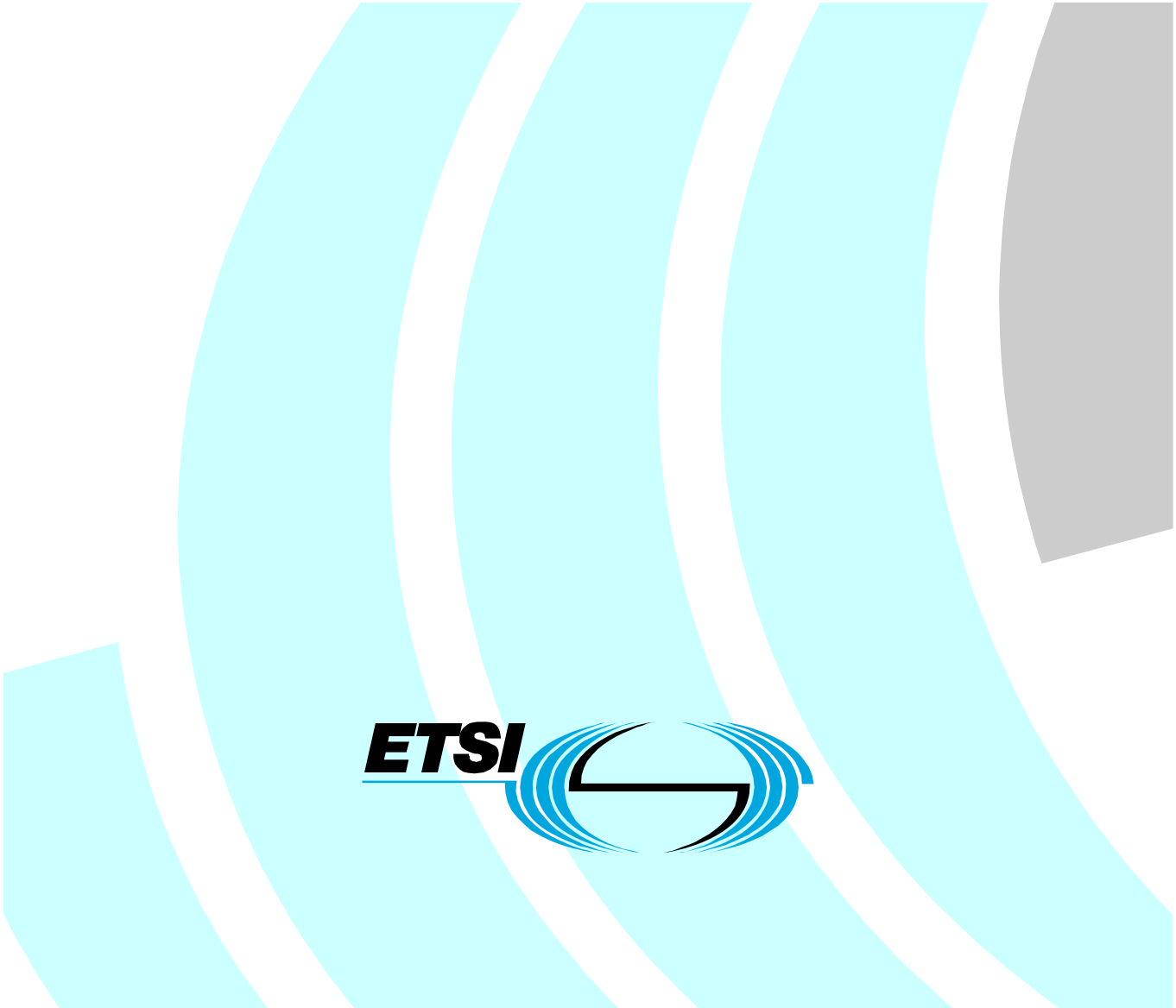
ETSI TS 102 637-2 V1.2.1 (2011-03)

Technical Specification

Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service



Reference
RTS/ITS-0010018

Keywords
ITS, application, basic, service

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Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

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

The present document is part 2 of a multi-part deliverable covering Vehicular Communications; Basic Set of Applications, as identified below:

Part 1: "Functional Requirements";

Part 2: "Specification of Cooperative Awareness Basic Service";

Part 3: "Specification of Decentralized Environmental Notification Basic Service";

Part 4: "Operational Requirements".

