ETSI TS 103 900 V2.2.1 (2025-02)

Intelligent Transport Systems (ITS);
Facilities Layer;
Cooperative Awareness Service;
Release 2

Reference
RTS/ITS-001983

Keywords
application, ITS, safety, service, transport

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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

Cooperative awareness within road traffic means that road users and roadside infrastructure are informed about each other's position, dynamics and attributes. Road users are all kind of road vehicles like cars, trucks, motorcycles, bicycles or even pedestrians and roadside infrastructure equipment including road signs, traffic lights or barriers and gates. The awareness of each other is the basis for several road safety and traffic efficiency applications with many use cases, for example as described in ETSI TR 102 638 [i.1]. It is achieved by regular exchange of information among vehicles (V2V, in general all kind of road users) and between vehicles and road side infrastructure (V2I and I2V) based on wireless networks, called V2X network and as such is part of Intelligent Transport Systems (ITS).

The information to be exchanged for cooperative awareness is packed up in the periodically transmitted Cooperative Awareness Message (CAM). The construction, management and processing of CAMs is done by the Cooperative Awareness service (CA service), which is part of the facilities layer within the ITS communication architecture ETSI TS 103 898 [i.2] supporting several ITS applications.

The CA service is a mandatory facility for all kind of ITS-Stations (ITS-S), which take part in the road traffic (vehicle ITS-S, personal ITS-S, etc.). The present document focuses on the specifications for CAMs transmitted by all vehicle ITS-Ss participating in the V2X network. Nevertheless, the present document defines the CAM format with flexibility in order to be easily extendable for the support of other types of ITS-Ss or future ITS applications.

The requirements on the performance of the CA service, the content of the CAM and the quality of its data elements are derived from the Basic Set of Applications (BSA) as defined in ETSI TR 102 638 [i.1] and in particular from the road safety applications as defined in the C2C-CC Basic System Profile [i.3] and the C-Roads Release [i.4]. Further use cases are specified in the C2C-CC Roadmap [i.5].

The Release 1 edition of the CA service has been published as ETSI EN 302 637-2 [i.6]. The first Release 2 version of the present document provides an improved specification of the Release 1 version as a basis for future Release 2 versions of the CA service. The present document specifies extensions to the CAM Release 1 format to support additional use cases in a way allowing the facilities layer standard to be used with different security and lower layer technologies.

To ensure backward compatibility, all future CA service Release 2 versions will be based on this first CA service Release 2 version. Further it will be ensured that the Release 1 implementations can receive and decode Release 2 CAM and utilize the Release 1 content without the need to understand the Release 2 content.

1 Scope

The present document provides the specification of the Release 2 Cooperative Awareness (CA) service.

This includes definition of the syntax and semantics of the Cooperative Awareness Message (CAM) and detailed specifications on the message handling.

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 in the ETSI docbox.

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.

[1] ETSI TS 102 894-2: "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary; Release 2".

[2] Recommendation ITU-T X.691/ISO/IEC 8825-2 (02/2021): "Information technology -- ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)".

[3] ETSI TS 103 097: "Intelligent Transport Systems (ITS); Security; Security header and certificate formats; Release 2".

[4] ETSI TS 103 836-4-1: "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; Release 2".

[5] ETSI TS 103 836-5-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol; Release 2".

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 TR 102 638: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions".

[i.2] ETSI TS 103 898: "Intelligent Transport Systems (ITS); Communications Architecture; Release 2".

[i.3] Car2Car Communication Consortium: "Basic System Profile".

[i.4] C-Roads: "The C-Roads Platform publishes harmonised C-ITS specifications for Europe".

[i.5] Car2Car Communication Consortium: "Guidance for day 2 and beyond roadmap".

[i.6] ETSI EN 302 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[i.7] ETSI TS 103 938: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Local Dynamic Map (LDM); Release 2".

[i.8] ISO 1176: "Road vehicles - Masses - Vocabulary and codes".

[i.9] ETSI TS 102 894-1: "Intelligent Transport Systems (ITS); Users and applications requirements; Part 1: Facility layer structure, functional requirements and specifications; Release 2".

[i.10] ETSI TS 103 831: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Decentralized Environmental Notification Service; Release 2".

[i.11] Void.

[i.12] ETSI TS 103 301: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services; Release 2".

[i.13] Void.

[i.14] Void.

[i.15] ETSI TS 103 836-3: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network Architecture; Release 2".

[i.16] ETSI TS 102 940: "Intelligent Transport Systems (ITS); Security; ITS communications security architecture and security management; Release 2".

[i.17] ETSI TS 102 965: "Intelligent Transport Systems (ITS);Application Object Identifier (ITS-AID); Registration; Release 2".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 898 [i.2], LDM given in ETSI TS 103 938 [i.7] and the following apply:

basic set of applications: group of applications, supported by vehicular communication system

NOTE: The basic set of applications is defined in ETSI TR 102 638 [i.1].

Cooperative Awareness (CA) service: facility at the ITS-S facilities layer to generate, receive and process the CAM

Cooperative Awareness Message (CAM): CA service PDU

Cooperative Awareness Message (CAM) data: partial or complete CAM payload

Cooperative Awareness Message (CAM) protocol: ITS facilities layer protocol that operates the CAM transmission and reception

empty vehicle: complete vehicle kerb mass as defined in ISO 1176 [i.8], clause 4.6

Vehicle-to-Everything (V2X): type of communication that includes, e.g. Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and/or Infrastructure-to-Vehicle (I2V), Vehicle-to-Pedestrian (V2P) and/or Pedestrian-to-Vehicle (P2V)

3.2 Symbols

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

IF.CAM	Interface between CAM service and LDM or ITS application
IF.FAC	Interface between CAM service and other facilities layer entities
IF.N&T	Interface between CAM service and ITS networking & transport layer
IF.SEC	Interface between CAM service and ITS security entity

3.3 Abbreviations

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

API	Application Programming Interface
ASN.1	Abstract Syntax Notation 1
BSA	Basic Set of Applications
BTP	Basic Transport Protocol
C2C-CC	Car to Car Communication Consortium
CA	Cooperative Awareness
CAM	Cooperative Awareness Message
DCC	Decentralized Congestion Control
DDP	Device Data Provider
DE	Data Element
DENM	Decentralized Environmental Notification Message
DF	Data Frame
FL-SDU	Facility Layer Service Data Unit
GN	GeoNetworking
HF	High Frequency
HMI	Human Machine Interface
I2V	Infrastructure-to-Vehicle
ID	IDentifier
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITS-AID	ITS-Application IDentifier
ITS-S	ITS Station
ITU-T	International Telecommunication Union - Telecommunications
LDM	Local Dynamic Map
LF	Low Frequency
MIB	Management Information Base
MSB	Most Significant Bit
N&T	Networking & Transport layer
OID	Object IDentifier
PCI	Protocol Control Information
PDU	Packet Data Unit
POTI	Position and Time management
RSU	Road Side Unit
SHA	Secure Hash Algorithm
SHB	Single-Hop Broadcasting
SSP	Service Specific Permissions
TR	Technical Report
TS	Technical Specification
UPER	Unaligned Packed Encoding Rules
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything

4 CA service introduction

4.1 Background

Cooperative Awareness Messages (CAMs) are messages exchanged in the ITS network between ITS-Ss to create and maintain awareness of each other and to support cooperative performance of vehicles using the road network. A CAM contains status and attribute information of the originating ITS-S. The content varies depending on the type of the ITS-S. For vehicle ITS-Ss the status information includes time, position, motion state, activated systems, etc. and the attribute information includes data about the dimensions, vehicle type and role in the road traffic, etc. On reception of a CAM the receiving ITS-S becomes aware of the presence, type, and status of the originating ITS-S. The received information can be used by the receiving ITS-S to support several ITS applications. For example, by comparing the status of the originating ITS-S with its own status, a receiving ITS-S is able to estimate the collision risk with the originating ITS-S and if necessary may inform the driver of the vehicle via HMI or in-vehicle system. Multiple ITS applications may rely on the CA service. It is assigned to domain application support facilities in ETSI TS 102 894-1 [i.9].

