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Release 2

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The ETSI EN 302 665 [i.1] specifies a general ITS architecture with C-ITS station elements while Release 1 ETSI ETSI TR 101 607 [i.2] only defines Cooperative-ITS (C-ITS) applications [i.7].

1 Scope

The present document specifies Multi-Channel Operation (MCO) related requirements which are applied on the Release 2 C-ITS communication architecture. It extends the Release 1 communication architecture as defined in the ETSI EN 302 665 [i.1] for MCO.

The present document is based on the Release 1 specifications as specified in the ETSI TR 101 607 [i.2], as well as the Release 2 ETSI EN 302 890-1 [i.3], ETSI TR 103 439 [i.6], and other ITS standards as the ISO CALM architecture ISO 21217:2014 [i.9], the IEEE WAVE architecture IEEE 1609.3 [i.11] and the LTE architecture ETSI TS 136 300 [i.10].

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 302 665 (V1.1.1): "Intelligent Transport Systems (ITS); Communications Architecture".

[i.2] ETSI TR 101 607 (V1.2.1): "Intelligent Transport Systems (ITS); Cooperative ITS (C-ITS); Release 1".

[i.3] ETSI EN 302 890-1 (V1.2.1): "Intelligent Transport Systems (ITS); Facilities layer function; Part 1: Services Announcement (SA) specification".

[i.4] ETSI TS 103 175: "Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium".

[i.5] CODECS.

NOTE: Available at https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-transport/intelligent-transport-systems/codecs.

[i.6] ETSI TR 103 439: "Intelligent Transport Systems (ITS); Multi-Channel Operation Study; Release 2".

[i.7] ETSI TR 102 638 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Release 2".

[i.8] ITU Recommendation X.200 (1994): "Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".

[i.9] ISO 21217-2014: "Intelligent transport systems - Communications access for land mobiles (CALM) - Architecture".

[i.10] ETSI TS 136 300: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300)".

[i.11] IEEE 1609.3-2016™: "EEE Standard for Wireless Access in Vehicular Environments (WAVE) -- Networking Services".

[i.12] EU C-ITS platform and reports.

NOTE: Available at https://ec.europa.eu/transport/themes/its/c-its_en.

[i.13] C-Roads hybrid architecture.

NOTE: Available at https://www.c-roads.eu/fileadmin/user_upload/media/Dokumente/C-Roads_Position_paper_on_59GHz_final.pdf.

[i.14] ETSI EN 302 571: "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".

[i.15] ETSI EN 302 637-2 (V1.4.1) Release 1: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[i.16] ETSI TR 103 562 (V2.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Analysis of the Collective Perception Service (CPS); Release 2".

[i.17] C2C-CC BSP 1 Triggering conditions.

NOTE: Available at https://www.car-2-car.org/fileadmin/documents/Basic_System_Profile/Release_1.2.0/C2CCC_RS_2037_BasicSystemProfile_R120.pdf.

3 Definition of terms, symbols, and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

C-ITS methodology: sharing transport (traffic situation) related information among traffic stakeholders, openly, to realize common traffic safety and traffic efficiency related benefit for all

CCAM C-ITS related application: part of the CCAM applications are C-ITS oriented and therefore seen as C-ITS applications

NOTE 1: CCAM applications are a subset of ITS applications.

NOTE 2: For instance high definition map updates are part of CCAM but are not part of C-ITS while Manoeuvre Coordination information sharing is CCAM and C-ITS.

Cellular-V2X (C-V2X): umbrella term which encapsulates all 3GPP V2X technologies, including both direct (PC5) and mobile network communications (Uu)

Cooperative-Intelligent Transport Systems (C-ITS): Intelligent Transport Systems where the cooperation between two or more ITS sub-systems (personal, vehicle, roadside and/or central) enables and provides ITS user services to serve the C-ITS Methodology

Ecosystem (ICT specific): ICT Ecosystem encompassing the policies, strategies, processes, information, technologies, applications, and stakeholders that together make up a technology environment for a country, government, or enterprise

entity: singular, identifiable, and separate object realizing a function or functions

NOTE: It refers to individuals, organizations, systems, bits of data, or even distinct system components that are considered significant in and of themselves.

function: self-contained module that accomplishes a specific task

NOTE: Functions usually "take in" data, process it, and "return" a result.