Introduction

V2X systems are supported by wireless networks for exchange of information between vehicles (V2V) and road side infrastructure (V2I). The V2X system enables a wide range of beneficial use cases. Road safety and traffic efficiency use cases are appealing as they hold potentials for meeting European Union [i.1] societal objectives. Interoperability is an important aspect to be ensured by the V2X system at different OSI layers. At the facilities layer in particular, basic common functionalities are defined in order to ensure the correct system functioning and to satisfy the interoperability requirement. Respecting common functionalities allows correct and efficient information exchange between nodes participating in V2X networks. This requirement is met by identifying a set of basic functional components at facilities layer. The present document specifies the Cooperative Awareness Basic Service, which provides by means of periodic sending of status data a cooperative awareness to neighbouring nodes. Quality requirements are also proposed for this mandatory facility in order to provide reliable component performance for application development.

The Basis Set of Applications (BSA) are defined in [i.2]. Each application implements one or more use cases. BSA are applications that are considered as deployable with reasonable efforts within 3 years after the complete standardization of the system. This requires efforts from different stakeholders. The quality requirements are identified based on analysis of the BSA.

1 Scope

The present document provides:

- general overview of the Cooperative Awareness Basic Service;
- quality requirements;
- messages formats and specifications.

This includes definition of the syntax and semantics of the Cooperative Awareness Message (CAM) and detailed specifications on the message handling. Furthermore, the present document considers the CAM specifications defined by CAR 2 CAR Communication Consortium [i.3].

2 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 reference document (including any amendments) applies.

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

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

2.1 Normative references

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

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

[2] ETSI TS 102 637-3: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

[3] ISO/TS 18234-4: 2006: "Traffic and Travel Information (TTI) -- TTI via Transport Protocol Expert Group (TPEG) data-streams -- Part 4: Road Traffic Message (RTM) application".

[4] SAE J2735: "Dedicated Short Range Communications (DSRC) message set dictionary".

NOTE: Available at: http://www.itsware.net/itsschemas/DSRC/DSRC-03-00-36/.

2.2 Informative references

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] European Union:.

NOTE: Available at http://europa.eu/.

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

[i.3] CAR 2 CAR Communication Consortium (C2CCC). .

NOTE: Available at http://www.car-to-car.org/.

[i.4] ETSI TR 102 863: "Intelligent Transport System (ITS); Vehicular Communications; Basic Set of Applications; Local Dynamic Map (LDM); Rationale for and guidance on standardization".

[i.5] ETSI TS 102 636-4-1: "Intelligent Transport System (ITS); Vehicular communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media independent functionalities".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in [1] and the following apply:

application support: sub set of facilities, providing support elements for applications

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

NOTE: Basic set of applications can be deployed simultaneously at a targeted time (day 1) after the standard completion with the objective to serve societal and business objectives of private and public road transport stakeholders. BSA definition is provided in [1].

communication support: sub set of facilities, providing support for communications

cooperative awareness messages management: implementation of the cooperative awareness basic service within facility layer

facilities: functionalities, services or data provided by the facilities layer

NOTE: These application functionalities and data are gathered into the Facilities layer which contains some generic application elements (middleware), presentation and session layers of the OSI (Open System Interconnection) Reference Model.

information support: sub set of facilities, providing support for data management

ITS application: system that defines and implements an ITS service to users of the system

ITS use cases: procedure of executing an ITS application in a particular situation with a specific purpose

LDM: local georeferenced database containing a C2X-relevant image of the real world. Applications retrieve these data by means of the LDM Management [i.4]

V2I, I2V: in the present document context, it means direct Vehicle to road Infrastructure communication using a wireless local area network

V2V: in the present document context, it means direct Vehicle(s) to Vehicle(s) communication using a wireless local area network

NOTE: Other radio access technology can be used for use case development. The selection of the best network in term of cost-efficiency will be dynamically achieved, in the future, according to the local availability of networks, their respective costs and performances.