Besides the support of applications the awareness of other ITS-S gained by the CA service may be used in the networking & transport layer for the position dependent dissemination of messages, e.g. DENM [i.10] by GeoBroadcasting as specified in ETSI TS 103 836-4-1 [4]. The generation and transmission of CAM is managed by the CA service by implementing the CAM protocol.

4.2 Services provided by CA service

The CA service is a facilities layer entity that operates the CAM protocol. It provides two services: sending and receiving of CAMs. The CA service uses the services provided by the protocol entities of the ITS networking & transport layer to disseminate the CAM.

4.3 Sending CAMs

The sending of CAMs comprises the generation and transmission of CAMs. In the course of CAM generation the originating ITS-S composes the CAM, which is then delivered to the ITS networking & transport layer for dissemination. The dissemination of CAMs may vary depending on the applied communication system. CAMs may be sent by the originating ITS-S to all ITS-Ss within the direct communication range. This communication range may, inter alia, be influenced in the originating ITS-S by changing the transmit power.

CAMs are generated periodically with a frequency controlled by the CA service in the originating ITS-S. The generation frequency is determined taking into account the change of own ITS-Ss status, e.g. change of position or speed as well as the radio channel load.

4.4 Receiving CAMs

Upon receiving a CAM, the CA service makes the content of the CAM available to the ITS applications and/or to other facilities within the receiving ITS-S, such as a Local Dynamic Map (LDM) [i.7].

5 CA service functional specification

5.1 CA service in the ITS architecture

The CA service is a facilities layer entity of the ITS-S architecture as defined in ETSI TS 103 898 [i.2]. It may interface with other entities of the facilities layer and with the ITS application layer in order to collect relevant information for CAM generation and to forward the received CAM content for further processing. The CA service within the ITS-S architecture and the logical interfaces to other layers and potentially to entities within the facility layer are presented in Figure 1.

In ITS-S, entities for the collection of data may be the Device Data Provider (DDP) and the Position and Time management (POTI) and for received data the Local Dynamic Map (LDM) and/or ITS application as receiving entities. For vehicle ITS-S, the DDP may be connected with the vehicle network and provides the vehicle status information. The POTI provides the position of the ITS-S and time information. The LDM as outlined in ETSI TS 103 938 [i.7] is a database in the ITS-S, which may be updated with received CAM data. ITS applications may retrieve information from the LDM for further processing.

The CA service interfaces through the IF.N&T with the Networking & Transport (N&T) layer for exchanging of CAMs with other ITS-Ss, the IF.Sec with the security entity to access security services for CAM transmission and CAM reception, the IF.Mng with the management entity and the IF.App with the application layer if received CAM data are provided directly to the applications.

The operation of the CA service on ITS infrastructure devices is specified in ETSI TS 103 301 [i.12].

The functionalities of the CA service are defined in clause 5.2, the interfaces in Figure 2 are defined in clause 5.3.

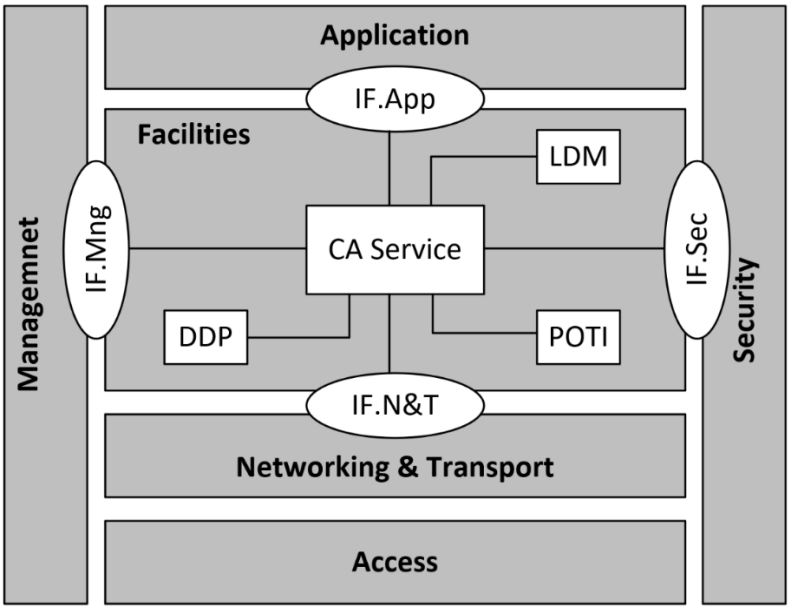

Figure 1: CA service within the ITS-S architecture

5.2 CA service functional architecture

The CA service is part of the Application support domain of the facilities layer according to ETSI TS 102 894-1 [i.9]. Figure 2 shows the functional block diagram with the functional blocks of the CA service and interfaces to other facilities and layers, which are detailed in the following. The interfaces to other entities and layers are defined in clause 5.3.

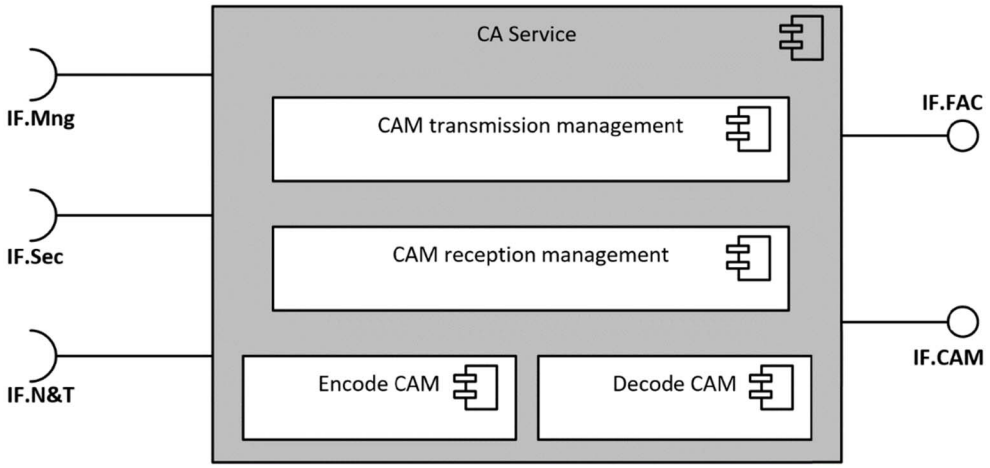

Figure 2: Functional block diagram of the CA service

For sending and receiving CAMs, the CA service shall provide the following sub-functions:

- **Encode CAM:** This sub-function constructs the CAM according to the format specified in annex A. The most recent device data shall be included in CAM.
- **Decode CAM:** This sub-function decodes the received CAMs.
- **CAM transmission management:** This sub-function implements the protocol operation of the originating ITS-S, as specified in clause B.2, including in particular:
  - Activation and termination of CAM transmission operation.
  - Determination of the CAM generation frequency.
  - Trigger the generation of CAM.
- **CAM reception management:** This sub-function implements the protocol operation of the receiving ITS-S, as specified in clause B.3, including in particular:
  - Trigger the "decode CAM" function at the reception of CAM.
  - Provision of the received CAM data to LDM and/or ITS applications of the receiving ITS-S.
  - Optionally, checking the information of received CAMs.