Intelligent Transport Systems (ITS): systems which aim to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer, more coordinated, and "smarter" use of transport networks

plane: logical grouping of functions over different layers in a networking context

NOTE: The main planes recognized are the management or control plane, the data plane, and the security plane.

sourcing applications: entity which triggers the generation of messages to inform other stations

NOTE 1: E.g. Release 1 specification CAS ETSI EN 302 637-2 [i.15], the Release 2 specification CPS ETSI TR 103 562 [i.16] with their generation rules, and message generation triggering e.g. as specified by C2C-CC BSP [i.17] triggering conditions.

NOTE 2: As identified in ETSI TR 103 439 [i.6], C-ITS application realizes one or more use cases by using besides internal C-ITS station sensor information also sensor or other information received by other C-ITS stations. A use case can be realized by received information from sourcing applications triggering message generation. Theses sourcing functionality can be part of the application itself or from other applications. Applications may consist of a data sourcing and/or data consuming part.

3.2 Symbols

Void.

3.3 Abbreviations

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

3GPP	3rd Generation Partnership Project
API	Advanced Programming Interface
BSP	Basic System Profile
CAM	Cooperative Awareness Message
CAS	Cooperative Awareness Service
CCAM	Cooperative, Connected and Automated Mobility
C-ITS	Cooperative Intelligent Transport Systems
C-ITS-S	Cooperative Intelligent Transport Systems Station
CPS	Collective Perception Service
C-V2X	Cellular-V2X
EU	European Union
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HD	High Definition
ICT	Information Communication Technology
ITS	Intelligent Transport Systems
MCO	Multi-Channel Operation
OSI	Open System Interconnection

SA	Service Announcement
SAP	Service Access Point
V2X	Vehicle to Everything

NOTE: Communications between vehicles and all transport equipment used or implemented in or by vehicles, trucks, Powered Two-Wheelers (PTW), bikes, pedestrians, trains, ships, and other transport equipment's.

4 Background

ETSI EN 302 665 [i.1] ITS communication architecture specification was published in 2010 as part of the full set of Release 1 specifications listed in the ETSI TR 101 607 [i.2] as deployed from 2019 onwards. ETSI EN 302 665 [i.1] specifies a general ITS station architecture for the benefit of realizing C-ITS applications that improve the efficiency and safely use of the transport infrastructure and transport means (vehicles, trains, planes, and ships).

ETSI EN 302 665 [i.1] illustrates the generalized ITS system context and limits itself to only describing an ITS station architecture. It does not identify the difference between ITS and C-ITS, while C-ITS has some time critical and liability specific requirements and should be seen as a subset of ITS. Release 1 basic set of applications, as captured in ETSI TR 102 638 [i.7], are C-ITS specific. Release 2 applications as identified in ETSI TR 103 439 [i.6] are C-ITS and CCAM C-ITS related. Therefore, the Release 2 communication architecture should support the implementation of C-ITS applications including CCAM C-ITS related applications. As the Release 2 specifications cover C-ITS only, C-ITS Ecosystem related trust needs to be realized in this communication architecture.

The Release 1 technical specifications cover only the C-ITS applications supporting functionalities required to exchange the C-ITS relevant information via direct communication. A Release 2 C-ITS communication architecture should recognize also C-ITS and CCAM information exchange via cellular networks as identified in the EU project CODECS [i.5] and EU C-ITS platform workshops and report [i.12], as realized in the EU project C-Roads [i.13]. The identified hybrid communication approach should be reflected in an updated Release 2 C-ITS communication architecture. The Release 2 C-ITS communication architecture should recognize the hybrid communication architecture requirements affecting the end-to-end operation of the system.

Besides the communication and station architecture as defined in ETSI EN 302 665 [i.1], a Release 2 C-ITS communication architecture needs to consider alignment with the C-ITS communication architectures defined elsewhere such as in the IEEE 1609.3-2016 (WAVE) [i.11], in the ETSI TS 136 300 (LTE) [i.10] developed in 3GPP and in the ISO 21217 (CALM) [i.9] standards. Additionally, the use of the terminologies as identified in ETSI EN 302 665 [i.1] should be reconsidered based on the general usage of these terms.

