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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

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 (CAS), which is part of the facilities layer within the ITS communication architecture supporting several ITS applications.

The CAS is a facility that can be deployed in all kind of ITS-Stations (ITS-S), which take part in the road traffic. The present document focuses on the specifications for CAMs transmitted for vehicle and for road infrastructure awareness. Nevertheless, the present document defines the CAM format with flexibility in order to be easily extendable for the support of other types of awareness or future ITS applications.

The requirements on the performance of the CAS, 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 CAS has been published as ETSI EN 302 637-2 [i.6]. 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.

All Release 2 versions are based on the latest Release 1 version of the CAS and will be backwards compatible with it in the sense that 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 Service (CAS).

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 103 097: "Intelligent Transport Systems (ITS); Security; Security header and certificate formats; Release 2".

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

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

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

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.

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The following referenced documents may be useful in implementing an ETSI deliverable or add to the reader's understanding, but are not required for conformance to the present document.

[i.1] ETSI TR 102 638: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Release 2".

[i.2] ETSI TR 103 902: "Intelligent Transport Systems (ITS); ITS Framework; Terms, Symbols and Abbreviations; Release 2".

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

[i.4] C-Roads: "C-Roads Releases".

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

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TR 103 902 [i.2] and the following apply:

Cooperative Awareness Message (CAM): Cooperative Awareness 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

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

3.2 Symbols

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

CA_Activation	Interface provided by the CAS for activating/terminating periodic CAM dissemination
CA_Control	Interface required by the CAS to management plane entity(ies)
CA_DataIn	Interface required by the CAS to gather CAMs and other service data
CA_DataOut	Interface required by the CAS to disseminate CAM
CA_DataProvision	Interface provided by the CAS for making collected CAMs available
CA_DynDataIn	Interface required by the CAS for the collection of the ITS-S internal dynamic data
CA_Security	Interface required by the CAS to security plane entity(ies)

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TR 103 902 [i.2] and the following apply:

CA	Cooperative Awareness
CAM	Cooperative Awareness Message
CAS	Cooperative Awareness Service
DCC	Decentralized Congestion Control
LSB	Least Significant Bit
PCI	Protocol Control Information
RM	Resource Management
SSP	Service Specific Permissions

4 CAS introduction

4.1 Background

The Cooperative Awareness Service (CAS) is an application support functionality operating at the facilities layer. The CAS is responsible for the generation of Cooperative Awareness Messages (CAMs). 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 awareness 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 CAS.

Besides the support of applications the awareness of other ITS-S gained by the CAS may be used in the Networking & Transport Layer (NTL) for the position dependent dissemination of messages. The generation and transmission of CAM is managed by the CAS by implementing the CAM protocol.

4.2 Services provided by CAS

The CAS is a facilities layer entity that operates the CAM protocol. It provides two services: sending and receiving of CAMs. The CAS uses the services provided by the protocol entities of the ITS Networking & Transport Layer (NTL) 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 (NTL) 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 CAS 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 CAS 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).

5 CAS functional specification

5.1 CAS in the ITS station

The CAS is a facilities layer entity of the ITS-S that may interface with other entities of the facilities layer in order to collect relevant information for CAM generation and to provide the collected CAM content for further processing. The CAS within the ITS-S and the logical interfaces to other layers and potentially to entities within the facility layer are presented in Figure 1.

CAS may interact with other facilities layer entities, in particular:

- The Local Dynamic Map (LDM) service which is a facilities layer database at the receiving ITS-S may be updated with information from collected CAMs. ITS-S applications may then retrieve this information from the LDM for further processing.
- The Position and Time (POTI) service which provides estimates of the kinematic state of the ITS-S and on time information to the sending CAS.
- The facilities layer Resource Management services to manage the dissemination of CAMs.
- The facilities layer Security services to manage the security aspects of the CAMs.

The CAS may interface directly with lower layer for exchanging of CAMs with other ITS-Ss.