5.3 Interfaces of the CA service

5.3.1 Interface to ITS application layer

An ITS application is an application layer entity that implements the logic for fulfilling one or more ITS use cases. Example ITS applications are defined in the C2C-CC Basic System Profile [i.3], the C-Roads Release [i.4] and the C2C-CC Roadmap [i.5].

For the provision of received data the CA service provides the interface IF.CAM to LDM or to ITS application layer, as illustrated in Figure 2.

NOTE: The interface to the ITS application layer may be implemented as API and data are exchanged between the CA service and ITS applications via this API. In another possible implementation, the interface to the application layer may be implemented as IF.App.

5.3.2 Interface to data provisioning facilities

For the generation of CAMs, the CA service interacts with other facilities layer entities in order to obtain the required data. This set of facilities that provides data for CAM generation is referred to as data provisioning facilities. Data is exchanged between the data provisioning facilities and the CA service via the interface IF.FAC.

NOTE: Specifications of the interface to the data provisioning facilities and the corresponding protocols are out of scope of the present document.

5.3.3 Interface to the Networking & Transport layer

The CA service exchanges information with ITS networking & transport layer via the interface IF.N&T as depicted in Figure 2.

At the originating ITS-S, the CA service shall provide the CAM embedded in a Facility-Layer Service Data Unit (FL-SDU) together with Protocol Control Information (PCI) to the ITS networking & transport layer. At the receiving ITS-S, the ITS networking & transport layer will pass the received CAM to the CA service, if available.

The minimum data set that shall be passed between CA service and ITS networking & transport layer for the originating and receiving ITS-S is specified in Table 1.

Table 1: Data passed between CA service and the ITS networking & transport layer

Category	Data	Data requirement	Mandatory/Optional
Data passed from the CA service to the ITS networking & transport layer	CAM	*{cam}* as specified in annex A	Mandatory
	PCI	Depending on the protocol stack applied in the networking and transport layer as specified in clause 5.3.4	Optional
Data passed from the ITS networking & transport layer to the CA service	Received CAM	*{cam}* as specified in annex A	Mandatory

The interface between the CA service and the networking & transport layer relies on the services of the GeoNetworking/BTP stack as specified in clause 5.3.4.1 or to the IPv6 stack and the combined IPv6/GeoNetworking stack as specified in clause 5.3.4.2.

5.3.4 Interfaces protocol stacks of the networking & transport layer

5.3.4.1 Interface to the GeoNetworking/BTP stack

A CAM may rely on the services provided by the GeoNetworking/BTP stack. If this stack is used, the GN packet transport type Single-Hop Broadcasting (SHB) shall be used. In this scenario only nodes in direct communication range may receive the CAM.

PCI being passed from CA service to the GeoNetworking/BTP stack shall comply with Table 1 and Table 2.

Table 2: PCI from CA service to GeoNetworking/BTP at the originating ITS-S

Data	Data requirement	Mandatory/Conditional
BTP type	BTP header type B (ETSI TS 103 836-5-1 [5], clause 7.2.2)	Conditional The data shall be passed if the value is not provided by the ITS-S configuration, e.g. defined in a Management Information Base (MIB) or if the value is different from the default value as set in the MIB.

Data	Data requirement	Mandatory/Conditional
Destination port	As specified in ETSI TS 103 836-5-1 [5] (see note)	Conditional The data shall be passed if the value is not provided by the ITS-S configuration, e.g. defined in a Management Information Base (MIB) or if the value is different from the default value as set in the MIB.
Destination port info	As specified in ETSI TS 103 836-5-1 [5]	Conditional The data shall be passed if the value is not provided by the ITS-S configuration, e.g. defined in a Management Information Base (MIB) or if the value is different from the default value as set in the MIB.
GN Packet transport type	GeoNetworking SHB	Conditional The data shall be passed if the value is not provided by the ITS-S configuration, e.g. defined in a Management Information Base (MIB) or if the value is different from the default value as set in the MIB.
GN Communication profile	Unspecified, Direct communication	Conditional The data shall be passed if the value is not provided by the ITS-S configuration, e.g. defined in a Management Information Base (MIB) or if the value is different from the default value as set in the MIB.
GN Security profile	SECURED or UNSECURED	Conditional The data shall be passed if the value is not provided by the ITS-S configuration, e.g. defined in a Management Information Base (MIB) or if the value is different from the default value as set in the MIB.
GN Traffic Class	As defined in ETSI TS 103 836-4-1 [4]	Mandatory.
GN Maximum packet lifetime	Shall not exceed 1 000 ms	Mandatory.
Length	Length of the CAM	Mandatory.

5.3.4.2 Interface to the IPv6 stack and the combined IPv6/GeoNetworking stack

A CAM may use the IPv6 stack or the combined IPv6/GeoNetworking stack for CAM dissemination as specified in ETSI TS 103 836-3 [i.15].

NOTE: When the CAM dissemination makes use of the combined IPv6/GeoNetworking stack, the interface between the CA service and the combined IPv6/GeoNetworking stack may be identical to the interface between the CA service and IPv6 stack. The transmission of CAM over the IPv6 stack is out of scope of the present document.

5.3.5 Interface to the ITS management entity

The CA service may exchange primitives with management entity of the ITS-S via the IF.Mng interface as depicted in Figure 1. In case of the ITS-G5 access layer, an originating ITS-S the CA service gets information for setting the *T_GenCam_DCC* from the management entity defined in clause 6.1.3 via the IF.Mng interface, as depicted in Figure 2.

NOTE: Specifications of the IF.Mng and the corresponding protocol are out of scope of the present document.

5.3.6 Interface to the ITS security entity

The CA service may exchange primitives with the security entity of the ITS-S via the IF.Sec interface as depicted in Figure 1 using the IF.Sec interface provided by the security entity as depicted in Figure 2.

NOTE: Specifications of the IF.Sec and the corresponding protocol are out of the scope of the present document.

6 CAM dissemination

6.1 CAM dissemination concept

6.1.1 CAM dissemination requirements

Point-to-multipoint communication, specified in ETSI TS 103 836-3 [i.15], is used for CAMs dissemination. The CAM shall be disseminated only from the originating ITS-S in a single hop to the receiving ITS-Ss located in the direct communication range of the originating ITS-S. A received CAM shall not be forwarded to other ITS-Ss.

6.1.2 CA service activation and termination

CA service activation may vary for different types of ITS-S, e.g. vehicle ITS-S, road side ITS-S, personal ITS-S. As long as the CA service is active, the CAM generation shall be triggered and managed by the CA service.

For vehicle ITS-S, the CA service shall be activated with the ITS-S activation. The CA service shall be terminated when the ITS-S is deactivated.

The activation and deactivation of the CA service other than the vehicle ITS-S is not specified in the present document.

6.1.3 CAM generation frequency management for vehicle ITS-Ss

The CAM generation frequency is managed by the CA service; it defines the time interval between two consecutive CAM generations. The upper and lower limits of the transmission interval are set as follows:

- The CAM generation interval shall not be less than *T_GenCamMin* = 100 ms. This corresponds to the CAM generation rate of 10 Hz.
- The CAM generation interval shall not be greater than *T_GenCamMax* = 1 000 ms. This corresponds to the CAM generation rate of 1 Hz.

Within these limits the CAM generation is triggered depending on the originating ITS-S dynamics and the channel congestion status. In case the dynamics of the originating ITS-S lead to a reduced CAM generation interval, this interval is maintained for a number of consecutive CAMs.

The conditions for triggering the CAM generation shall be checked repeatedly every *T_CheckCamGen.* *T_CheckCamGen* shall be equal to or less than *T_GenCamMin*.