ITS information may be location-based. C-ITS information however is always location-based. Additionally, ITS applications are not all cooperative and, for instance, can be logistics oriented. The essential aspect of C-ITS is to bring awareness by sharing information about traffic related aspects and parameters recognized by C-ITS stations in an area in which these aspects and parameters may be of value to other C-ITS stations (C-ITS-Ss) where this information may be of safety relevance. For instance, Release 1 CAM transmission brings pure awareness. CAM provides the static and dynamic state of a C-ITS-S (for instance a vehicle) to all other C-ITS-Ss in the same safety relevance area.

CCAM [i.12] made a start with the identification of road and vehicle automation applications that require sharing information among the road infrastructure and road users as well as between road users themselves (i.e. V2X). Many are expected to be safety-related, but many also are not and therefore it can be expected that only a part of the CCAM [i.12] applications require direct safety-related communication within the C-ITS Ecosystem. The required information exchange is identified in ETSI TR 103 439 [i.6]. This includes, for instance, the sharing of HD map information and the exchange of awareness information about other road users that may not be detected by on-board sensors such as radars and cameras. Solutions will require different communications media as well as cooperative information exchange and CAM is just one of them. The Release 2 MCO communication potential requirements are captured in ETSI TR 103 439 [i.6] to serve both C-ITS and CCAM applications.

5 The Cooperative-Intelligent Transport Systems

5.1 Introduction

According to clause 4, the ETSI ITS Release 1 ETSI TR 102 607 [i.2] set of specifications covers the C-ITS applications and not the whole area of ITS applications. This is the case, although the ITS communication architecture as defined in the ETSI EN 302 665 [i.1] does provide a generalized ITS communication architecture. The following clauses specify C-ITS specific elements in more detail.

5.2 The C-ITS Ecosystem

Clause 4 identified the difference between ITS and C-ITS. In relation to that in ITS many Ecosystem are already today represented. There are, for instance, Ecosystems related to truck management, public transport or logistics. Beside these there is the safety and CCAM related C-ITS Ecosystem. The C-ITS Ecosystem includes all elements of C-ITS that are required to realize awareness user services based on direct information exchange. These elements may include other information exchange communication sub-systems, including GNSS (GPS/Galileo/…) as illustrated in Figure 1 taken from ETSI EN 302 665 [i.1] to facilitate C-ITS and CCAM application realization as identified in ETSI TR 103 439 [i.6].

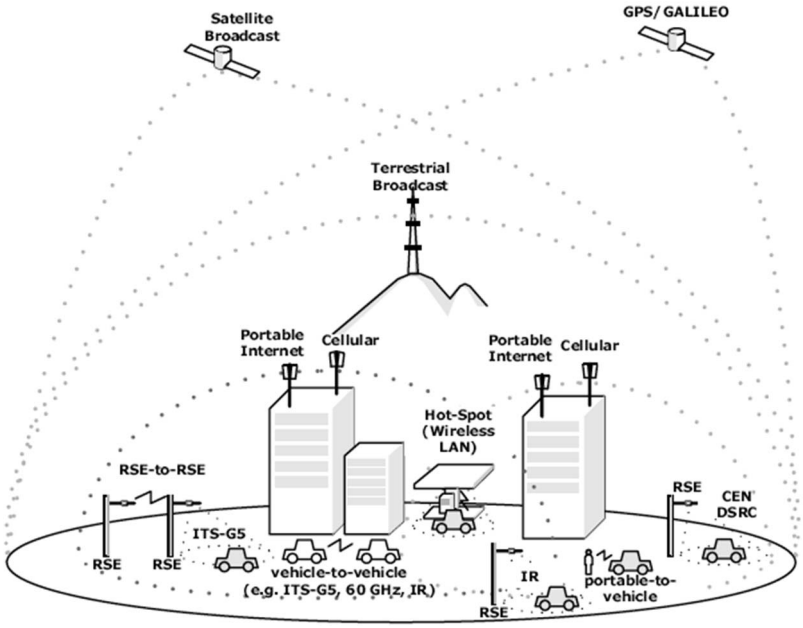

Figure 1: Communication systems illustration

The C-ITS operation is based on an information-sharing mechanism, as identified in clause 4. The lower C-ITS communication layers do not include mechanisms to inform that there is information available or to see whether there are others who have the interest to receive safety information. In the C-ITS Ecosystem, multiple C-ITS-Ss share information via direct ad-hoc communication. Possibly the same information can be sent through alternative communication methods.