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

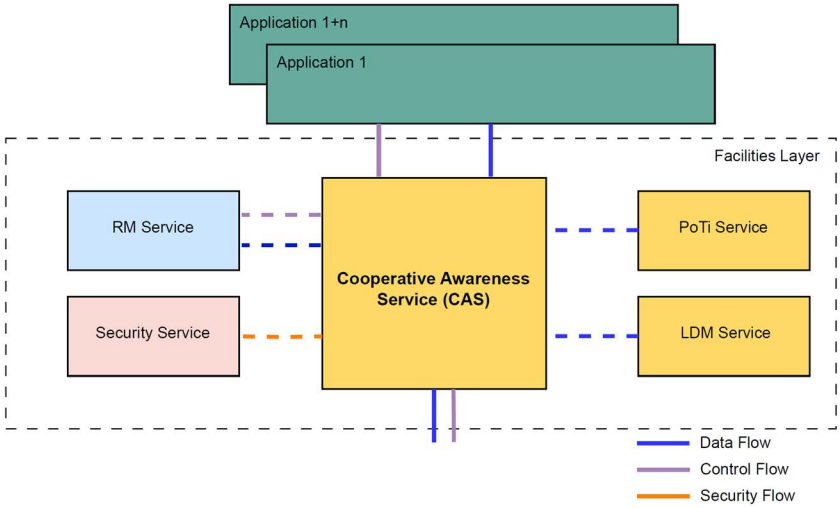

Figure 1: CAS and logical interfaces

5.2 CAS functionality

Figure 2 illustrates the component diagram with the functional blocks of the CAS 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.

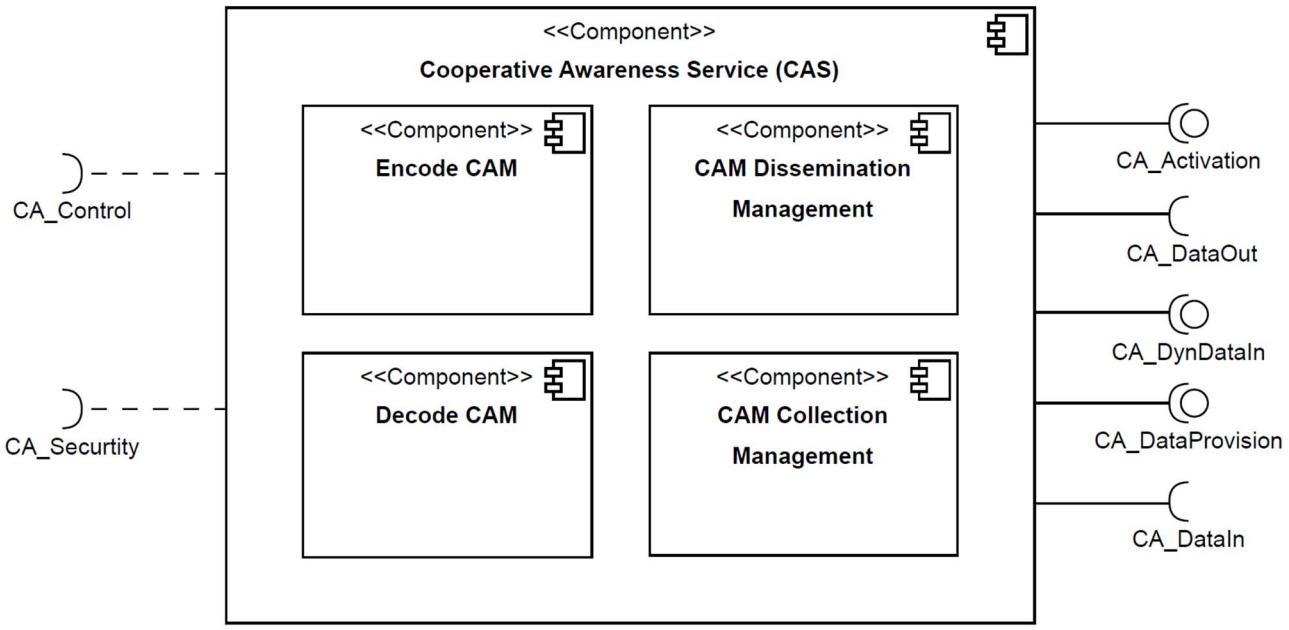

Figure 2: CAS component diagram

The CAS shall provide the following sub-functions:

- **Encode CAM:** This function constructs the CAM according to the format specified in Annex A. The most recent available device data shall be used to construct the CAM.
- **Decode CAM:** This function decodes the received CAMs.
- **CAM Dissemination Management:** This function implements the protocol operation of the originating ITS-S, as specified in clause B.2, including in particular:
  - Activating the *Encode CAM* function to generate the CAM.
  - Determination of the CAM generation frequency.
  - Activation and termination of CAM dissemination by passing the CAM to either another facility layer entity such as Resource Management (RM) or a lower layer functionality such as the Networking & Transport Layer (NTL) for transmission.
- **CAM Collection Management:** This function implements the protocol operation of the receiving ITS-S, as specified in clause B.3, including in particular:
  - The gathering of CAM from either another facilities layer entity such as Resource Management or a lower layer functionality such as the Networking & Transport Layer (NTL).
  - Activating the *Decode CAM* function to decode the collected 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 CAS

5.3.1 Interface to the ITS-S applications

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 activation and termination the repetitive CAM transmissions at the originating ITS-S, the CAS provides the interface CA_Activation to ITS applications as illustrated in Figure 2.

The CAS uses interface CA_DynDataIn to the ITS-S applications for the collection of the internal dynamic data, necessary to construct CAMs as illustrated in Figure 2.

For the provision of received data the CAS provides the interface CA_DataProvision to ITS applications, as illustrated in Figure 2.

5.3.2 Interface to management plan entities

The CAS may exchange primitives with in the entity(ies) in the ITS management plan via the interface CA_Control as depicted in Figure 2. In case of the ITS-G5 access layer, an originating ITS-S the CAS gets information for setting the *T_GenCam_DCC* from the management entity defined in clause 6.1.2 via the CA_Control interface, as depicted in Figure 2.

NOTE: The specifications of the interface between the CAS and the management entity is out of scope of the present document.

5.3.3 Interface to security plan entities

In case ETSI ITS security [1] at the facilities layer is used, the CAS exchanges information directly with the entity(ies) in the security plane (see Figure 2) via the interface CA_Security.

NOTE: The specifications of the interface between the CAS and the security entity is out of scope of the present document.

5.3.4 Interface to CA_DataIn and CA_DataOut

The CAS shall pass the CAM for dissemination to either another facilities layer entity such as Resource Management or a lower layer functionality such as the Networking & Transport Layer (NTL) as specified in Table 1. The CAS uses the CA_DataOut interface for this purpose.

The CAS shall gather CAM from either another facility layer entity such as Resource Management (RM) or a lower layer functionality such as the NTL as specified in Table 1. The CAS uses CA_DataIn interface for this purpose.

Table 1: CAM exchanged over interfaces CA_DataIn and CA_DataOut

Category	Data	Data requirement	M/C (see note)	Remark/Condition
Data provided by the CAS via CA_DataOut	CAM	*{cam}* as specified in Annex A.	M	
	SCI	Additional control information related to security, such as ITS-AID and SSP, which shall be listed in the Authorization Ticket associated to the private key used to sign the message at the NTL.	C	If a security scheme (e.g. ETSI security [1]) at NTL requiring SCI is used.
	PCI	Additional control information depending on the protocol stack applied in the NTL.	C	If a NTL protocol requiring PCI is used
	RMI	Additional control information related to Resource Management.	C	if RM is available in the ITS-S and the default parameters have not been configured or need to be overwritten for a specific CAM.
Data gathered by the CAS via CA_DataIn	Received CAM	*{cam}* as specified in Annex A.	M	
	SCI	Additional control information related to security, such as ITS-AID and SSP that are listed in the Authorization Ticket attached to the message, and the result of the security check at NTL.	C	If a security scheme (e.g. ETSI security [1]) at NTL requiring SCI is used.
	PCI	Additional control information depending on the protocol stack applied in the NTL.	C	If a NTL protocol requiring PCI is used.
NOTE: M/C are as follows: "M" indicates that the data shall always be included. "C" indicates that the data shall be included only if the condition is satisfied.				

The CAS may request data from the PoTi service using the CA_DynDataIn.

NOTE 1: The specifications of the interface between the CAS and the PoTi service is out of scope of the present document.

The CAS may provide CAMs to the LDM using the CA_DataOut.

NOTE 2: The specifications of the interface between the CAS and the LDM is out of scope of the present document.