The parameter *T_GenCam_Dcc* shall provide the minimum time interval between two consecutive CAM generations in order to reduce the CAM generation according to the channel usage of the undelaying radio technology. This facilitates the adjustment of the CAM generation rate to the remaining capacity of the radio channel in case of channel congestion. The parameter *T_ GenCam_Dcc* can be provided by the management entity. The value range of *T_GenCam_Dcc* shall be limited to $T\_GenCamMin \leq T\_GenCam\_Dcc \leq T\_GenCamMax$. If *T_GenCam_Dcc* is not provided, then *T_GenCam_Dcc* shall be set to *T_GenCamMin.*

The parameter *T_GenCam* represents the currently valid upper limit of the CAM generation interval. The default value of *T_GenCam* shall be *T_GenCamMax*. *T_GenCam* shall be set to the time elapsed since the last CAM generation, if a CAM is triggered due to condition 1). After triggering the number of *N_GenCam* consecutive CAMs due to condition 2), *T_GenCam* shall be set to *T_GenCamMax*. The value of the parameter *N_GenCam* can be dynamically adjusted according to some environmental conditions. The default and maximum value of *N_GenCam* shall be 3.

EXAMPLE: *N_GenCam* can be increased when approaching an intersection in order to increase the probability of CAM reception.

In detail the CAM generation trigger conditions shall be as follows:

1) The time elapsed since the last CAM generation is equal to or greater than *T_GenCam_Dcc*, as applicable, and one of the following ITS-S dynamics related conditions is given:

   - the absolute difference between the current heading of the originating ITS-S and the heading included in the CAM previously transmitted by the originating ITS-S exceeds 4°;

   - the distance between the current position of the originating ITS-S and the position included in the CAM previously transmitted by the originating ITS-S exceeds 4 m;

   - the absolute difference between the current speed of the originating ITS-S and the speed included in the CAM previously transmitted by the originating ITS-S exceeds 0,5 m/s.

2) The time elapsed since the last CAM generation is equal to or greater than *T_GenCam* and is also equal to or greater than *T_GenCam_Dcc.*

If one of the above two conditions is satisfied when the CAM triggering condition is checked, a CAM shall be generated.

The process to check for the CAM triggering conditions shall be started at an arbitrary random point in time and shall not be synchronized with a real time clock.

When a CAM needs to be generated, the CA service shall construct the mandatory containers as specified in clause 7.1. The mandatory containers mainly include the high dynamic information of the originating ITS-S, as *{CAM.cam.basicContainer}* and *{CAM.cam.camParameters.highFrequencyContainer}* as specified in annex A. Optionally, a CAM may include optional data. The optional data mainly include the status of the originating ITS-S which is less dynamic, as *{CAM.cam.camParameters.lowFrequencyContainer}* and specific information as included for a specific type of originating ITS-S, as *{CAM.cam.camParameters.specialVehicleContainer}* as specified in annex A.

The low frequency container shall be included in the first CAM generation since the CA service activation. After that the low frequency container of CAM shall be included if time elapsed since the generation of the last CAM with the low frequency container generation is equal to or greater than 500 ms.

For special vehicles, the special-vehicle container shall be included in the first CAM generation since the CA service activation. After that, a special vehicle container shall be included if the time elapsed since the generation of the last CAM with a special vehicle container is equal to or greater than 500 ms.

For two wheeler vehicles (e.g. station type cyclist, moped or motorcycle), the two wheeler container shall be included in all CAMs starting from the CA service activation.

The eHorizon location sharing container may be included in CAMs generated by vehicles. The recommended inclusion algorithm includes the container in the first CAM when the required data is available. The container may be included after at least *T_GenCam_LocationSharing* time has passed since the previous inclusion. The recommended value for *T_GenCam_LocationSharing* is 1950 ms. The eHorizon location sharing container may be included earlier if the originator considers a discrepancy between the current and last reported container to be significant and potentially critical. To save bandwidth, sending earlier than after *T_GenCam_EHorizonLocationSharing* should only happen in exceptional cases.

NOTE 1: In order to get reliable segment behind and ahead, a vehicle usually needs some initial movement.

The very low frequency container shall be included in the second CAM generation since the CA service activation. After that the very low frequency container of CAM shall be included if time elapsed since the generation of the last CAM with the very low frequency container generation is equal to or greater than 10 seconds and if the low frequency and the special vehicle container are not included.

The path prediction container may be included in CAMs generated by vehicles. The recommended inclusion algorithm is the following. The algorithm may only include the container in the CAM if the environmental and driving conditions for prediction are met. The algorithm includes the container in the CAM if *T_GenCam_PathPrediction* time has passed and the low frequency container is not included in the current message. The path prediction container may also be included if at least *T_GenCam_PathPrediction* has passed since the last time the container was included and the last inclusion attempt failed due to the inclusion of the low frequency container. The recommended value for *T_GenCam_PathPrediction* is 950 ms. The path prediction container may be included earlier if the originator considers a discrepancy between the current and last reported container to be significant and potentially critical. To save bandwidth, sending earlier than after *T_GenCam_PathPrediction* should only happen in exceptional cases.

NOTE 2: The prediction environmental and driving conditions are outside of the scope of the present document.

The generalized lane position container may be included in CAMs generated by vehicles. The recommended inclusion algorithm includes the container in the first CAM when the required data is available. The algorithm may only include the container in the CAM if the environmental and driving conditions for lane position detection are met. The container may be included after at least *T_GenCam_GeneralizedLanePosition* time has passed since the previous inclusion. The recommended value for *T_GenCam_GeneralizedLanePosition* is 950 ms.

NOTE 3: The lane position detection environmental and driving conditions are outside of the scope of the present document.

The vehicle movement control container may be included in CAMs generated by vehicles. The recommended inclusion algorithm is the following. The algorithm may only include the container in the CAM if the related service requirements, environmental and driving conditions for example prediction of the future driving path are met. The recommended value for *T_GenCam_VehicleMovementControl* is 500 ms.

NOTE 4: The prediction of environmental and driving conditions are outside of the scope of the present document.

6.1.4 CAM generation frequency management for RSU ITS-Ss

The CAM generation frequency for RSU ITS-Ss defined by the time interval between two consecutive CAM generations shall be set in such a way, that at least one CAM is transmitted while a vehicle is in the communication zone of the RSU ITS-S and that an inlineP2pcdRequest for an unknown authorization authority certificate from that same vehicle can be answered according to ETSI TS 103 097 [3] at least once thereafter. The time interval shall be greater than or equal to 500 ms.

NOTE: The probability for the reception of a CAM from an RSU by a passing vehicle depends on the generation rate of the CAM and the time the vehicle is within the communication zone, which depends on the vehicle speed and the RSU transmission power.

6.1.5 CAM time requirement

6.1.5.1 CAM generation time

Besides the CAM generation frequency the time required for the CAM generation and the timeliness of the data taken for the message construction are decisive for the applicability of data in the receiving ITS-Ss. In order to ensure proper interpretation of received CAMs, each CAM shall be time-stamped.

NOTE: An acceptable time synchronization between the different ITS-Ss is expected.

Time required for a CAM generation shall be less than 50 ms. The time required for a CAM generation refers to the time difference between time at which CAM generation is triggered and time at which the CAM is delivered to networking transport layer.

6.1.5.2 CAM Time stamp

The following requirements shall apply:

- The time stamp given in the vehicle ITS-S CAM shall correspond to the time at which the reference position of the originating ITS-S given in this CAM was determined. The format and range of the time stamp is defined in ETSI TS 102 894-2 [1].
- The time stamp given in the RSU ITS-S CAM shall be the time of generation.
- The difference between CAM generation time and time stamp shall be less than 32 767 ms.

NOTE 1: This requirement is set to avoid time stamp wrap-around situation.

NOTE 2: The specification of the ITS-S Time precision and synchronization is out of scope of the present document.

