

A trace shall describe a list of geographical locations leading from the event position back to the first path point.

For trailer-based use cases, the PathDeltaTime should be sent in every PathPoint in the first DENM traces element. [4]</td></tr>
<tr><td>RS_Uu_CSP_f04 (based on RS_RSP_061)</td><td>This requirement is only applicable to trailer-based use cases: When standing for a long time, the PathDeltaTime of the first PathPoint of the first DENM traces element shall be fixed to the maximum value specified in ETSI EN 302 637-3 [11]. Therefore, PathPoints do not ‘fall out’ of the first DENM traces element when standing for a long time. [4]</td></tr>
<tr><td>RS_Uu_CSP_f05 (based on RS_RSP_062)</td><td>The DENM traces may contain additional PathHistory elements. Unlike the first element, these additional PathHistory elements shall describe alternative routes to the event location. These routes may or may not be available at the time that the event is detected. In the alternative routes, the PathPoints shall be position-ordered (i.e. shortest-path routes) and not include the PathDeltaTime.</td></tr>
<tr><td>RS_Uu_CSP_f06 (based on RS_RSP_063)</td><td>The traffic class value for Message Sets shall be set as defined as:
<table>
<tr><td>Services</td><td>Message Sets</td><td>Traffic Class</td></tr>
<tr><td>Roadworks Warning (RWW)</td><td>DENM</td><td>1</td></tr>
<tr><td>Hazardous Location Notifications (HLN)</td><td>DENM</td><td>Following the value specified in RS_RSP_063 [4]</td></tr>
<tr><td>In-Vehicle Signage (IVS)</td><td>IVI</td><td>Following the value specified in RS_RSP_063 [4]</td></tr>
</table></td></tr>
</table>

	Signalised Intersections (SI)	SPATEM/MAPEM	Following the value specified in RS_RSP_063 [4]
RS_Uu_CSP_f07 (based on RS_RSP_069)	The PathDeltaTime data elements of the PathPoints in the first DENM traces element shall be updated only if the DENM is updated. Furthermore, the cases in which DENM Updates are triggered shall be specified on a case-by-case basis in the corresponding triggering conditions in [9].		

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

Title

Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities Layer Protocols and Communication Requirements for Infrastructure Services. [12]

Purpose

ETSI TS 103 301 provides specifications of infrastructure-related ITS services to support communication between infrastructure ITS equipment and traffic participants using ITS equipment (e.g. vehicles, pedestrians). It defines services in the Facilities layer for communication between the infrastructure and traffic participants. The specifications cover the protocol-handling for infrastructure-related messages as well as requirements to lower layer protocols and to the security entity.

Status

ETSI TS 103 301 [12] is available.

Relevance

ETSI TS 103 301 [12] is the European standard to construct SPATEM, MAPEM, and IVIM.

6.2.2.1 Main specifications of ETSI TS 103 301

ETSI TS 103 301 [12] specifies:

Definitions SPATEM, MAPEM, and IVIM supporting Signalised Intersections and In-Vehicle Signage services.

6.2.2.2 Uu-CSP settings of ETSI TS 103 301

ETSI TS 103 301 Facilities layer protocols and communication requirements for infrastructure services	
RS_Uu_CSP_f08 (based on RS_RSP_065 and RS_RSP_066)	Infrastructure to Vehicle Information (IVI) services shall be applied according to ETSI TS 103 301 [12] and as specified in [9]. NOTE: ISO/TS 19321 [13] is normatively referenced in ETSI TS 103 301 [12] for IVIM.

6.3 ITS network and transport layer

6.3.1 List of relevant documents

The relevant ITS network and transport layer standards are listed in Table 3.

Requirements of ETSI ITS network and transport layers are included in this Uu-CSP because the existing ETSI ITS standards note that ITS security operations – i.e. message signing and verification – can only be performed to

GeoNetworking packets. ETSI ITS standards for ITS security operations at the Facility layer are still missing. Therefore, configurations of GeoNetworking protocols related to multi-hop and other features not suitable to the Uu long-range communication are disabled in the Uu-CSP.