5.3 C-ITS Communications

For the exchange of information, any communication method can be used which satisfy the functional, operational, and legal requirements. Figure 2 shows the C-ITS communication architecture including information sharing via direct ad-hoc communications and infrastructure-based cellular 3G, 4G, and 5G communications to enable also the information exchange via cellular networks within the same C-ITS Ecosystems.

Figure 2 shows that the information managed at the traffic management centre may use direct ad-hoc communication and/or cellular networks for its information distribution.

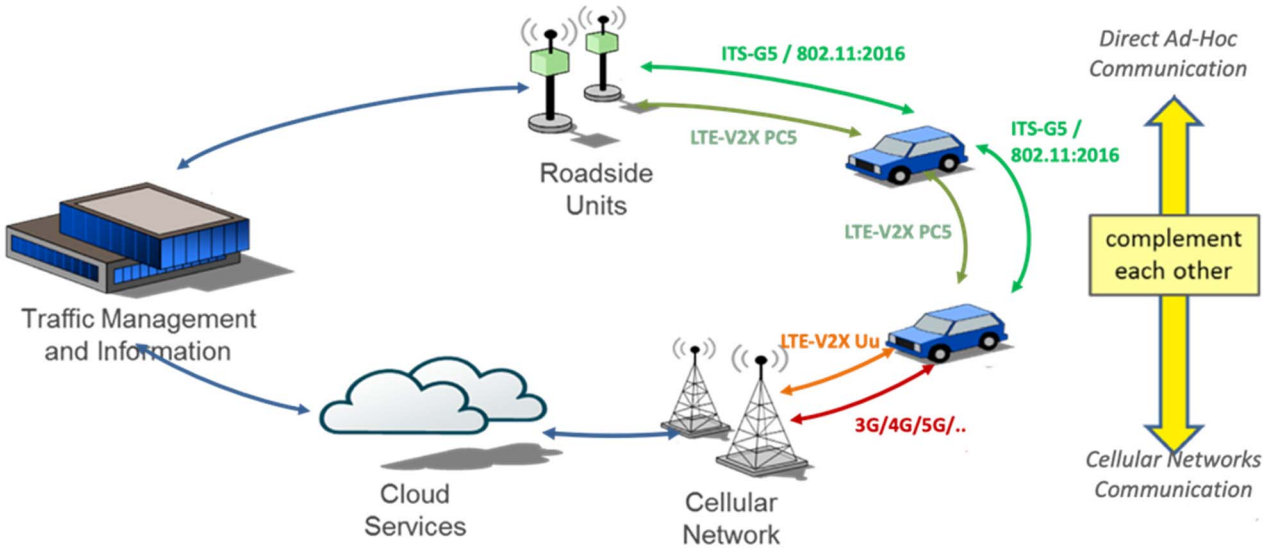

Figure 2: Release 2 C-ITS communication

5.4 C-ITS Station architecture

As identified in clause 4, various interpretations of the ITS communication architecture and terminologies are in use, whether in ETSI EN 302 665 [i.1], ETSI (3GPP) ETSI TS 136 300 [i.10], IEEE (e.g. IEEE 1609.3 [i.11]), or ISO 21217:2014 [i.9], all use the OSI model [i.8] as a basis. With respect to the OSI model, ETSI EN 302 665 [i.1], Release 1, is not consistent in the use of the terminology; the security and management are identified as entities while one will have a varying amount of management entities where each of the entities may support different functions on different layers. In other standards such as from IEEE and 3GPP, functional planes are recognized. In ETSI (3GPP) ETSI TS 136 300 [i.10] the management or control plane and the data plane are recognized. IEEE 1609.3 [i.11] additionally identifies the security plane. Each plane is characterized by a specific type of information flow between the layers. In the management plane, there are interfaces between management entities residing in the same or different layers, each having their specific interfaces between themselves and with for instance data entities (to derive management information). The ETSI EN 302 665 [i.1] also uses the word Service Access Point (SAP) without specifying the exact meaning and puts SAP, interface and application programming interfaces (APIs) at the same level. A SAP is a conceptional reference point between two adjacent layers. An interface is an exchange point between entities on adjacent layers that is going through an SAP. An API is an interface that one entity provides for other entities. In future standards in the C-ITS domain those concepts should be used accordingly.