6.2 CAM dissemination constraints

6.2.1 General Confidence Constraints

Several data elements of the CAM may vary with regard to accuracy or confidence. These confidence constraints are presented in the data element and data frame definitions as specified in annex A of the present document and in ETSI TS 102 894-2 [1].

6.2.2 Security constraints

6.2.2.1 Introduction

Clause 6.2.2 is applicable to ITS stations that use the trust model according to ETSI TS 102 940 [i.16] and ITS certificates according to ETSI TS 103 097 [3].

NOTE: For other scenarios, the trust model and the mechanisms for trust enforcement for inter-connected ITS stations can agreed among participating actors.

The security mechanisms for ITS consider the authentication of messages transferred between ITS-Ss with certificates. A certificate indicates its holder's permissions to send a certain set of messages and optionally privileges for specific data elements within these messages. The format for the certificates is specified in ETSI TS 103 097 [3].

Within the certificate the permissions and privileges are indicated by a pair of identifiers, the ITS-AID and the SSP.

The ITS-Application Identifier (ITS-AID) as given in ETSI TS 102 965 [i.17] indicates the overall type of permissions being granted: for example, there is an ITS-AID that indicates that the sender is entitled to send CAMs.

The Service Specific Permissions (SSP) is a field that indicates specific sets of permissions within the overall permissions indicated by the ITS-AID: for example, there may be an SSP value associated with the ITS-AID for CAM that indicates that the sender is entitled to send CAMs for a specific vehicle role.

An incoming signed CAM is accepted by the receiver if the certificate is valid and the CAM is consistent with the ITS-AID and SSP in its certificate.

6.2.2.2 Service Specific Permissions (SSP)

CAMs shall be signed using private keys associated to Authorization Tickets that contain SSPs of type BitmapSsp as specified in ETSI TS 103 097 [3].

The CAM-SSP octet scheme allows the SSP format to accommodate current and future versions of the present document. The octet scheme is constructed out of three octets as illustrated in Figure 3.

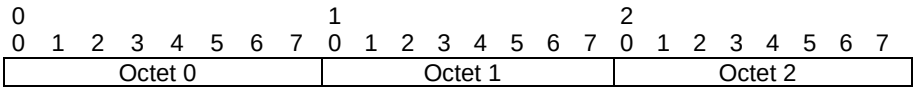

Figure 3: Format for the Octets

EXAMPLE of bit order: The decimal value 199 is represented as shown below:

0	1	2	3	4	5	6	7
1	1	0	0	0	1	1	1

For each octet, the Most Significant Bit (MSB) shall be the leftmost bit. The transmission order shall always be the MSB first. The first octet shall control the SSP version and be interpreted in the following way:

0: no version, length one octet; the value shall only be used for testing purposes.

1: first version, length three octets, SSP contains the CAM Release 1 information as defined in the present document.

2: second version, length three octets, SSP contains CAM Release 1 extended with CAM Release 2 information as defined in the present document.

3 to 255: reserved for future usage.

The SSP has a maximum length as specified in ETSI TS 103 097 [3]. The first octet shall reflect the version of the present document. As future versions of the present document are published, the first octet shall be incremented only in case of changes in the assignment of the already assigned SSP bits. The remaining octets shall be based on the permissions described in the present document (see Table 3 and Table 4).

Length of SSP is the length of the Octet String.

Table 3: Octet Scheme for CAM SSPs

Octet #	Description
0	SSP version control
1 to 2	service-specific parameter
3 to 30	reserved for future usage

A vehicle may be assigned one or more permissions.

When the ITS-AID is set for the CA service, the SSPs shall be defined as in Table 4.

Each bit in SSP represents a dedicated part of message content.

If SSP bit is set to 1, then the certificate is allowed to sign the message with correspondent content.

If SSP bit is set to 0, then the certificate is not allowed to sign the message with correspondent content, and the message signed using this certificate shall be considered as invalid from security perspective.

Table 4: SSP Definitions for Permissions in CAM

Octet	Bit position	Protected content	CAM content description
1	0 (80h) (MSBit)	protectedCommunicationZonesRSU	The message contains the stationType set to 'roadSideUnit' (15) RSUContainerHighFrequency container with the protectedCommunicationZonesRSU field present.
1	1 (40h)	publicTransportContainer	The message contains the vehicleRole set to 'publicTransport' (1) and the PublicTransportContainer present (see clause 7.4)
1	2 (20h)	specialTransportContainer	The message contains the vehicleRole set to 'specialTransport' (2) and the SpecialTransportContainer present (see clause 7.4)
1	3 (10h)	dangerousGoodsContainer	The message contains the vehicleRole set to 'dangerousGoods' (3) and the DangerousGoodsContainer present (see clause 7.4)
1	4 (08h)	roadWorksContainerBasic	The message contains the vehicleRole set to 'roadWork' (4) and the RoadWorksContainerBasic present (see clause 7.4)
1	5 (04h)	rescueContainer	The message contains the vehicleRole set to 'rescue' (5) and the RescueContainer present (see clause 7.4)
1	6 (02h)	emergencyContainer	The message contains the vehicleRole set to 'emergency' (6) and the EmergencyContainer present (see clause 7.4)
1	7 (01h) (LSBit)	safetyCarContainer	The message contains the vehicleRole set to 'safetyCar' (7) and the SafetyCarContainer present (see clause 7.4)
2	0 (80h) (MSBit)	closedLanes	The message contains the vehicleRole set to 'roadWork' (4) and the RoadWorksContainerBasic contains the closedLanes element present. The bit 4 of octet 1 shall be test to 1 if this bit is set to 1.
2	1 (40h)	requestForRightOfWay	The message contains the vehicleRole set to 'emergency' (6) and the EmergencyContainer contains the emergencyPriority element with the bit requestForRightOfWay (0) set to 1. The bit 6 of octet 1 shall be test to 1 if this bit is set to 1.

Octet	Bit position	Protected content	CAM content description
2	2 (20h)	requestForFreeCrossingAtATrafficLight	The message contains the vehicleRole set to 'emergency' (6) and the EmergencyContainer contains the emergencyPriority element with the bit requestForFreeCrossingAtATrafficLight (1) set to 1. The bit 6 of octet 1 shall be test to 1 if this bit is set to 1.
2	3 (10h)	noPassing	The message contains the vehicleRole set to 'safetyCar' (7) and the SafetyCarContainer contains the trafficRule element set to 'noPassing'. The bit 7 of octet 1 shall be test to 1 if this bit is set to 1.
2	4 (08h)	noPassingForTrucks	The message contains the vehicleRole set to 'safetyCar' (7) and the SafetyCarContainer contains the trafficRule element set to 'noPassingForTrucks'. The bit 7 of octet 1 shall be test to 1 if this bit is set to 1.
2	5 (04h)	speedLimit	The message contains the vehicleRole set to 'safetyCar' (7) and the SafetyCarContainer contains the speedLimit element present. The bit 7 of octet 1 shall be test to 1 if this bit is set to 1.
2	6 (02h)	twoWheeler	The message contains an element in extensionContainers with containerId equal to 'twoWheelerContainer'. This SSP bit usage requires the SSP version greater than 2.
2	7 (01h) (LSBit)	twoWheeler-cyclist	The message contains a TwoWheelerContainer, containing typeSpecificInformation element with 'cyclist' element selected. The bit 6 of octet 2 shall be test to 1 if this bit is set to 1. This SSP bit usage requires the SSP version greater than 2.

6.2.3 General priority constraints

If the GeoNetworking / BTP stack is used, the priority constraint is given by the Traffic Class as specified in ETSI TS 103 836-4-1 [4].

7 CAM Format Specification

7.1 General structure of a CAM PDU

A CAM is composed of one common ITS PDU header and multiple containers, which together constitute a CAM.