Table 3 Relevant documents for the ITS Facility layer

Document	Title	Short description
ETSI EN 302 636-4-1 [17]	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical Addressing and Forwarding for Point-to-Point and Point-to-Multipoint Communications; Sub-part 1: Media-Independent Functionality.	Defines the media-independent functionalities of GeoNetworking.
ETSI EN 302 636-5-1 [18]	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol.	Specifies the Basic Transport Protocol.
ETSI EN 302 931 [19]	Vehicular Communications; Geographical Area Definition.	Specifies the location referencing method, enables ITS stations to exchange location-related information.

6.3.2 GeoNetworking: media-independent part

Title

Vehicular Communication; GeoNetworking; Part 4 Geographical Addressing and Forwarding for Point-to-Point and Point-to-Multipoint Communications; Sub-part 1: Media-Independent Functionality.

Purpose

Specifies the media-independent functionalities of GeoNetworking.

Status

ETSI EN 302 636-4-1 [17] is available

6.3.2.1 Main specifications of ETSI EN 302 636-4-1

ETSI 302 636-4-1 [17] mainly specifies addressing, data structure, packet structure, protocol operation, as well as security and privacy of GeoNetworking.

6.3.2.2 Uu-CSP settings of EN 302 636-4-1

RS_Uu_CSP_x01 (based on RS_RSP_030)	GeoNetworking (GN) shall be applied as ITS networking protocol according to ETSI EN 302 636-4-1 [17].
RS_Uu_CSP_x02 (based on RS_RSP_031)	All constants and parameters settings of GeoNetworking that are not defined in this Uu-CSP shall be set according to Annex G of ETSI EN 302 636-4-1 [17].
RS_Uu_CSP_x03 (based on RS_RSP_032)	GN security shall always be enabled, i.e. itsGnSecurity = ENABLED (1).

RS_Uu_CSP_x04 (based on RS_RSP_033)	‘Anonymous address’ may be chosen for GN address configuration, i.e. itsGnLocalAddrConfMethod = ANONYMOUS (2).
RS_Uu_CSP_x05 (based on RS_RSP_034)	80 km² shall be the maximum size of geographical areas in GBC or GBA to avoid Denial of Service (DOS) attacks, i.e. itsGnMaxGeoAreaSize = 80
RS_Uu_CSP_x06 (based on RS_RSP_035)	GN shall be used with itsGnIfType = Unspecified (0) for ITS stations using long-range cellular Uu communication.
RS_Uu_CSP_x07 (based on RS_RSP_036)	itsGnMinPacketRepetitionInterval shall not be set, i.e. GN packet repetition shall be disabled.
RS_Uu_CSP_x08 (based on RS_RSP_037)	The packet header type GeoBroadcast (GBC) shall be used for all DENM, IVIM, SPATEM and MAPEM packets, i.e. HT = 4, HST = 0, 1 or 2.
RS_Uu_CSP_x09 (based on RS_RSP_038)	The LifeTime (LT) field of all Single Hop Broadcast (SHB) packets shall be set to 1 second. NOTE: this requirement may not be applicable to DENM, IVIM, SPATEM and MAPEM, as GBC instead of SHB is used.
RS_Uu_CSP_x10 (based on RS_RSP_039)	The LifeTime (LT) field of all GBC packets shall be set to ValidityDuration, but shall not exceed the itsGnMaxPacketLifetime parameter, specified in Annex G of ETSI EN 302 636-4-1[17].
RS_Uu_CSP_x11 (based on RS_RSP_040)	‘Store-carry-forward’ shall be disabled; in other words, the SCF bit in the Traffic Class (TC) field may be set to 0.
RS_Uu_CSP_x12 (based on RS_RSP_041)	The ITS station using long-range cellular Uu communication shall have at least a buffer size of 1024 kb, as specified in Annex G of ETSI EN 302 636-4-1 [17].
RS_Uu_CSP_x13 (based on RS_RSP_042)	‘Channel offload’ shall always be disabled, i.e. the channel offload bit in the TC field shall be set to 0.
RS_Uu_CSP_x14 (based on RS_RSP_043)	The Infrastructure Roadside System shall only use the DCC profiles specified in 3.1.5.2 of [4]; and the DCC Profile ID bits of the TC (Traffic Class) field shall only use the DPID values defined in 3.1.5.2 of [4]. NOTE: DCC functionality is not available in long-range cellular Uu communication (this setting will be ignored by the lower layer in this profile).
RS_Uu_CSP_x15 (based on RS_RSP_044)	For mobile ITS stations the itsGnIsMobile bit of the Flags field shall be set to 1 (or 0).
RS_Uu_CSP_x16 (based on RS_RSP_045, RS_RSP_046 and RS_RSP_047)	The ITS station using long-range cellular Uu communication shall set the Maximum Hop Limit (MHL) field to 1. NOTE: The multi-hop operation mode of GeoNetworking should not be configured in the implementation using long-range cellular Uu communication.
RS_Uu_CSP_x17 (based on RS_RSP_048)	Duplicate packet detection may be used; and the algorithm specified in A.2 and A.3 of ETSI EN 302 636-4-1 can be used for detecting duplicate packets. NOTE: Duplicate packet detection is not needed for ITS stations using long-range cellular Uu communication.
RS_Uu_CSP_x18 (based on RS_RSP_049)	The ITS station using long-range cellular Uu communication shall set the beacon retransmit timer to the maximum value, i.e. itsGnBeaconServiceRetransmitTimer = 65535. NOTE: The beacon is used for advertising the GeoAdHoc router’s position vector, which is not needed for ITS stations using long-range cellular Uu communication, however, the current EN 302 636-4-1 does not allow beacons to be disabled so the