3.2 Abbreviations

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

BSA	Basic Set of Applications
C2CCC	Car to Car Communication Consortium
CAM	Cooperative Awareness Message
CAN	Controller Area Network
DENM	Decentralized Environmental Notification Message
I2V	Infrastructure-to-Vehicle

ITS	Intelligent Transportation Systems
ITS-G5	5 GHz wireless communication
LDM	Local Dynamic Map
OSI	Open System Interconnection
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	V2V and/or V2I

4 General Overview

4.1 Description

The Cooperative Awareness Messages (CAMs) are distributed within the ITS-G5 (802.11p) network and provide information of presence, positions as well as basic status of communicating ITS stations to neighbouring ITS stations that are located within a single hop distance. All ITS stations shall be able to generate, send and receive CAMs, as long as they participate in V2X networks. By receiving CAMs, the ITS station is aware of other stations in its neighbourhood area as well as their positions, movement, basic attributes and basic sensor information. At receiver side, reasonable efforts can be taken to evaluate the relevance of the messages and the information. This allows ITS stations to get information about its situation and act accordingly.

Information distributed by CAM Management is commonly used by related use cases and therefore the CAM Management is a mandatory facility. The Approaching Emergency Vehicle and Slow Vehicle Warning are just two use cases which benefit from CAM.

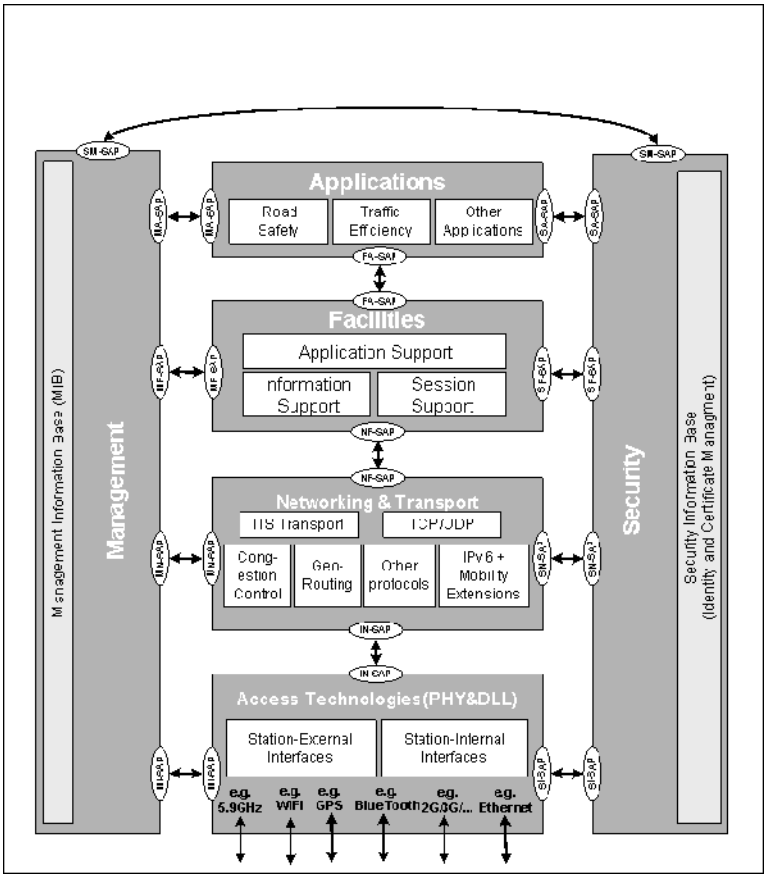

Figure 1: ITS Station Reference Architecture

Within the ITS Station Reference Architecture (see Figure 1), the CAM Management belongs to the Facilities Application Support and more detailed it is assigned to the Messages Management (see Figure 2).

