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Foreword

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

Modal verbs terminology

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

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Introduction

The present document specifies the Collective Perception Service (CPS) and how a transmitting ITS station (ITS-S) can inform other ITS-Ss about the kinematic and attitude dynamics and other attributes of objects (e.g. vehicles, pedestrians, animals and others) detected by sensors such as radars, lidars and cameras to which the transmitting ITS-S has access. The CPS increases awareness among ITS-Ss by sharing information about perceived objects in the local environment.

The Collective Perception Message (CPM) enables the interoperable sharing of basic information about the disseminating ITS-S (required for the interpretation of the transmitted data), its sensory capabilities, perceived objects and road-related perception regions. CPMs are generated quasi-periodically as determined by CPM generation events.

1 Scope

The present document specifies the CPS. Conceptually, Collective Perception involves sharing safety-relevant information about the current context of the ITS-S's environment. This includes the definition of the syntax and semantics of the CPM and the specification of the data and message handling of the CPM to increase the awareness of the environment in a cooperative manner.

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.

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

[3] ETSI TS 102 894-2 (V2.1.1): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary; Release 2".

[4] ETSI EN 302 890-2: "Intelligent Transport Systems (ITS); Facilities Layer function; Part 2: Position and Time management (PoTi); Release 2".

[5] 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".

[6] 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".

[7] ETSI TS 103 141: "Intelligent Transport Systems (ITS); Facilities layer function; Multi-Channel Operation (MCO) for Cooperative ITS (C-ITS); 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 103 562: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Analysis of the Collective Perception Service (CPS); Release 2".

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

[i.3] ETSI EN 302 895: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Local Dynamic Map (LDM)".

[i.4] Car 2 Car Communication Consortium: "Technical Report on CPM Object Quality".

[i.5] ISO EN 17419: "Intelligent Transport Systems -- Cooperative Systems -- Classification and management of ITS applications in a global context" Definition of terms, symbols and abbreviations".

[i.6] ETSI TS 103 836-3: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network Architecture; Release 2".

[i.7] ETSI TS 102 723-5: "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 5: Interface between management entity and facilities layer; Release 2".

[i.8] ETSI TR 102 965: "Intelligent Transport Systems (ITS); Application Object Identifier (ITS-AID); Registration list".

[i.9] ETSI TS 102 940: "Intelligent Transport Systems (ITS); Security; ITS communications security architecture and security management; Release 2".

[i.10] ETSI TR 103 460: "Intelligent Transport Systems (ITS); Security; Pre-standardization study on Misbehavior Detection; Release 2".

[i.11] ETSI TS 102 890-1: "Intelligent Transport Systems (ITS); Facilities layer function; Part 1: Services Announcement (SA) specification".

[i.12] ETSI TS 103 300-3: "Intelligent Transport Systems (ITS); Vulnerable Road Users (VRU) awareness; Part 3: Specification of VRU awareness basic service; Release 2".

[i.13] 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".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

central ITS-S: ITS-S in a backend, e.g. traffic control centre, traffic management centre, or cloud system from road authorities, ITS application suppliers or automotive OEMs

classification confidence level: measure related to the certainty, generally a probability, with which a perceived object can be linked to a specific object class or type (e.g. with X % probability the object is of type A)

NOTE: The sum of the object classification confidence levels for each perceived object may not exceed 100 % (e.g. in the example above, the classification confidence for an object to be of type B will not exceed (100-X) %).

Collective Perception (CP): concept involving sharing of information (generated by sensor systems) about the perceived environment of an ITS-S

Collective Perception Message (CPM): message generated by the CPS

Collective Perception Message (CPM) data: some or all data included in a CPM

Collective Perception Service (CPS): functionality in the ITS-S facilities layer to support ITS-S applications, CPM management and CPM dissemination

Collective Perception Service (CPS) protocol: ITS facilities layer protocol for CPM dissemination and reception

confidence level: probability with which the estimate of a statistical parameter (e.g. an arithmetic mean) in a sample survey is also true for the entire population from which the samples were taken

confidence value: estimated absolute accuracy (i.e. closeness of a measured value to a standard or known value) of a measured value of a parameter with a specified confidence level (generally 95 % in the present document)

ITS station (ITS-S): functional entity specified by the ITS station (ITS-S) reference architecture

object: material thing that can be seen and touched and therefore detected and with which parameters can be associated that can be measured and/or estimated

object list: collection of objects

object perception quality: quantification of the estimated likelihood that a detected object exists, i.e. has been detected previously and has continuously been detected by a sensor

perception region confidence: quantification of the estimated likelihood that objects or unoccupied regions may be detected within a perception region

roadside ITS-S: ITS-S operating in the context of roadside ITS equipment

state space representation: mathematical description of a detected object consisting of state variables such as position, velocity, attitude, angular rate, etc.