	beacon interval is set to the maximum value in the standard for ITS stations using long-range cellular Uu communication.

6.3.3 ETSI 302 636-5-1 Basic Transport Protocol

Title

Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol.

Purpose

It specifies the BTP protocol providing an end-to-end, connection-less and unreliable transport service on top of GeoNetworking.

Status

ETSI EN 302 636-5-1 [18] is available.

6.3.3.1 Main Specifications of ETSI 302 636-5-1

ETSI EN 302 636-5-1 [18] mainly specifies packet structure, header format, and protocol operation of BTP.

6.3.3.2 Uu-CSP settings of EN 302 636-5-1

RS_Uu_CSP_x19 (based on RS_RSP_051)	The Basic Transport Protocol shall be applied according to ETSI EN 302 636-5-1 [18] and the following specifications in this section.
RS_Uu_CSP_x20 (based on RS_RSP_052)	The ITS station using long-range cellular Uu communication shall employ BTP-B headers, i.e. the GeoNetworking common header shall use a value of 2 for the NH field.
RS_Uu_CSP_x21 (based on RS_RSP_053)	The ITS station using long-range cellular Uu communication shall set the destination port information field to the value 0.
RS_Uu_CSP_x22 (based on RS_RSP_054)	The ITS station using long-range cellular Uu communication shall set the destination port inside the BTP-B header according to ETSI TS 103 248 [20].

6.3.4 ETSI EN 302 931 Geographical Area Definition

Title

Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition.

Purpose

It specifies the location referencing method enabling ITS stations to exchange location-related information. It facilitates ITS communication protocols to address geographical areas and to disseminate information in these areas.

Status

EN 302 931 [19] is available.

6.3.3.1 Main specifications of EN 302 931

ETSI EN 302 931 [19] mainly defines geographical areas such as circular area, rectangular area, and elliptical area, as well as elementary geometric function to determine spatial characteristics of a point P(x,y).

6.3.3.2 Uu-CSP settings of EN 302 931

RS_Uu_CSP_x23 (based on RS_RSP_055)	Geographical areas shall be applied according to ETSI EN 302 931 [19] and the following specifications in this section.
RS_Uu_CSP_x24 (based on RS_RSP_056)	Circular, rectangular and ellipsoidal geographical areas defined in ETSI EN 302 931 [19] shall be supported; each use case defined in this profile shall specify one of the above geographical area types and indicate it through the GN header as specified in ETSI EN 302 636-4-1.
RS_Uu_CSP_x21 (based on RS_RSP_057)	When an ITS station 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 be used, taking care to avoid large rounding errors on low-precision floating point systems (these can be avoided using, for example, the haversine formula).