The ITS PDU header is a common header that includes the information of the protocol version, the message type and the ITS-S ID of the originating ITS-S.

For vehicle ITS-Ss a CAM shall comprise one basic container and one high frequency container, and may also include one low frequency container and one or more other special containers:

- The basic container includes basic information related to the originating ITS-S.
- The high frequency container contains highly dynamic information of the originating ITS-S.
- The low frequency container contains static and not highly dynamic information of the originating ITS-S.
- The special vehicle container contains information specific to the vehicle role of the originating vehicle ITS-S.
- The two-wheeler container contains detailed dynamic information of the two-wheeler-type originating ITS-S.
- The eHorizon location sharing container contains contextual, map-based location information of the originating ITS-S.

- The very low frequency container contains additional static or not highly dynamic information of the originating ITS-S.
- The path prediction container contains the predicted future path of the originating ITS-S.
- The generalized lane position container contains detailed information about the road layout that the IT-S is currently using.
- The vehicle movement control container contains brake and acceleration pedal position status and information about mechanisms for lateral and longitudinal movements dimensions of the ITS-S station (information about engagement of systems for e.g. automated parking or assisted parking).

All CAMs generated by RSU ITS-S shall include a basic container and optionally more containers.

The general structure of a CAM is illustrated in Figure 4.

Each container is composed of a sequence of optional or mandatory Data Elements (DE) and/or Data Frames (DF). DEs and DFs are mandatory unless specified otherwise. The present document provides CAM content specifications for vehicle ITS-Ss. CAM format and content specifications for other types of ITS-Ss is expected to be added in the future.

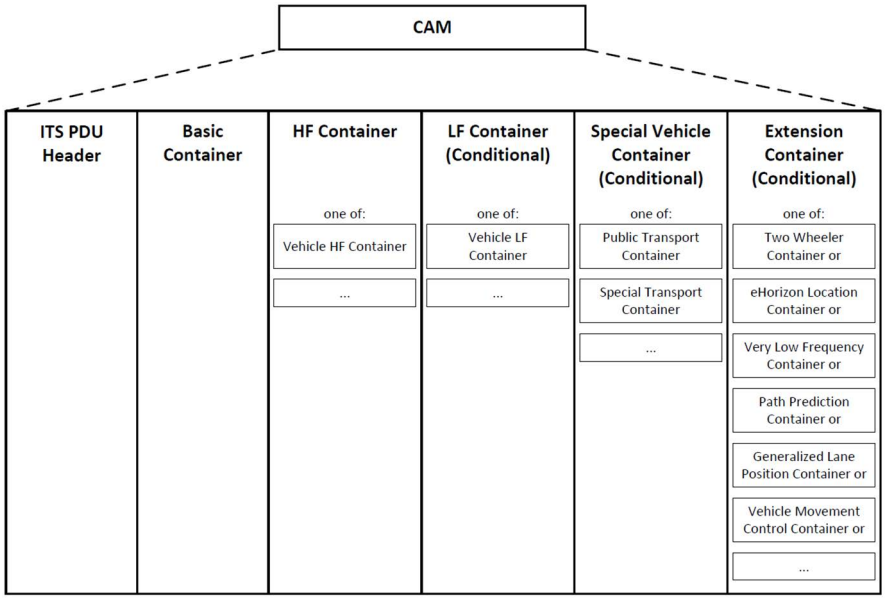

Figure 4: General structure of a CAM

7.2 ITS PDU header

The ITS PDU header shall be as specified in ETSI TS 102 894-2 [1]. Detailed data presentation rules of the ITS PDU header in the context of CAM shall be as specified in annex A.

7.3 Basic container

The basic container provides basic information of the originating ITS-S:

- type of the originating ITS-S;
- the latest geographic position of the originating ITS-S as obtained by the CA service at the CAM generation.

The basic container shall be present for CAM generated by all ITS-Ss implementing the CA service.

Detailed data presentation rules shall be as specified in annex A.

7.4 Vehicle ITS-S containers

All CAMs generated by a vehicle ITS-S shall include at least a High Frequency vehicle (Vehicle HF) container, and optionally a Low Frequency vehicle (Vehicle LF) container. The Vehicle HF container contains all fast-changing (dynamic) status information of the vehicle ITS-S such as heading or speed. The Vehicle LF container contains static or slow-changing vehicle data like the status of the exterior lights.

Vehicle ITS-Ss which use a value of vehicleRole in the Vehicle LF container,
i.e. *{CAM.cam.basicVehicleContainerLowFrequency.vehicleRole}* other than the value default(0) shall provide further status information in special vehicle containers according to Table 5.

Table 5: Special vehicle container according to the vehicle role

CAM data requirement Value of *{CAM.cam.basicVehicleContainerLowFrequency.vehicleRole} shall be set to*	**Special vehicle container** represented as
publicTransport(1)	public transport container,*{CAM.cam. specialVehicleContainer. publicTransportContainer}*
specialTransport(2)	special transport container, *{CAM.cam. specialVehicleContainer. specialTransportContainer}*
dangerousGoods(3)	dangerous goods container, *{CAM.cam. specialVehicleContainer. dangerousGoodsContainer}*
roadWork(4)	road work container, *{CAM.cam.specialVehicleContainer.roadWorksContainer }*
rescue(5)	rescue container, *{CAM.cam. specialVehicleContainer. rescueContainer}*
emergency(6)	emergency container, represented as *{CAM.cam. specialVehicleContainer.emergencyContainer}*
safetyCar(7)	Safety car container, represented as *{CAM.cam. specialVehicleContainer. safetyCarContainer}*
agriculture(8), commercial(9), military(10), roadOperator(11), taxi(12), uvar(13)	No special vehicle container defined in the present document.

7.5 RSU ITS-S containers

RSU ITS-S CAMs shall provide at least one HF container. Additional LF containers may be added.

7.6 CAM format and coding rules

7.6.1 Common data dictionary

The CAM format makes use of the common data dictionary as defined in ETSI TS 102 894-2 [1].

Where applicable, DEs and DFs that are not defined in the present document shall be imported from the common data dictionary as specified in ETSI TS 102 894-2 [1].

NOTE: Detailed descriptions of all DEs and DFs in the context of CAM are presented in annex A of the present document.

7.6.2 CAM data presentation

The CAM format is presented in ASN.1. Unaligned Packed Encoding Rules (UPER) as defined in Recommendation ITU-T X.691/ISO/IEC 8825-2 [2] shall be used for CAM encoding and decoding.

The ASN.1 representation of CAM shall be as specified in annex A of the present document.

Annex A (normative): ASN.1 module

This clause provides the normative ASN.1 module containing the syntactical specification of the CAM PDU, its containers, data frames and data elements defined in the present document.

The CAM-PDU-Descriptions module is identified by the Object Identifier {itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) camPduRelease2 (103900) major-version-2 (2) minor-version-2 (2)}. The module can be downloaded as a file as indicated in Table A.1. The associated SHA-256 cryptographic hash digest of the referenced file offers a means to verify the integrity of that file.

The semantical specification of the CAM components, its containers, data frames, and data elements is contained in the same module in the form of ASN.1 comments and is also available in readable format as indicated in Table A.1.

Table A.1: ETSI TS 103 900 ASN.1 module information

Module name	CAM-PDU-Descriptions
OID	{itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) camPduRelease2 (103900) major-version-2 (2) minor-version-2(2)}
ASN.1 Link	https://forge.etsi.org/rep/ITS/asn1/cam_ts103900/-/raw/v2.2.1/CAM-PDU-Descriptions.asn
SHA-256 hash	12ebd2d18701f8d4f7ac2b2bf827fd215c6652c63af5f40f52cfab96ddec5e99
Readable format	https://forge.etsi.org/rep/ITS/asn1/cam_ts103900/-/blob/v2.2.1/docs/CAM-PDU-Descriptions.md

Annex B (informative): Protocol operation of the CA service

B.1 Introduction

This annex provides a timer controlled approach for the protocol operation as one potential variant compliant to the present document. It is distinguished between the originating ITS-S operation and the receiving ITS-S operation considered in the following clauses.