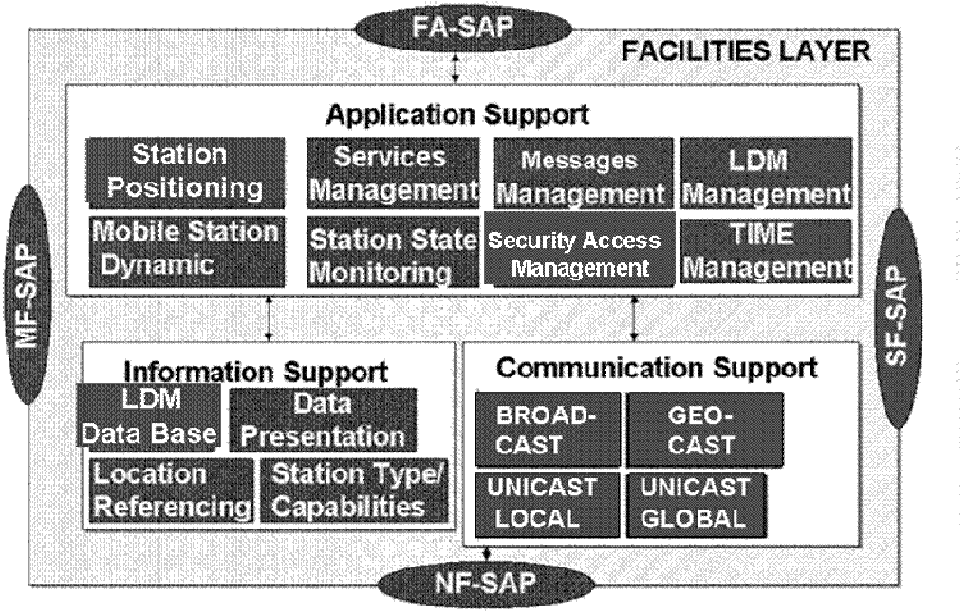

Figure 2: Facilities Layer Architecture

4.2 Usage

Observing several rules, the CAM Management generates CAMs using the facilities time management, station state monitoring and/or mobile station dynamic as data sources. In order to send out the CAM, the communication support hands the CAM to the layer below.

The CAM Management passes the valid CAMs to the LDM management, which analyses the messages and updates in real time the LDM data base. The LDM is in principle a local georeferenced database containing a C2X-relevant image of the real world. Applications retrieve these data by means of the LDM Management.

5 Quality Requirements

Based on the use case requirements of the BSA, following quality requirements for the CAM Management were derived.

5.1 Timing Requirements

Table 1 contains the BSA use cases based on CAMs and the corresponding timing requirements.

Some use cases require high frequency in order to ensure low reception latency after first contact. In this case DENM with situation specific communication attributes shall be used. These communication attributes might include forwarding.

Table 1: Overview Use Cases based on CAM

Use Case	min Frequency (Hz)	min Latency (ms)
Emergency Vehicle Warning	10	100
Slow Vehicle Indication	2	100
Intersection Collision Warning	10	100
Motorcycle Approaching Indication	2	100
Collision Risk Warning	10	100
Speed Limits Notification	1 to 10	100
Traffic Light Optimal Speed Advisory	2	100

CAMs are generated by the CAM Management and passed to lower layers according to following rules:

- maximum time interval between CAM generations: 1 s
- minimum time interval between CAM generations is 0,1 s

More detailed generation rules are provided for information in Annex B.

The system shall ensure that processing time of CAM construction does not exceed 50 ms. If no other channel load is present, the system transmission time between message construction and message being sent shall neither exceed 50 ms.

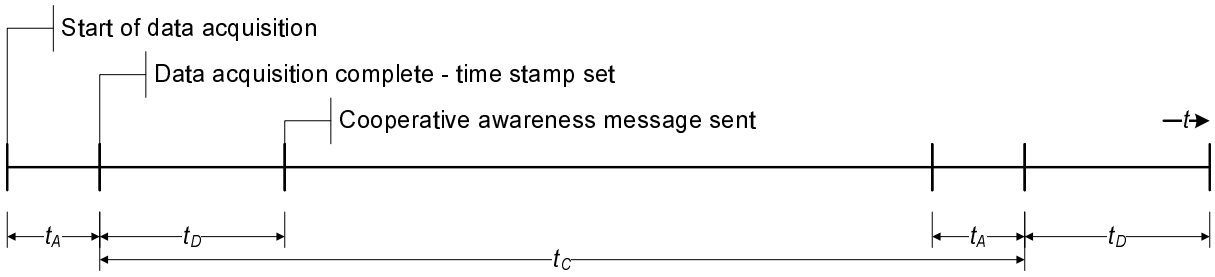

Figure 2a: time requirements for CAM generation and CAM processing

The above requirements are set as:

$t_A \leq 50$ ms;

$t_D \leq 50$ ms.

5.2 General Confidence Constraints

The following accuracy description method shall apply:

The data element "Confidence" provides the symmetric interval of 95 % confidence level for a current reported value. If not defined differently the confidence limits of the interval are calculated based on the granularity of the corresponding measurement data element and the provided data element according to:

- Limit = ±LSB_Value × $2^{Confidence}$; Confidence is set to 15 if no other value is available.