Vehicle-to-Everything (V2X): type of communication that includes Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Infrastructure-to-Vehicle (I2V), or Vehicle-to-Network (V2N), and Network-to-Vehicle (N2V) communications

Vehicle ITS-S: ITS-S operating in the context of vehicular ITS equipment

3.2 Symbols

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

IF.CPS	Interface between CPS and LDM or ITS applications
IF.APP	Interface between CPS and ITS applications
IF.FAC	Interface between CPS and other facilities layer entities
IF.MCO	Interface between CPS and the MCO facility layer entity
IF.Mng	Interface between CPS and ITS management entity
IF.N&T	Interface between CPS and ITS network & transport layer
IF.SEC	Interface between CPS 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 One
CAM	Cooperative Awareness Message
CP	Collective Perception
CPM	Collective Perception Message
CPS	Collective Perception Service
DCC	Decentralized Congestion Control
DDP	Device Data Provider
DE	Data Element
DF	Data Frame
FoV	Field of View
I2V	Infrastructure to Vehicle
ITS	Intelligent Transport Systems
ITS-S	Intelligent Transport Systems Station
LDM	Local Dynamic Map

MCI	MCO Control Information
MCO	Multi Channel Operations
MIB	Management Information Base
MTU	Maximum Transmission Unit
PCI	Protocol Control Information
R-ITS-S	Roadside ITS Station
SA	Service Announcement
SCH	Service Channel
SCO	Single Channel Operations
UPER	Unaligned Packed Encoding Rule
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VAM	VRU Awareness Message
VoI	Value of Information
VRU	Vulnerable Road User

4 CPS introduction

Collective Perception Messages (CPMs) are transmitted by ITS-Ss in order to share information about perceived objects (such as vehicles, pedestrians, animals and other collision relevant objects) and perception regions (road regions that allow receiving ITS-Ss to determine unoccupied regions) in the local environment. This enhances the environmental perception of CPS-enabled ITS-Ss by providing information about non-V2X-equipped road users, other collision relevant objects, unoccupied regions and also increases the number of information sources for V2X-equipped road users. The availability of multiple sources of information associated with an object or an unoccupied region allows ITS-Ss to perform data fusion which generally leads to lower uncertainty in both the classification of objects and in their properties such as their sizes and their kinematic and attitude states. Even if data manipulated or corrupted at the source are received, a sufficient number of independent sources that maintain integrity may allow identification of such data.

A CPM contains a set of perceived objects and regions, along with their observed status and attributes. The content may vary depending on the type of the road user or object and the detection capabilities of the originating ITS-S. For perceived objects, the status information is expected to include at least the detection time, position, and optionally other elements of the kinematic and attitude state. To support the CPM interpretation at any receiving ITS-S, a sender can also include information about its sensors, such as sensor types and fields of view.

On reception of a CPM, receiving ITS-Ss become aware of the presence, type, and status of a recognized road user, object or region that was detected by the transmitting ITS-S. The received information can then be used by the receiving ITS-S to support ITS applications that increase safety and improve traffic efficiency thereby generally decreasing travel time. For example, by monitoring the status of a detected road user or object, a receiving ITS-S can estimate the collision risk with that road user or object and can inform the user via the HMI of the receiving ITS-S or take corrective actions automatically. Data distributed by the CPS is clearly useful for a large number of ITS safety and efficiency-related applications making the CPS an essential component of any ITS deployment, especially where any form of autonomous activity is anticipated.

ETSI TR 103 562 [i.1] provides an analysis of the Collective Perception Service with further information and simulation results.

5 CPS functional specification

5.1 CPS in the ITS architecture

The CPS is a facilities layer entity in 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 ITS applications to collect relevant information for CPM generation and for forwarding received CPM content for further processing. Figure 1 depicts the CPS within the ITS-S architecture along with the logical interfaces to other layers and entities within the Facilities layer.

The entities for the collection of data to generate a CPM may be the Device Data Provider (DDP), the Position and Time management (POTI) and the Local Dynamic Map (LDM). For vehicle ITS-Ss, the DDP may be connected to the in-vehicle network to provide the vehicle state information. For roadside ITS-Ss and central ITS-S, the DDP may be connected to sensors mounted on the roadside infrastructure such as poles or gantries. The POTI entity provides estimates of the kinematic state of the ITS-S and time information as specified in ETSI EN 302 890-2 [4]. An LDM as outlined in ETSI EN 302 895 [i.3] is a database in an ITS-S, which in addition to on-board sensor data may be updated with received CAM and CPM data. ITS applications may retrieve information from the LDM for further processing. The CPS may also interface with the Service Announcement (SA) Service [i.11] to indicate an ITS-S's ability to generate CPMs and to provide details about the communication technology used.