Following specification of the protocol operation is organized in three parts:

1) Protocol data setting rules specify the setting of the relevant data elements used by the protocol.

2) The general protocol operation specifies the sequence of protocol operations.

3) Exception handling specifies additional protocol operations that extend the general protocol operation. They are applied when special conditions, referred to exceptions (for example inconsistent data) occur.

An ITS-S maintains a local data structure, referred to as "ITS-S message table". This data structure holds information about sent or received CAM messages.

It is out of scope of the present document to describe how this data structure is implemented.

B.2 Originating ITS-S operation

B.2.1 Protocol data setting rules

The data settings for the originating ITS-S operation are specified in annex A.

B.2.2 T_CheckCamGen

The timer *T_CheckCamGen* schedules the time at which the CAM generation conditions are checked by the CA service, its time out value is specified in clause 6.1.3.

B.2.3 Originating ITS-S message table

The CA service stores at least the following information for the CAM originating ITS-S operation:

- CAM generation time;
- ITS-S position as included in CAM;
- ITS-S speed as included in CAM;
- ITS-S heading as included in CAM.

B.2.4 General protocol operation

The originating ITS-S protocol starts when the CA service is activated as specified in clause 6.1.1. An originating ITS-S may execute the following operations:

1) set *T_ CheckCamGen* and start the timer;
2) when the timer *T_CheckGenCam* expires, check the CAM generation conditions:
   a) if any of the condition is satisfied, continues the operation;
   b) if none of the condition is satisfied, skip step 3) to step 7);
3) collect data for mandatory containers;
4) check if optional containers are to be added for CAM generation:
   a) if yes, check the ITS-S type and ITS-S role and collect data for optional containers;
   b) if no, continue the operation;
5) encode CAM;
6) pass CAM to the ITS networking & transport layer;
7) save data required as specified in clause B.2.3 for next CAM generation;
8) restart the timer *T_ CheckCamGen.*

B.2.5 CAM construction exception

If the CA service could not construct a CAM successfully in step 5) as defined in clause B.2.4, the CA service is expected to omit step 6) to step 8) and is expected to restart the timer *T_CheckCamGen*.

NOTE 1: The failure of the CAM construction may happen, if the CA service was not able to collect all required data for the CAM construction, or the collected data are not compliant to the CAM format as specified in annex A (e.g. the value of a data is out of authorized range of the ASN.1 definition).

NOTE 2: If the CAM construction failure was due to a data provided by other entities via the interface IF.FAC, CA service may provide a failure notification to the corresponding data provision facilities via the IF.FAC.

B.3 Receiving ITS-S operation

B.3.1 Protocol data setting rules

No protocol data need to be set for the receiving ITS-S.

B.3.2 General protocol operation

The ITS-S receiver protocol starts when the CA service receives a CAM and executes the following operations:

1) decode received CAM;
2) make CAM data available by e.g. passing to the ITS application layer or to the LDM;
3) end of operation, wait for the next CAM reception.

B.3.3 Exception handling

B.3.3.1 CAM decoding exception

If the CA service could not decode a CAM successfully in step 1) as defined in clause B.3.2, the CA service omits step 2) and step 3).

NOTE: The failure of the CAM decoding may happen, if the CA service checks that the data included in a received CAM is not compliant to the CAM format as specified in annex A (e.g. the value of a data is out of authorized range of the ASN.1 definition).

Annex C (informative): Flow chart for CAM generation frequency management

Figures C.1 to C.3 illustrate the CAM frequency management specified in clause 6.1.3.