6 Interfaces

6.1 Interface to Applications

The CAM Management is application independent. For this reason there is no interface to applications.

6.2 Interface to Data Provisioning Services

The CAM Management has interfaces to following facilities:

- Station State Monitoring (provides current static state of ITS stations).
- Mobile Station Dynamic Monitoring (provides real time kinematics of ITS stations).
- Time Management (provides global time reference for time stamping).
- LDM Management.

NOTE: Functionality of Facilities is outlined in [i.2].

7 Message Format Specification

7.1 General Structure

In Figure 3 the CAM definition is listed. Packet encoding and decoding shall be done according to ASN.1 unaligned packet encoding rules.

```
-- ASN1START

CAM-PDU-Descriptions {
 itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) ts (102637) cam (2) version1
(1)
}

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
  ItsPduHeader, VehicleCommonParameters, ProfileParameters, StationID, TimeStamp, ReferencePosition
FROM DENM-PDU-Descriptions { itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) ts
(102637) denm (3) version2 (2) };

-- The root data frame for cooperative awareness messages
CamPdu ::= SEQUENCE {
   header             ItsPduHeader,
   cam                CoopAwareness
}

CoopAwareness ::= SEQUENCE {
   stationID          StationID,
   -- Basic characterization of an ITS station.
   stationCharacteristics   SEQUENCE {
         mobileItsStation             BOOLEAN, -- will ITS station change position?
         privateItsStation            BOOLEAN, -- not public authority
         physicalRelevantItsStation   BOOLEAN, -- can another station crash into this station?
         ...
   },
   referencePosition  ReferencePosition,
   camParameters      CamParameters OPTIONAL
   ...
}

CamParameters ::= SEQUENCE {
   vehicleCommonParameters  VehicleCommonParameters,
   profileDependent         ProfileParameters OPTIONAL,
   ...
}

-- ASN1STOP
```

Figure 3: ASN.1 definition of Cooperative Awareness Message (CAM)

7.2 ITS Station Profiles

For different ITS station types, the mandatory, situational mandatory and optional content of taggedList is defined in following ITS station profiles. Situational mandatory fields are just mandatory in explicitly defined situations. If due to a defect or by default data is not available, the according data element shall not be used, even if it is mandatory.

Further information, e.g. station ID, position, speed, heading, etc. are part of the header of lower layers see [i.5]. Announcement of services is not handled by the use of CAMs.

Profile: basicVehicle

The profile "basicVehicle" is mainly used for private vehicles. This profile serves as basis for further profiles, e.g. emergencyVehicle.

stationCharacteristics:	'111'B mobile, private and physical relevant
mandatory TaggedValue:	vehicleType, vehicleSpeed, vehicleSpeedConfidence, heading, headingConfidence, stationLength, stationWidth, curvature, curvatureConfidence, longAcceleration, posConfidenceEllipse, exteriorLights, accelerationControl
situational mandatory TaggedValue:	confidenceStationLength/confidenceStationWidth, if vehicle length/width is not precise determined (e.g. trailer) crashStatus, in case of crash signal is activated dangerousGoods, in case any are transported
Optional TaggedValue:	distanceToStopLine, turnAdvice, occupancy, dooropen, curvatureChange

Profile: basicIRS

The basicIRS is an ITS Roadside Station which can offer all functionality of the infrastructure. It serves as basis for more specialized profiles. The station is installed in a way it is not physically relevant and therefore no danger for the traffic.

stationCharacteristics:	'000'B stationary, not private and not physical relevant
mandatory TaggedValue:	--
situational mandatory TaggedValue:	--
optional TaggedValue:	--

Profile: emergencyVehicle

stationCharacteristics:	'101'B mobile, not private and physical relevant
mandatory TaggedValue:	as "basicVehicle" plus emergencyResponseType
situational mandatory TaggedValue:	as "basicVehicle"
optional TaggedValue:	lightBarInUse, sireneInUse

Profile: publicTransportVehicle

stationCharacteristics:	'101'B mobile, not private and physical relevant
mandatory TaggedValue:	as "basicVehicle" plus PublicVehicleType
situational mandatory TaggedValue:	as "basicVehicle" plus "DoorOpen", during doors open and 30s after closed
optional TaggedValue:	as "basicVehicle" plus PTLineDescription, trafficLightPriority, scheduleDeviation, occupancy

Annex A (normative): Basic Data Elements

Following basic data elements are based on simTD basic data elements.