Figure 1 presents the CPS in the ITS-S architecture as well as its logical interfaces with other entities and layers.

NOTE: The CPS may exchange information with additional facilities layer entities for the purpose of generation, transmission, forwarding and reception of CPM. For simplicity reason, these interfaces are not illustrated in Figure 1.

The functionalities of the CPS are defined in clause 5.2 and the interfaces are defined in clause 5.3.

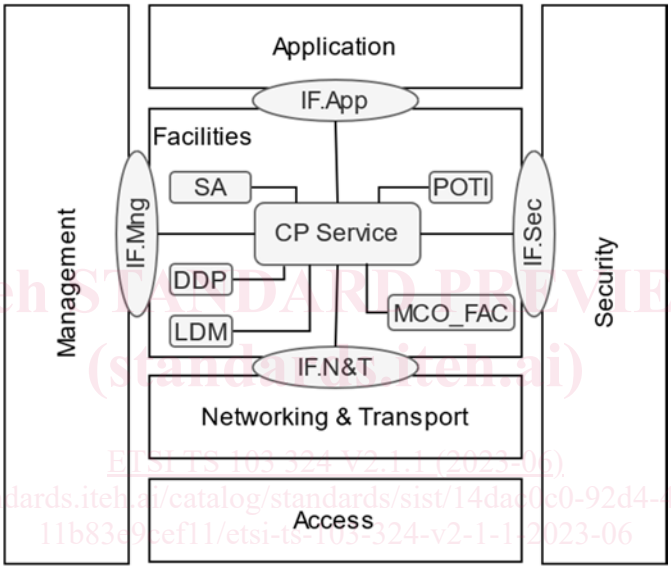

Figure 1: CPS within the ITS-S architecture

NOTE: IF.App in Figure 1 can be implemented as IF.CPS as shown in Figure 2.

5.2 CPS functional architecture

For sending and receiving CPMs, the CPS shall provide the following sub-functions:

- **Encode CPM:** This sub-function shall construct the CPM according to the format specified in Annex A. The most recent abstract CP object information, sensor information and perception region information data shall be included in the CPM.
- **Decode CPM:** This sub-function shall decode the received CPM.
- **CPM transmission management:** This sub-function implements the protocol of the originating ITS-S including:
  - Activation and termination of CPM transmission operation.
  - Determination of the CPM generation event frequency.
  - Triggering the generation of the CPM.
- **CPM reception management:** This sub-function implements the protocol in the receiving ITS-S including:
  - Triggering the decoding of the CPM upon receiving an incoming CPM.

- Provisioning of the decoded CPM to the LDM and/or ITS applications of the receiving ITS-S.
- Optionally, checking the validity of the information of received CPMs.

NOTE: Details for checking the validity of received CPM information is provided in ETSI TR 103 460 [i.10].

Figure 2 shows the functional block diagram of the CPS and interfaces to other facilities and layers (clause 5.3).

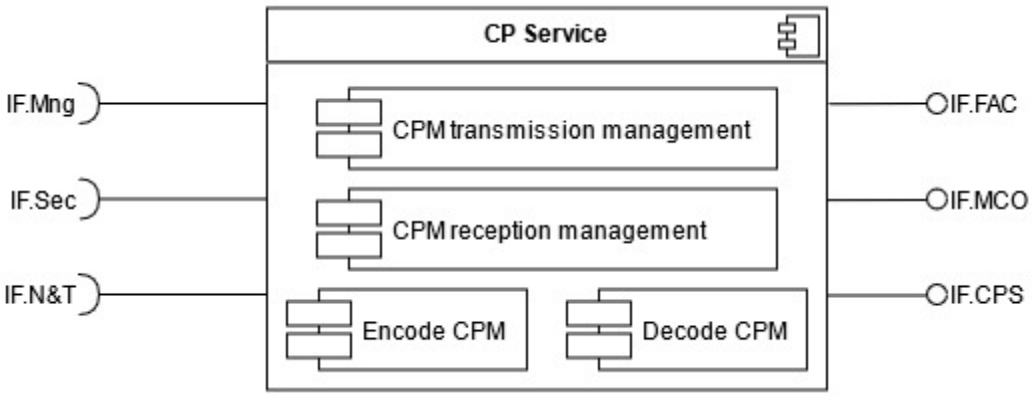

Figure 2: Functional block diagram of the CPS

5.3 Interfaces of the CPS

5.3.1 Interface to ITS applications

An ITS application is an application layer functionality that implements the logic for fulfilling one or more ITS use cases.