Note: The GeoNetworking packet is referred to as ITS packet in the discussion of packet transport over the long-range cellular Uu interface for C-ITS services in section 6.4.

6.4 Transport of ITS packets over long-range cellular Uu interface

The Uu-CSP does not specify the configuration of standards at the ITS access layer. Instead, implementation according to the Uu-CSP can be supported on top of an IP-based protocol stack, e.g. UDP/IP, TCP/IP, MQTT/TCP/IP, etc., which is in turn supported by the cellular Uu interface. TCP or UDP shall be used above the IP layer, while further protocols above TCP and UDP are not precluded. In principle this profile can be applied to any access layer technology, including the cellular Uu interface, that supports IP as the network layer protocol. In reality, many deployed IP-networks implement encapsulations resulting in more than one transport layer and network layer processing the PDU and adding/removing the corresponding protocol headers. This is sometimes also referred to as tunnelling. Annex A illustrates some examples of protocol stack over the Uu interface based on existing pilots and demonstration projects.

The interoperability of C-ITS services is ensured by the Uu-CSP profile covering ITS Facility layer, Application layer, and ITS security related standards, as specified in Section 6.2, 6.3, and 6.5.

RS_Uu_CSP_t01	When using the long-range cellular Uu interface for communication, ITS stations shall use the IP-based protocol stack for delivering DENM, IVIM, SPATEM, and MAPEM. To ensure the interoperability of C-ITS services, all message transmissions shall fulfil requirements specified in section 6.2 and section 6.3 for the ITS network and transport layer, the ITS Facility layer, and the ITS Application layer.

Note: the detailed configuration of IP-based protocol stacks is out of scope of this profile.

IP address resolution of ITS stations depends on the C-ITS services, communication scenarios, and the implementation of ITS. Annex A provides example IP address resolution solutions for C-ITS services. It is noted that secured and interoperable C-ITS services communication at the facility layer is ensured by the main text of this profile and not affected by different solutions of resolving IP address for ITS stations.

6.5 ITS Security

6.5.1 List of relevant documents

Table 4 provides the list of relevant documents for ITS security.

Table 4 Relevant documents for ITS security

Document	Title	Short Description

ETSI TS 103 097 [14]	Intelligent Transport Systems (ITS); Security; Security Header and certificate formats.	Defines secured data structure including header and certificate formats for ITS.
ETSI TS 102 941 [16]	Intelligent Transport Systems (ITS); Security; Trust and Privacy Management.	Specifies trust and privacy management for ITS.

6.5.2 ETSI TS 103 097 security header and certificate formats

Title

Intelligent Transport Systems (ITS) Security; Security Header and Certificate Formats.

Purpose

Specifications of secured data structure including header and certificate formats for ITS.

Status

ETSI TS 103 097 [14] is available

6.5.2.1 Main specifications of ETSI TS 103 097

ETSI TS 103 097 [14] specifies:

Secured data structure, certificate format, and security profiles for ITS messages

6.5.2.2 Uu-CSP requirements regarding ETSI TS 103 097

ETSI TS 103 097 Security Header and Certificate Formats	
RS_Uu_CSP_s01	Secured ETSI ITS messages shall follow the data structure and certificate format defined in ETSI TS 103 097 [14].

6.5.3 ETSI TS 102 941 trust and privacy management

Title

Intelligent Transport Systems (ITS); Security; Trust and Privacy Management.

Purpose

Specifications of the trust and privacy management for Intelligent Transport System (ITS) communications.

Status

ETSI TS 102 941 [16] is available.

6.5.3.1 Main specifications of ETSI TS 102 941

ETSI TS 102 941 [16] identifies and specifies:

Security services for the establishment and maintenance of identities and cryptographic keys in ITS. Its purpose is to provide the functions upon which systems of trust and privacy can be built within ITS.

6.5.3.2 Uu-CSP requirements regarding ETSI TS 102 941

ETSI TS 102 941 Trust and Privacy Management

RS_Uu_CSP_s02	ITS stations shall follow ETSI TS 102 941 [16] for trust and privacy management based on the PKI architecture, as defined in ETSI TS 102 940 [15].