AccelerationControl

Current controlling mechanism for longitudinal movement (see TS 102 637-3 [2] ASN.1 notation of DENM).

AmbientAirTemperature

Outside temperature measured by a vehicle (see TS 102 637-3 [2] ASN.1 notation of DENM), *(see also SAE J2735 [4]* DE_AmbientAirTemperatur).

CauseCode

Cause of a potentially traffic relevant situation, according to TPEG-TEC Working Document V1.0 (9.03.2006, Mobile.Info) table tec002. E.g. 3: Roadworks (see TS 102 637-3 [2] ASN.1 notation of DENM).

Confidence

The data element provides the symmetric interval of 95 % confidence level for a current reported value. If not defined differently the confidence limits of the interval are calculated based on the Granularity of the corresponding measurement data element according to: Limit = ±LSB_Value × $2^{Confidence}$ (see TS 102 637-3 [2] ASN.1 notation of DENM).

CourseOfJourney

A part of a Block continuously operated on one single line, without any interruption. Thus, a Block will include several Courses of Journeys if it consists of Vehicle Journeys serving more than one Line (see TS 102 637-3 [2] ASN.1 notation of DENM).

CrashStatus

The data element indicates a major crash event of the vehicle which prevents a normal continuation of journey, e.g. by air bag activation or roll over (see TS 102 637-3 [2] ASN.1 notation of DENM).

Curvature

Data elements describe the inverse of the current curve radius. Positive values indicate a curve to the right (see TS 102 637-3 [2] ASN.1 notation of DENM).

CurvatureChange

Data element describes the change of curvature over time. Positive values indicate steering to the right (see TS 102 637-3 [2] ASN.1 notation of DENM).

DataReference

Reference to additional data, i.e. URL for accessing data via web service (see TS 102 637-3 [2] ASN.1 notation of DENM).

DangerousGoods

Data element describes type of dangerous good according to UN Recommendations on the Transport of Dangerous Goods - Model RegulationsTwelfth revised edition (see TS 102 637-3 [2] ASN.1 notation of DENM).

Dimension

Dimension of an object, e.g. height, wheelbase (see TS 102 637-3 [2] ASN.1 notation of DENM).

Direction

Orientation of something, e.g. a street or station (see TS 102 637-3 [2] ASN.1 notation of DENM).

Distance

Any distance measurement, e.g. radius of a circle, mileage of a vehicle (see TS 102 637-3 [2] ASN.1 notation of DENM).

DistanceToStopLine

Distance from the vehicles front to the next stop line (see TS 102 637-3 [2] ASN.1 notation of DENM).

DoorOpen

Status of vehicle doors. This status is especially used for public transport vehicles (see TS 102 637-3 [2] ASN.1 notation of DENM).

Elevation

Elevation in a WGS84 co-ordinate system. Compliant to SAE J2735 [4] DE_Elevation (see TS 102 637-3 [2] ASN.1 notation of DENM).

EmergencyResponseType

Type of action an emergency vehicle is currently performing (see TS 102 637-3 [2] ASN.1 notation of DENM).

ExteriorLights

The bitfield describes the status of the most important exterior lights. The fogLightOn indicates the status of the tail fog lamp. If a vehicle is not equipped with a certain light the value is set to 0. If one, more, or all lamps corresponding to a certain "light group" (e.g. front, back and side lamp of indicator) are not functional the corresponding bit is set if the light is switched on by the driver or automatically by a vehicle system. The turn signal and hazard signal bits provide the corresponding switch status not the lamp status, i.e. they should not alternate with the blinking interval. The hazard indicator is indicated by the combination of both turn signals (see TS 102 637-3 [2] ASN.1 notation of DENM).

Reference SAE J2735[4] adapted from DE_ExteriorLights.

Heading

The current heading of a station or direction of a street. Station heading used as reference for the width and length direction and for movement. In context with a road segment this defines the normal heading of vehicles on this link. North shall be defined as the axis defined by the WSG-84 coordinate system and its reference ellipsoid. Headings "to the north" corresponds to 0° "to the east" to 90°. (see TS 102 637-3 [2] ASN.1 notation of DENM).