6 CAM dissemination

6.1 CAM dissemination concept

6.1.1 CAM dissemination requirements

For broadcast communication, CAMs are forwarded to the lower layer or to another facilities layer service responsible for this task.

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 CAM generation frequency management for vehicle awareness

The CAM generation frequency is managed by the CAS. It is defined as the inverse of the time interval between the generation of two consecutive CAMs. 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 CAS 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 CAS 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 CAS 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 be included in all CAMs starting from the CAS 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 CAS 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 road lane positions 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_RoadLanePositions* time has passed since the previous inclusion. The recommended value for *T_GenCam_RoadLanePositions* is 950 ms.

NOTE 3: The lane positions 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.

6.1.3 CAM generation frequency management for road infrastructure awareness

The CAM generation frequency shall be set in such a way, that at least one CAM is transmitted while a vehicle is in the communication zone of the road infrastructure and that an inlineP2pcdRequest for an unknown authorization authority certificate from that same vehicle can be answered according to ETSI TS 103 097 [1] at least once thereafter. The time interval between two consecutive CAMs shall be greater than or equal to 500 ms.

NOTE: The probability for the reception of a CAM 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 transmission power used by the originating ITS-S.

6.1.4 CAM time requirement

6.1.4.1 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 (NTL).

6.1.4.2 CAM time stamp

The following requirements shall apply:

- The time stamp given in the vehicle awareness 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 [2].
- The time stamp given in the road infrastructure awareness 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 [2].

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.7] and ITS certificates according to ETSI TS 103 097 [1].

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 [1].

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 [3] 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 shall contain the ITS-AID associated to the CAS as specified in ETSI TS 102 965 [3] and SSP of type BitmapSsp as specified in ETSI TS 103 097 [1].

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.

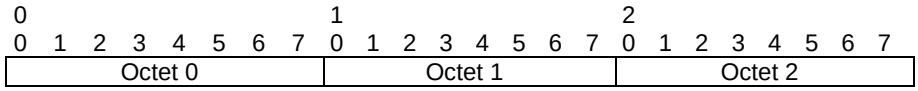

Figure 3: Format for the SSP Octets Scheme (BitmapSsp)

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 [1]. 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 2 and Table 3).

Length of SSP is the length of the Octet String.

Table 2: Octet Scheme for CAM SSP

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 CAS, the SSP shall be defined as in Table 3.

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 3: SSP definitions for permissions in CAM

Octet	Bit position	Protected content	CAM content description
1	0 (80h) (MSB)	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) (LSB)	safetyCarContainer	The message contains the vehicleRole set to 'safetyCar' (7) and the SafetyCarContainer present (see clause 7.4).
2	0 (80h) (MSB)	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.
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) (LSB)	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

The CAM priority is defined by the related use case specified in the C2C-CC Basic System Profile [i.3] and the C-Roads Release [i.4].

Priority information is provided in the PCI across the OSI layers and/or transmitted by lower layers as specified as Traffic Class. Therefore, it is not included in a CAM.