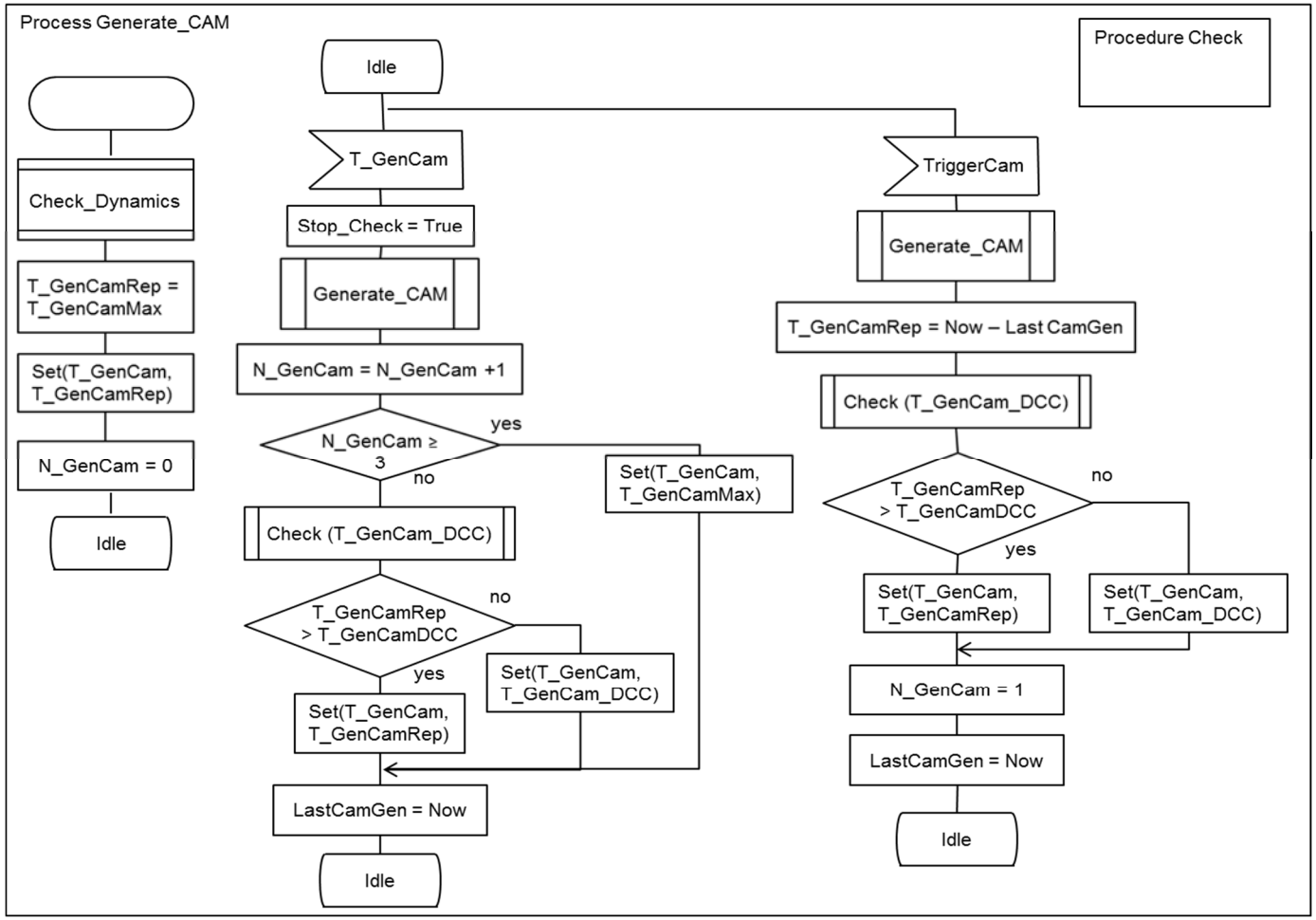

Figure C.1: Process CAM Generation

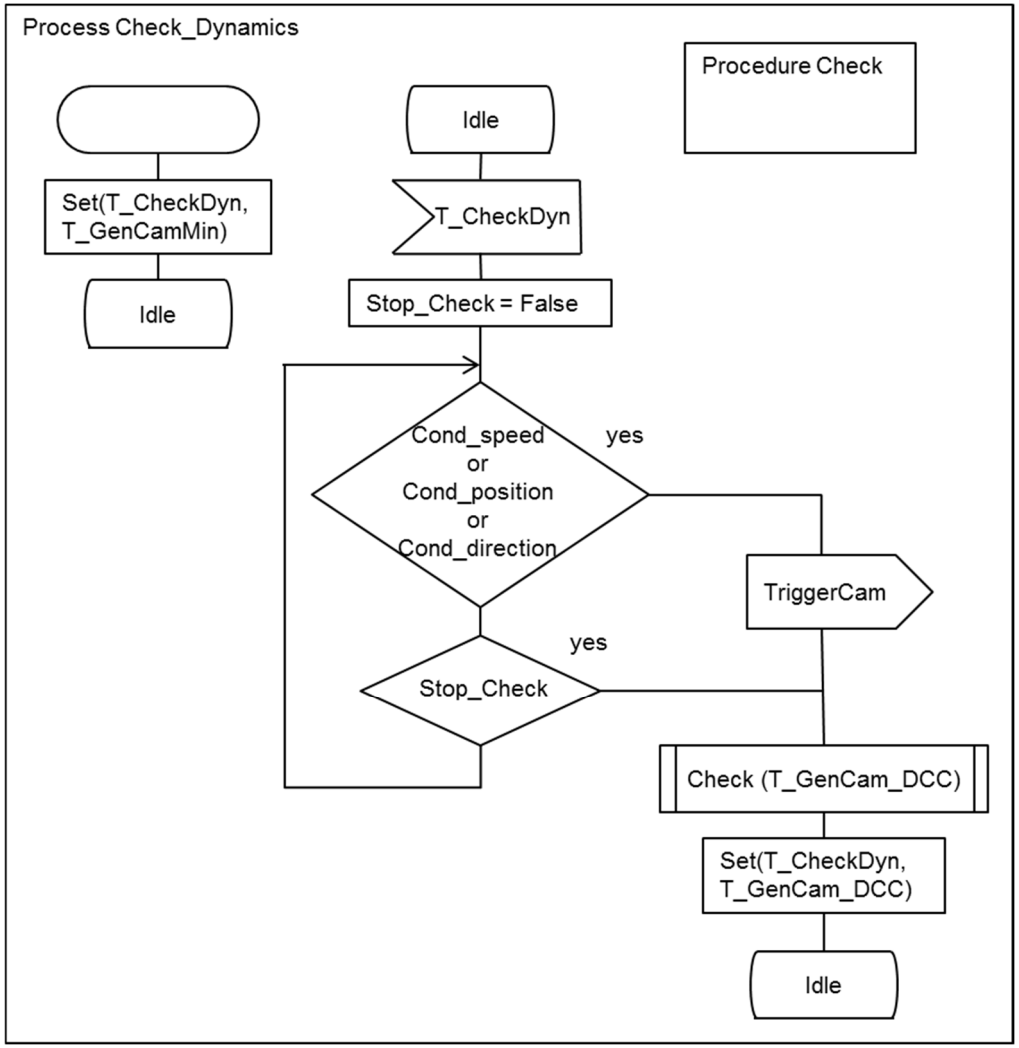

Figure C.2: Process Check Dynamics

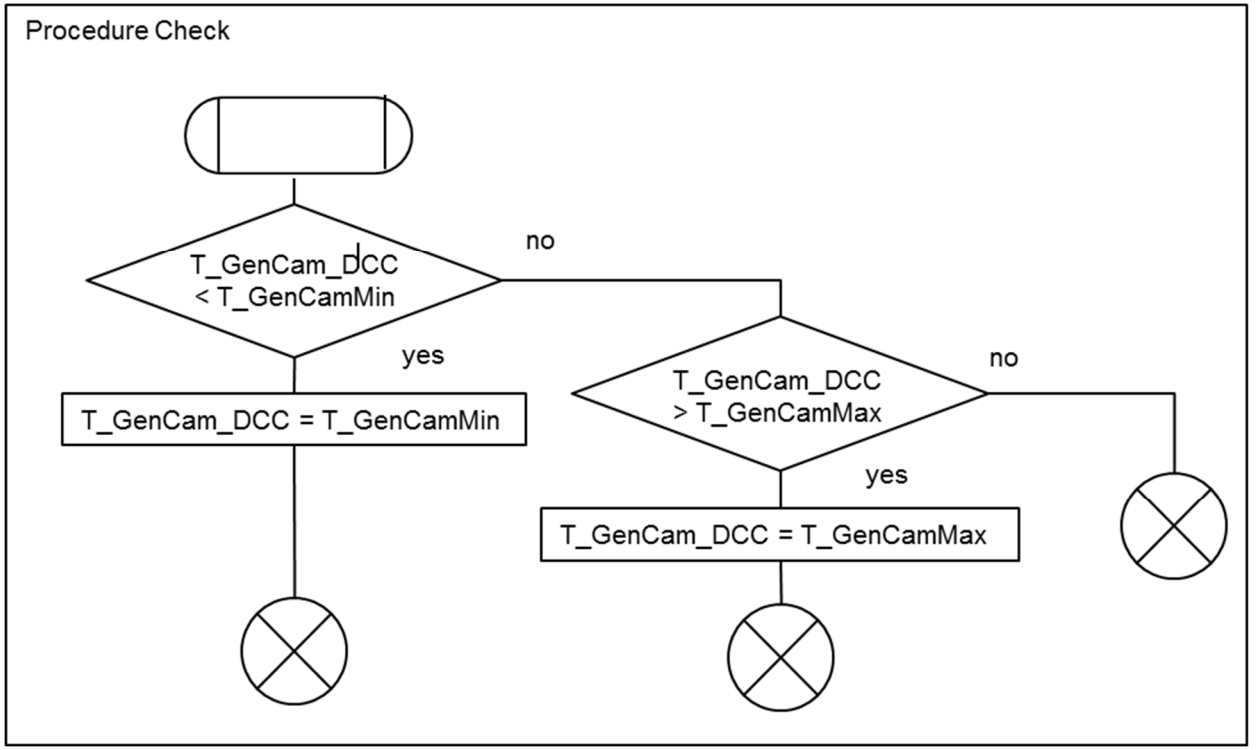

Figure C.3: Procedure Check

Annex D (informative): Extended CAM generation

This annex describes an additional trigger condition for the CAM message generation, which enables ITS applications to increase the CAM generation frequency.

Depending on the requirements of an ITS application it may provide the parameter *T_GenCam_App* representing the needed CAM generation interval. *T_GenCam_App* should be provided in the unit of milliseconds and with a value range of $T\_GenCamMin \leq T\_GenCam\_App \leq T\_GenCamMax$. In case an ITS application provides this parameter with a value below *T_GenCamMin*, *T_GenCam_App* would be set to *T_GenCamMin* and if the value is above *T_GenCamMax* or this parameter is not provided, the *T_GenCam_App* would be set to *T_GenCamMax*. In case several ITS applications require different values the lowest generation interval would be applied.

In addition to the CAM trigger conditions defined in clause 6.1.3, the following condition applies:

1) The time since last CAM generation is equal to or greater than *T_GenCam_Dcc*.

In case the requested CAM generation frequency will not be achieved, the CA service should return a failure notification to the requesting application.

History

Document history		
V2.0.0	July 2022	Publication
V2.1.1	November 2023	Publication
V2.2.1	February 2025	Publication