Note: ETSI TS 102 940 [15] ‘communications security architecture and security management’ is normatively referenced in ETSI TS 102 941 [16].

Annex A (informative): Geo-location based ITS message dissemination

A.1 Introduction

This annex outlines the transport of ITS packets over IP-based networks for ITS services. It specifies the tunnelling of ITS messages through IP-based networks using a Transport Layer Protocol, for example TCP or UDP, and IP version 4 or version 6 with any kind of fixed or radio access technology, or mix of both, below the IP layer.

A.2 Scope

The ubiquitous IP has become the de-facto standard of packet-based data networks assuring a high level of compatibility and interoperability, also reflected in the Internet of Things (IoT). It is particularly compatible with many (radio) access technologies including cellular, WiFi in ISM-bands and fixed networks.

Thus, IP-based networks are defined as any network (or network of networks) implementing IP as specified in IETF RFC 791 (version 4) and IETF RFC 8200 (version 6) as network layer protocols for routing messages between source and destination nodes. On top of that, the User Datagram Protocol (UDP), as defined by IETF RFC 768, or Transmission Control Protocol (TCP), among others defined in IETF RFC 793, is used as the Transport Layer Protocol but other protocols are not precluded.

A.3 Interfaces between layers in relation to ETSI-ITS communication architecture and implementation effort

A.3.1 IP to data link layer interface

The key success of IP lies in the fact that it was designed to support all kinds of (Radio) Access Technologies ((R)ATs) and therefore respective networks to link data layer interfaces. IEEE 802.11 (WiFi) and IEEE 802.3 (Ethernet) consign IEEE 802.2 (Logical Link Control (LLC)) as the interface between network and data link layer. 3GPP specifies the Packet Data Convergence Layer (PDCP). In reality, those ‘interfaces’ are operating system (OS) specific Application Programming Interfaces (API) between the OS and the network interface driver. All common OSs, including Linux, Windows, Android, and IOS are designed in a way to assure the IP layer can connect to a multitude of (R)ATs, even different ones simultaneously. Interoperability between the IP layer and data link layer(s) and corresponding (R)AT(s) is therefore assured.

A.3.2 GeoNetworking on top of IP-based protocol stacks

As described in Section 6.4, the Uu-CSP can be applied to any access layer technology, including the cellular Uu interface, which supports IP as the network layer protocol. In practice, many deployed IP-networks implement encapsulations resulting in more than one transport layer and network layer processing the PDU and adding/removing the corresponding protocol headers. This is sometimes also referred to as tunnelling. Figure 2 presents examples of IP-based protocol stacks on top of the Uu interface and supporting the Uu-CSP for ITS services.

(Radio) Access Technologies and respective network interface drivers enable OS-specific APIs used by the upper layer – e.g. GeoNetworking – to send and receive PDUs. With the existing ‘standardised’ implementation of TCP/IP and UDP/IP protocol stacks in operation systems over various platforms, encapsulation of GeoNetworking PDUs in UDP-IP or TCP-IP packets can therefore be realised with very limited implementation and no additional specification effort.