7 CAM 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 payload.

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

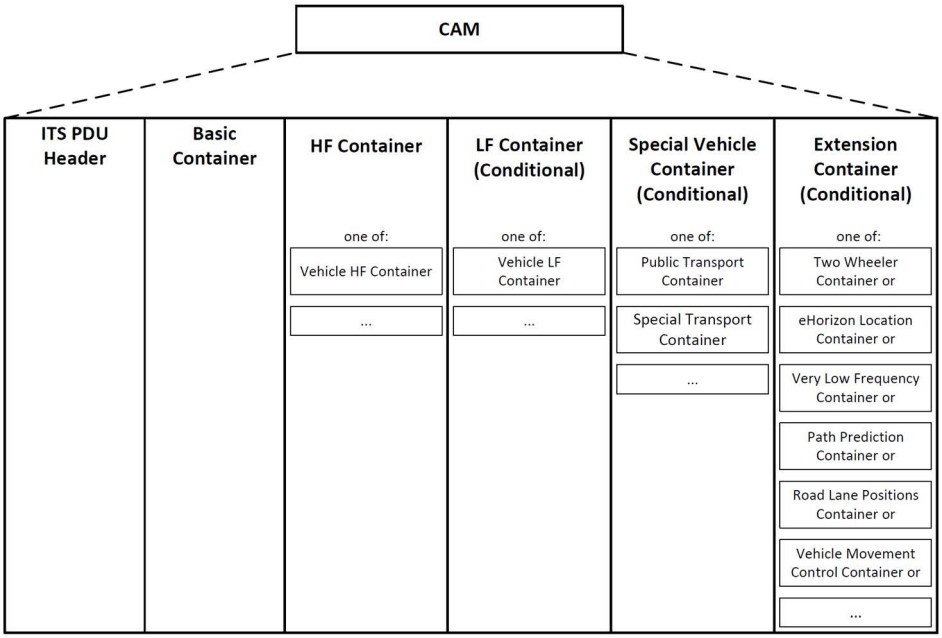

Figure 4: General structure of a CAM

The component *header* is a common header for facility layer PDUs. The component *cam* contains the payload composed of the component *generationDeltaTime* and the component *camParameters* that contains the CAM container.

The 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 vehicle containers and one or more extension containers:

- The component *basicContainer* represents the Basic container and contains basic information related to the originating ITS-S as defined in clause 7.3.
- The component *highFrequencyContainer* is a High Frequency container and contains information of the originating ITS-S as defined in clause 7.4.
- The component *lowFrequencyContainer* is a Low Frequency container and contains information of the originating ITS-S as defined in clause 7.5.
- The component *specialVehicle* is a Special Vehicle container and contains information specific to the role of the vehicle as defined in clause 7.6.
- The component *extensionContainer* is a Release 2 extension containing the additional CAM containers wrapped in a structure called *WrappedExtentionContainer* that includes the type identifier of the container and the container data itself. The component *extensionContainer as defined in clause 7* contains information specific to the use case related to various vehicle types which requires the transmission of additional information that is not included in the previous containers, as shown 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 and road infrastructure awareness. CAM format and content specifications for other types of ITS-Ss is expected to be added in the future.

7.2 ITS PDU header

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.

The ITS PDU header shall be included as specified in ETSI TS 102 894-2 [2]. 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:

- Station ID; a unique identifier for the transmitting station.
- Type of the originating ITS-S.
- The latest geographic position of the originating ITS-S as obtained by the CAS at the CAM generation.

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

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

7.4 High Frequency (HF) container

All CAMs generated for vehicle awareness shall include a High Frequency container of choice *basicVehicleContainerHighFrequency* (Vehicle HF container). The Vehicle HF container contains all fast-changing (dynamic) status information of the vehicle.

All CAMs generated for road infrastructure awareness shall include a High Frequency Container of choice *rsuContainerHighFrequency* (Roadside HF container). The Roadside HF container contains information about protected communication zones.

7.5 Low Frequency (LF) container

Only CAMs generated for vehicle awareness may contain the Low Frequency container of choice basicVehicleContainerLowFrequency (Vehicle LF container).

The optional Vehicle LF container contains static or slow-changing vehicle data such as the status of exterior lights.

7.6 Special Vehicle container

Only CAMs generated for vehicle awareness may contain the Special Vehicle container.

This container is optional and only included when the vehicle is classified as a special vehicle, i.e.it has a specific role in road traffic. It provides additional context that helps other road users and infrastructure systems react appropriately.

CAMs which contain 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 the Special Vehicle container according to Table 4.

Table 4: 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)	The use of any special vehicle container is optional

7.7 Extension container

Only CAMs generated for vehicle awareness may contain one or more Extension Container.

The extensionContainer component extension may contain the following containers:

- The *WrappedExtensionContainer* identified by the Id *twoWheelerContainer* is the Two-Wheeler container which contains detailed dynamic information of the two-wheeler-type originating ITS-S. It is meant to use for station type cyclist, moped and motorcycle.
- The *WrappedExtensionContainer* identified by the Id *eHorizonLocationSharingContainer* is the eHorizon Location Sharing container which contains contextual, map-based location information of the originating ITS-S.
- The *WrappedExtensionContainer* identified by the Id *veryLowFrequencyContainer* is a Very Low Frequency container which contains additional static or not highly dynamic information of the originating ITS-S such as vehicle hight, wiper status and brake control.
- The *WrappedExtensionContainer* identified by the Id *pathPredictionContainer* is a Path Prediction container contains the predicted future path of the originating ITS-S.
- The *WrappedExtensionContainer* identified by the Id *roadLanePositionsContainer* is a Road Lane Positions container contains detailed information about the transversal position of the ITS station with respect to the road and potentially about the lane type.
- The *WrappedExtensionContainer* identified by the Id *vehicleMovementControlContainer* is a Vehicle Movement Control container which 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).