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

5.3.2 Interface to data provisioning facilities

For the generation of CPMs, the CPS interacts with other Facilities layer entities to obtain the required data. This set of other facilities is referred to as data provisioning facilities, e.g. the ITS-S's POTI, DDP or LDM. Data is exchanged between the data provisioning facilities and the CP basic 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 MCO_FAC

If the ITS-S supports MCO, the CPS shall exchange information with the MCO_FAC via the interface IF.MCO specified in ETSI TS 103 141 [7] and depicted in Figure 2. This interface can be used to configure the default MCO settings for the generated CPMs and can also be used to configure the MCO parameters on a per message basis.

If the ITS-S supports MCO, the CPS shall provide the CPM embedded in a Facility-layer Service Data Unit (FL-SDU) together with protocol control information (PCI) to the MCO_FAC. In addition, it can also provide MCO Control Information (MCI) following ETSI TS 103 141 [7] to configure the MCO parameters of the CPM being provided. At the receiving ITS-S, the MCO_FAC shall pass the received CPM to the CPS.

The data set that is passed between CPS and the MCO_FAC for the originating and receiving ITS-S is specified in Table 1.

Table 1: Data exchanged between the CPS and the MCO_FAC

Category	Data	Data requirement	Mandatory/Conditional /Optional
Data passed from the CPS to the MCO_FAC	CPM	*{cpm}* as specified in Annex A	Mandatory
	PCI	Depending on the protocol stack applied in the networking and transport layer as specified in Table 2	Optional
	MCI	MCO parameters configuration. Needed if the default MCO parameters have not been configured or want to be overwritten for a specific CPM	Conditional
Data passed from the MCO_FAC to the CPS	Received CPM	*{cpm}* as specified in Annex A	Mandatory

If the GeoNetworking/BTP stack is used and GeoNetworking is used as the network layer protocol, the PCI being passed from CPS to the GeoNetworking/BTP stack shall comply with Table 2.

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

Category	Data	Data requirement	Mandatory/Conditional /Optional
Data passed from the CPS to GeoNetworking/BTP	BTP type	BTP header type B ETSI TS 103 836-5-1 [6], (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.
	Destination port	As specified in ETSI TS 103 836-5-1 [6] (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 [6]	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, ITS-G5 or LTE-V2X	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 [5]	Mandatory

Category	Data	Data requirement	Mandatory/Conditional /Optional
	GN Maximum packet lifetime	Shall not exceed 1 000 ms	Mandatory
	Length	Length of the CPM	Mandatory
NOTE: When a global registration authority for ITS application as specified in ISO EN 17419 [i.5] is operational, the BTP destination port registered with this authority shall be used.			

5.3.4 Interface to the Networking & Transport layer

If the ITS-S does not support MCO, the CPS exchanges information with the ITS Networking & Transport Layer via the interface IF.N&T, as depicted in Figure 2.

At the originating ITS-S, the CPS shall provide the CPM 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 passes the received CPM to the CPS, if available.

The data set that shall be passed between CPS and the ITS Networking & Transport Layer for the originating and receiving ITS-S is specified in Table 3.

Table 3: Data passed between the CPS and the ITS Networking & Transport Layer

Category	Data	Data requirement	Mandatory/Conditional /Optional
Data passed from the CPS to the ITS Networking & Transport Layer	CPM	*{cpm}* as specified in Annex A	Mandatory
	PCI	Depending on the protocol stack applied in the networking and transport layer as specified in Table 2	Optional
Data passed from the ITS Networking & Transport Layer to the CPS	Received CPM	*{cpm}* as specified in Annex A	Mandatory

If the GeoNetworking/BTP stack is used and GeoNetworking is used as the network layer protocol, the PCI being passed from CPS to the GeoNetworking/BTP stack shall comply with Table 2.

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

The CPS may use the IPv6 stack or the combined IPv6/GeoNetworking stack for CPM dissemination as specified in ETSI TS 103 836-3 [i.6].

NOTE 1: The specifications of the interface between the CPS and the IPv6 stack is out of scope of the present document.

NOTE 2: If IP-based transport is used to transfer the facility layer CPM between interconnected actors, security constraints as outlined in clause 6.2.1 may not be applicable. In this case trust enforcement among the participating actors, e.g. using mutual authentication, and authenticity of information can be based on other standard IT security methods, such as IPSec, DTLS, TLS or other VPN solutions that provide an end-to-end secure communication path between known actors.

NOTE 3: Security methods, sharing methods and other transport related information, such as messaging queuing protocols, transport layer protocol, ports to use, etc. can be agreed among interconnected actors.

When the CPM dissemination makes use of the combined IPv6/GeoNetworking stack, the interface between the CPS and the combined IPv6/GeoNetworking stack may be identical to the interface between the CPS and IPv6 stack.q

5.3.6 Interface to the ITS management entity

The CPS of an originating ITS-S obtains configuration parameters and other control information from the Management Information Base (MIB) located in the management entity via the IF.Mng interface, as depicted in Figure 2.