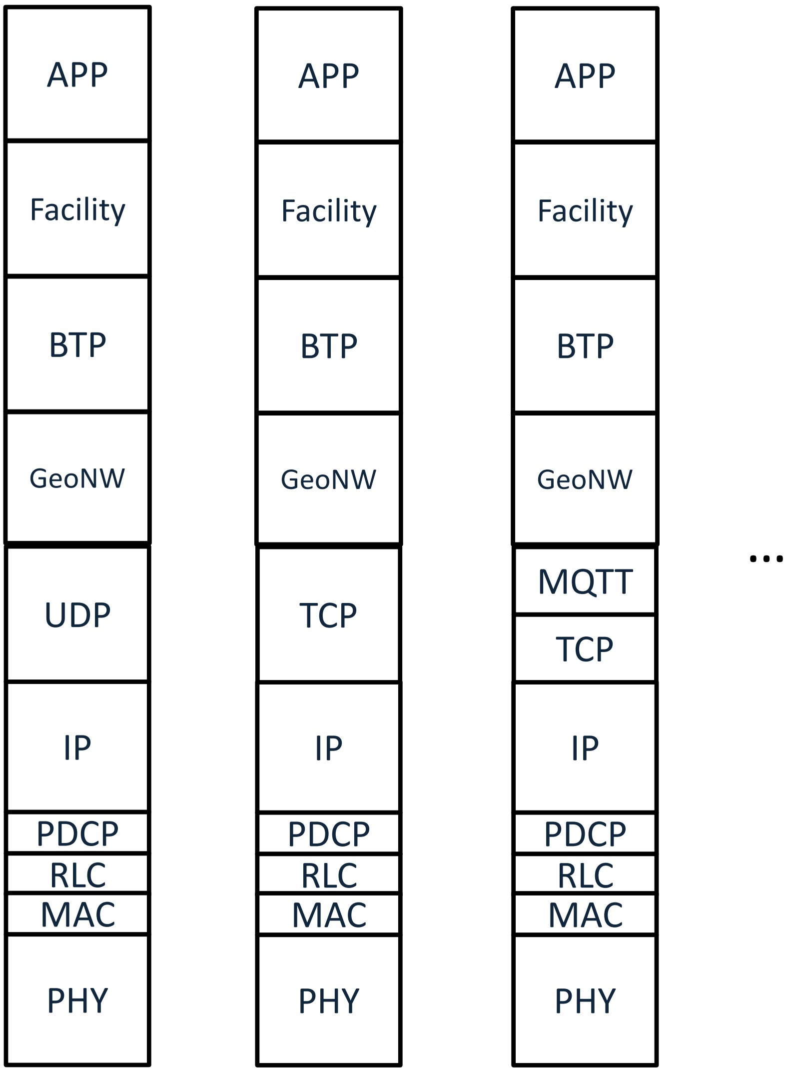

Figure 2 Example IP-based protocol stacks on top of Uu interface and supporting the Uu-CSP

A.4 IP address resolution for C-ITS services

The C-ITS service messages, e.g. DENM and SPATEM, address ITS stations in specific geographical areas. One of key technical features of using IP networking for tunnelling C-ITS messages is to resolve the IP addresses of the receiving ITS stations according to the information contained in the C-ITS messages, particularly the information of the relevant geographical area. Various technical solutions exist for IP address resolution in the C-ITS context, e.g. the Geomessaging Enabler specified in ETSI TR 102 962 [23] for cellular systems, where the backend system maintains the location information of the vehicles and distributes the message to relevant vehicles. The GeoMessaging Enabler supports two different IP addressing schemes for distribution purposes: unicast and multicast.

Technical and implementation details may vary from one solution to the other, but any solution that can correctly resolve IP addresses of ITS stations for C-ITS services should be adopted for the deployment of C-ITS following the Uu-CSP. Interoperability of C-ITS services is ensured by the main text of this system profile and not affected by different solutions for resolving the IP address of ITS stations.

Annex B (informative):
Privacy protection in Uu-based C-ITS systems

In contrast to short-range broadcast V2X communication, long-range V2X communication is based on well-proven cellular technology that provides connectivity to various application servers and thus enables communication among road users, including vehicles and pedestrians, road infrastructure, road authorities/operators and backend servers, e.g. at the OEM backend, the traffic control centre. Long-range cellular V2X communication covers user equipment (UE) to network (uplink), network to UE (downlink), or the combination of UE-to-network and network-to-UE communications. The establishment of communication links between UEs and application servers is a prerequisite of long-range cellular V2X communication.

The established communication link between UE and an application server makes it possible for the data subject, usually a vehicle owner, to give consent to the processing of his or her personal data by the data controller, e.g. an OEM backend server, or ITS server at the network side for C-ITS' purpose. Unlike short-range V2X communication, the legal basis of processing personal data in C-ITS using long-range V2X may not be a critical issue since consent is only needed from a few actors, e.g. the OEM (which likely already established informed consent through the telematics commands handling VRU protection).

Annex C:
Change history

Date	Meeting	TDoc	Subject/Comment
08.08.2018		S-180169	Initial version
28.08.2018		S-180175	Pre-release version PA01
04-09-2018		S-180175	Pre-release version PA02
05-09-2018		S-180175	V1.0 Release Candidate