These extension containers are specified in clause 7.8.

7.8 CAM format specification

The CAM syntax and semantics shall be as specified in ASN.1 in Annex A of the present document.

DEs and DFs that are not defined in the present document shall be imported from the Common Data Dictionary ETSI TS 102 894-2 [2] as specified in Annex A.

Detailed specifications of all components of CAM are provided in the normative Annex A and also additionally presented in the informative readable format.

Unaligned Packed Encoding Rules as defined in Recommendation ITU-T X.691/ISO/IEC 8825-2 [4] shall be used for CAM encoding and decoding.

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-3 (3)}. 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 is contained 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-3(3)}
ASN.1 Link	https://forge.etsi.org/rep/ITS/asn1/cam_ts103900/-/raw/v2.3.1/CAM-PDU-Descriptions.asn
SHA-256 hash	4abce4126042b6f702c1f80ff1dfe9f9cc1248950c9f505d68f8b79dac418800
Readable format	https://forge.etsi.org/rep/ITS/asn1/cam_ts103900/-/blob/v2.3.1/docs/CAM-PDU-Descriptions.md

Annex B (informative): Protocol operation of the CAS

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 CAS, its time out value is specified in clause 6.1.2.

B.2.3 Originating ITS-S message table

The CAS 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 CAS is activated. 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 (NTL);
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 CAS could not construct a CAM successfully in step 5) as defined in clause B.2.4, the CAS 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 CAS 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, CAS may provide a failure notification to relevant entities.

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

NOTE: The failure of the CAM decoding may happen, if the CAS 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 6.1.2.