For Release 2 the basic functional view on the C-ITS station architecture is given in Figure 3. It identifies several basic functions to be expected in a C-ITS-S. The Data Plane enables the exchange of information among C-ITS-S. The Security Plane handles all the security aspects (e.g. authentication, authorization, etc.). The Management Plane contains the necessary functions for the management of the different protocol layers.

The Applications and Facilities Layer entities are access technology independent. The Networking & Transport Layer entities may be access technology-dependent. The Access Layer management entities which may communicate with other layer entities are access technology-dependent.

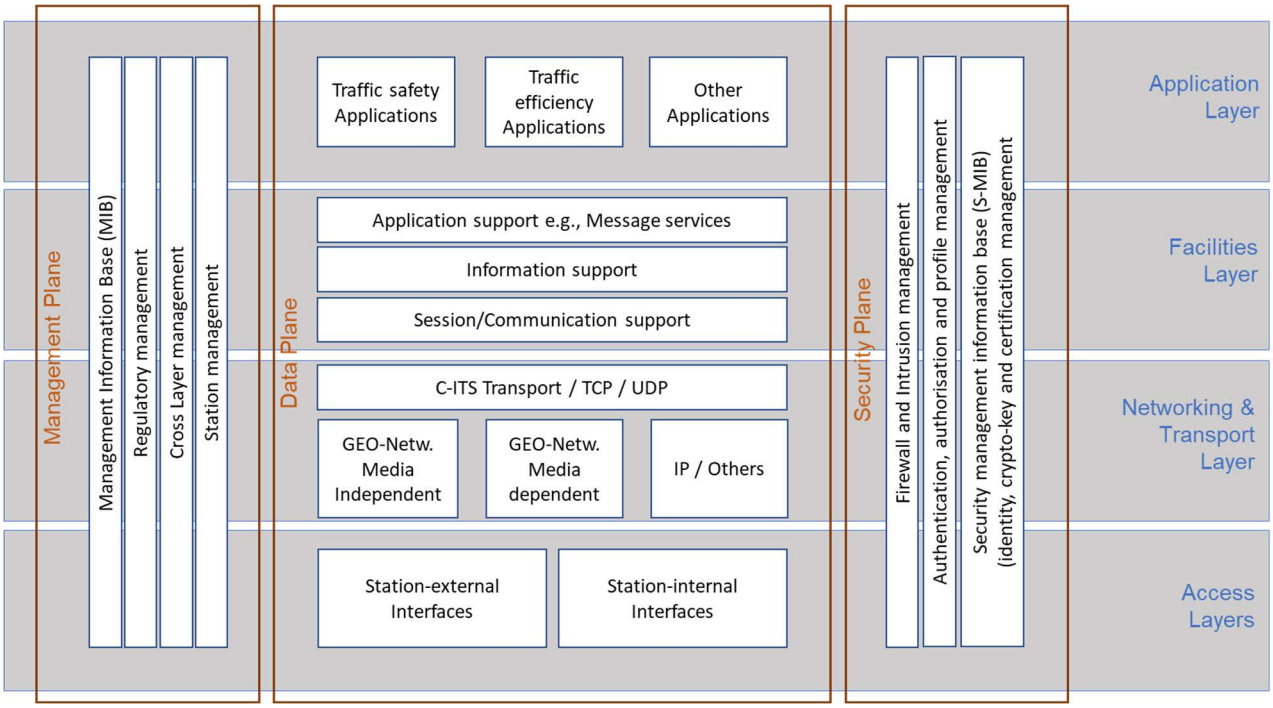

Figure 3: Functional view of the C-ITS station architecture based on an extended OSI model

In this functional view various entities are recognized specific to the plane they are active on. Figure 4 illustrates the C-ITS management, data, and security entities and it can be recognized that planes may cover all layers.

For the clarification of the operation of management, data or security entities, C-ITS specifications can represent this by including separated figures for the different planes relevant for the realization of each functionality. This to recognize and specify the relevant interfaces. The underlaying C-ITS specifications, e.g. MCO, may therefore include separate figures for each of the planes of the C-ITS station architecture.