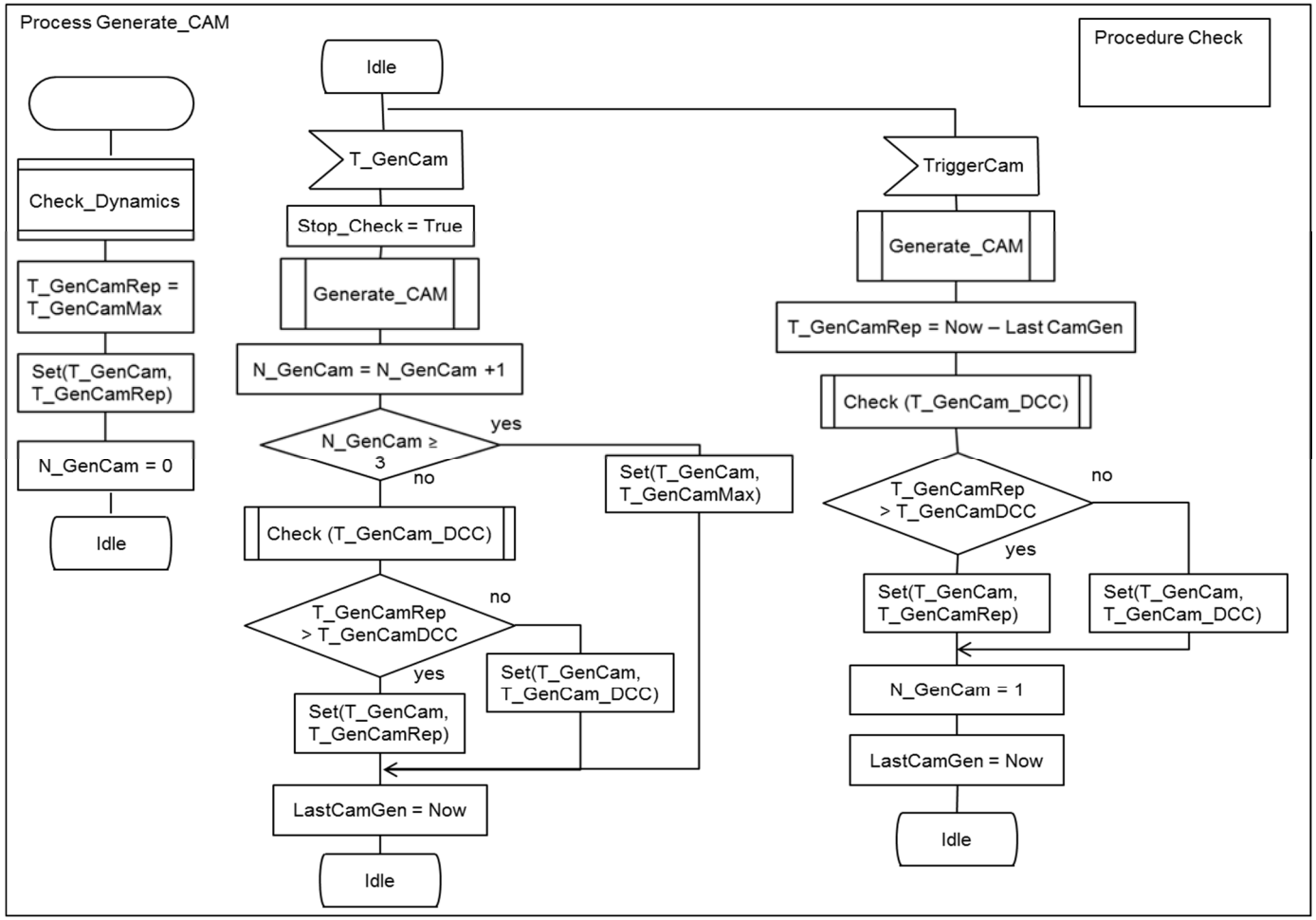

Figure C.1: Process CAM generation

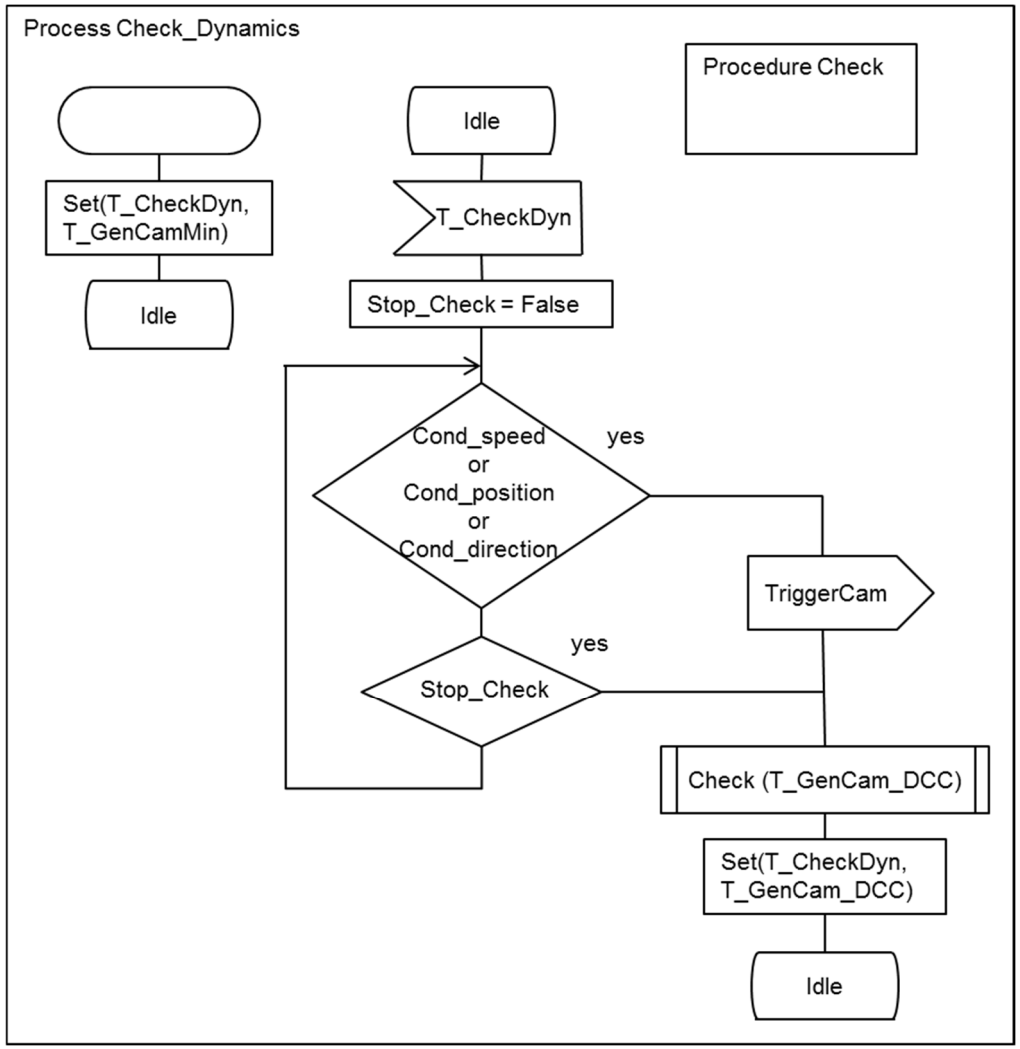

Figure C.2: Process check dynamics

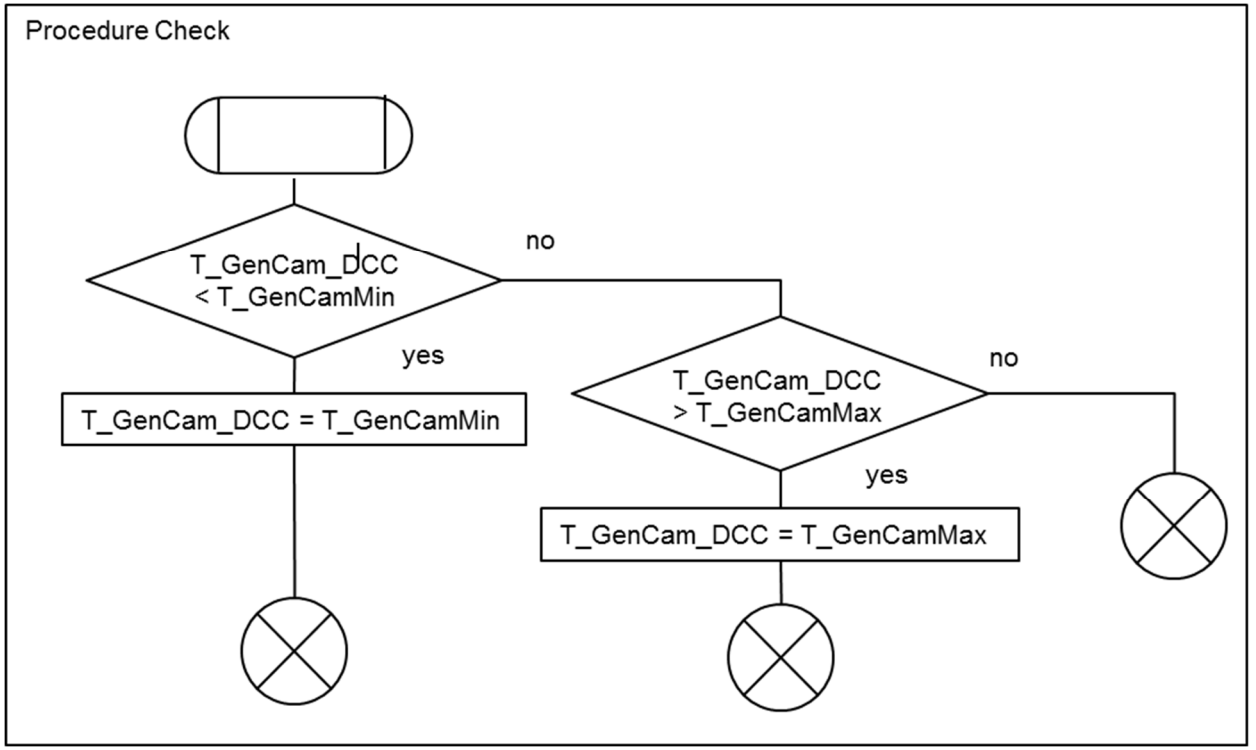

Figure C.3: Procedure check

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 6.1.2, 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 CAS should return a failure notification to the requesting application.

History

Version	Date	Status
V2.0.0	July 2022	Publication
V2.1.1	November 2023	Publication
V2.2.1	February 2025	Publication
V2.3.1	May 2026	Publication