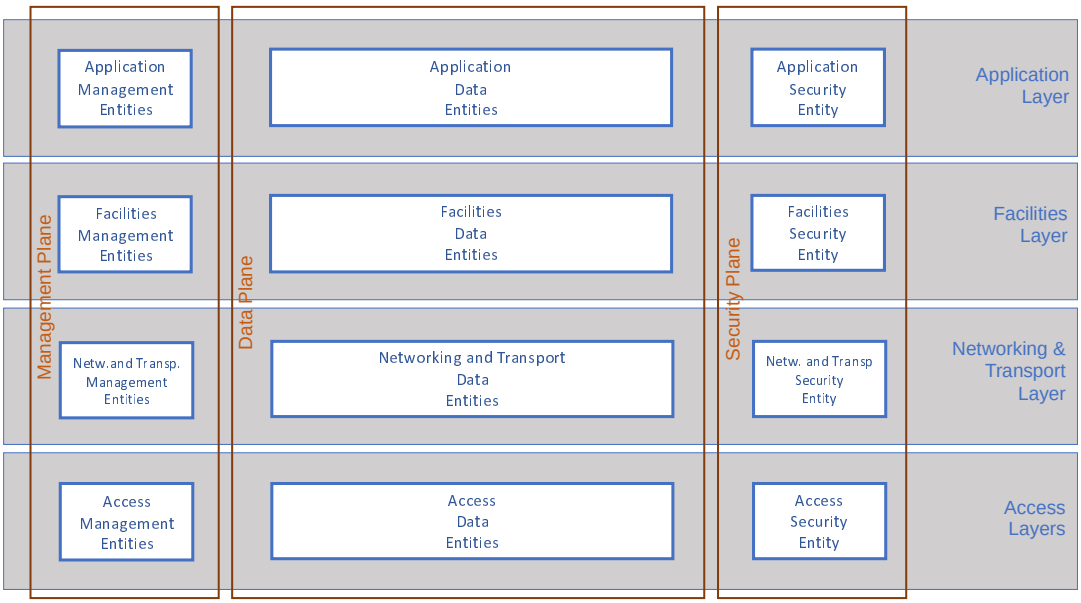

Figure 4: Entities in the C-ITS station architecture

6 MCO Communication Architecture Requirements

6.1 Introduction

This clause includes the architectural requirements as identified in the ETSI TR 103 439 [i.6]. Each of the following clauses lists a set of requirements related to specific specification or set of specifications of Release 2.

6.2 C-ITS MCO operation

As identified in clause 5.3, the C-ITS operational system identifies communication between C-ITS-Ss requiring MCO specific measures, which ensure concurrent operation of applications in all communication conditions:

- MCO is only applicable to direct short-range communications for C-ITS and CCAM since standard cellular networks have defined their own methods for managing information routing and managing communication channels.
- As information exchange via C-ITS communication is not managed at the networking and transport layer, as application and service requirement are only available at the facilities and application layer, the information routing shall be managed at the facilities layer for a close interaction with applications and services and their requirements. Any routing of information is functionally determined and can be message specific. Any MCO entity functionally responsible for managing information exchange shall reside at the facilities layer independent of the technologies used at the lower layers.
- MCO functionalities require information from other entities to perform their task(s).
- MCO functionalities may have interfaces to other facility services and applications to be able to determine the information exchange requirements from sourcing applications to maintain an overview of the information exchange requirements of all sourcing application such it may be able to assign exchange capabilities to applications statically and/or dynamically.
- Although channel interference levels are specified in ETSI EN 302 571 [i.14] (for Release 2 possibly to be updated), MCO functionalities shall safeguard that information initiated by applications as a total does comply the congestion limits at the facilities layer level as MCO is the functionality aware of the existence of all C-ITS information exchanging applications.
- There may be many sourcing applications active in a C-ITS-S, which are not and cannot be aware of each other's behaviour. An MCO service shall maximize the predictable operation by providing information to these entities about the information exchange possibilities.
- MCO functionalities shall be interoperable and backward compatible with Release 1 specifications as far as they are implemented.
- In a C-ITS constellation, C-ITS-Ss may exist which are equipped with various single or multiple channel radio configurations. MCO shall ensure that these configurations can coexist within the same constellation.
- C-ITS access layer may be monitoring and measuring the behaviour of information on the channel or channels (e.g. channel load) of only selected channels based on single or multiple channel radio configurations at C-ITS-S. To realize smooth MCO operation of semi-static or dynamic offloading/switching of application(s) to different channels, each C-ITS-S may need channel status information of other channels. MCO functionalities shall ensure C-ITS-S acquires channel status information for all associated channels.

6.3 C-ITS Sourcing Applications for MCO

As identified in the Release 1 of ETSI EN 302 665 [i.1], ITS are systems that aim to provide user services related to different modes of transport and traffic management. ETSI ITS C-ITS-related standards aim to realize conformity and interoperability for C-ITS and CCAM safety-related applications and traffic efficiency applications. C-ITS has the objective to maximize the awareness, to enable of making better and safer transport-related decisions.

Clause 4.2 of ETSI TR 103 439 [i.6], identifies that all ITS applications operate in one of the four following phases: information, active safety, integral safety, and passive safety. C-ITS is focusing on active and integral safety. The following MCO related communication architecture related requirements are identified:

- Cellular network-managed communication networks between C-ITS networks, requiring applications only know the destination address of the information. Underlying communication protocols handle the communications whatever technology is used. Ad-hoc direct communications inside C-ITS networks have no network management; C-ITS sourcing applications shall make their information available through specified communication means, e.g. channel assignment methods and technology parameters in order to ensure that data consuming applications can receive the relevant information.

- There may be many sourcing applications active in a C-ITS-S, which are not and cannot be aware of each other's behaviour. To allow MCO services to maximize the predictability of the operation of sourcing applications, the sourcing applications shall provide their information exchange requirements statically and possibly dynamically to these MCO services.

- The application communication requirements of specific user groups or specific use cases, may be managed by a service provider or by the use case itself e.g. through the use of Service Announcement (SA) mechanisms such as defined in Release 1 of ETSI EN 302 890-1 [i.3]. The support for generic services shall be realized by assigning specific communication requirements such as the channel used by SA to enable access for use by general services. The specific channel for safety related and none safety general SAs shall be specified.

NOTE: This could be realized as identified in the ETSI TR 103 439 [i.6].

6.4 C-ITS Facilities for MCO

6.4.1 General Aspects

The main part of the MCO management functionality is technology independent and reside at the facilities layer, other MCO entities may exist on any other layer:

- Other Release 2 C-ITS facilities layer services, entities and functions shall enable MCO, e.g. Position and Time service to enable MCO to operate.

- In MCO enabled C-ITS-Ss, the C-ITS-S facilities layer shall exchange MCO-related information to other layers.

- The MCO management functionality shall include measures ensuring that applications get predictable access to the communication means. It shall provide information to sourcing applications about the communication possibilities for each of them, based on the knowledge about their needs and the communication capabilities.

6.4.2 C-ITS Position and time

C-ITS-Ss that exchange information shall have the same notion of position and time:

- Position and time references shall be used as specified for each ETSI C-ITS release to meet the application position and time accuracy requirements such that MCO can relate time references used by different applications.

- A minimum set of position and time requirements shall be set for each specific release to support all identified applications part of the release. Depending on the technologies used, more stringent time requirements may be applicable.

- C-ITS applications may trigger message generation of different message types on different channels. Any MCO service shall ensure that the messages are transmitted within an acceptable time window for the proper operation of the C-ITS applications. MCO specifications shall identify to what position and time-related requirements applications shall comply.

- The Position and Time services shall provide the Position and Time parameters with an equal or better accuracy as required by the MCO functionalities.

6.5 C-ITS Networking and Transport for MCO

- Release 2 C-ITS networking & transport layer entities, including MCO entities at this layer, shall provide MCO functionalities and MCO-related operational parameters to other layers within a C-ITSs and to other C-ITS-Ss. This may include cross-channel packet forwarding, the exchange of channel-specific, media-dependent parameters as identified in Release 1 of ETSI TS 103 175 [i.4], and others.

6.6 C-ITS Access for MCO

- Release 2 C-ITS access layer functionalities shall provide technology independent parameters representing information about the behaviour of information on the channel or channels. e.g. channel load, number of available channels and other parameters to MCO entities at the same layer or other layers.

- The C-ITS access layer shall be capable of setting the MCO-related parameters as provided by the upper layers.

Annex A (informative): Change History

Date	Version	Information about changes
2020-10	2.1.1	Initial Version

History

Document history		
V2.1.1	November 2021	Publication