Latitude

Absolute geographical latitude in a WGS84 co-ordinate system. (Direction flag save bandwidth for aligned PER) (see TS 102 637-3 [2] ASN.1 notation of DENM).

Reference SAE J2735 [4]	Compliant to SAE J2735 [4] DE_Latitude
Reference TPEG	Latitude in TPEG-LOC ISO-TS18234-6 in 10 micro-degrees units
Granularity	0,1 microdegree

LightBarInUse

The data element describes the status of any sort of additional visible lighting-alerting system. For example, these additional visible lighting-alerting systems might be part of an emergency vehicle, transportation response vehicle, or maintenance vehicles. Derived from DE_LightbarInUse. Enumeration adapted to the general SimpleSystemState (see TS 102 637-3 [2] ASN.1 notation of DENM).

LineRef

A Line is a grouping of Routes that is generally known to the public by a similar name or number. These Routes are usually very similar to each other from the topological point of view, being variants of a core route with some deviations on certain parts only. Often the vehicle journeys on these Routes are scheduled jointly with tight synchronisation, in order to provide a regular service on this specific Line. They are often grouped together for presentation of the timetable to the public (see TS 102 637-3 [2] ASN.1 notation of DENM).

LongAcceleration

The data element represents the signed acceleration in direction of the node heading. Negative values indicate deceleration (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity 0,01 m/s^2

Longitude

Absolute geographical longitude in a WGS84 co-ordinate system. (Direction flag save bandwidth for aligned PER) range limited to 0,84° approx 50 km at 50° Latitude (see TS 102 637-3 [2] ASN.1 notation of DENM).

Reference SAE J2735 [4] Compliant to SAE J2735 [4] DE_Longitude

Reference TPEG Longitude in TPEG-LOC ISO-TS18234-6 in 10 micro-degrees units

Granularity 0,1 microdegree

Occupancy

The passenger load status of a vehicle is given in percent (see TS 102 637-3 [2] ASN.1 notation of DENM).

PosConfidenceEllipse

Description of the horizontal position confidence as ellipse (see TS 102 637-3 [2] ASN.1 notation of DENM).

PositionConfidence

Symmetric interval of 95 % confidence level for longitude and latitude (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity $0{,}1\ m \times 2^{PositionConfidence}$

Priority

Priority of information. Value of 0 means highest priority, value of 7 means lowest priority (see TS 102 637-3 [2] ASN.1 notation of DENM).

PTLineDescription

Composition of (1) Course of Journey (2) Line Reference (3) Route Reference (see TS 102 637-3 [2] ASN.1 notation of DENM).

PublicVehicleType

Characterization of a public transport vehicle according to TPEG rtm40 (ISO/TS 18234-4 [3]). E.g. 3: school bus (see TS 102 637-3 [2] ASN.1 notation of DENM).

ReferencePosition

Absolute geographical coordinates including accuracy (see TS 102 637-3 [2] ASN.1 notation of DENM).

RoadSegmentID

ID of a road segment on a common map (see TS 102 637-3 [2] ASN.1 notation of DENM).

RouteRef

The Route entity represents a conventional way of describing a path through the network, to be used by regular public transport services (see TS 102 637-3 [2] ASN.1 notation of DENM).

ScheduleDeviation

The estimated deviation from the schedule for a VEHICLE JOURNEY. Positive values are associated with vehicles that are behind their schedule, negative values with ones that are ahead (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity 1 s

SimpleSystemState

Harmonized very general description of a system state mainly used for optional systems at cars, e.g. ESP (see TS 102 637-3 [**2**] ASN.1 notation of DENM).

SireneInUse

The data element describes the status of any sort of audible alarm system beside the horn. This includes various common sirens as well as backup up beepers and other slow speed manoeuvring alerts. Derived from DE_SireneInUse. Enumeration adapted to the general SimpleSystemState (see TS 102 637-3 [2] ASN.1 notation of DENM).

Speed

Any speed. Negative values imply the vehicle in moving in reverse (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity 0,01 m/s

StationLength

The data element describes the stations length at the widest point along heading direction while straight movement. This shall include a trailer if present. If the length with trailer cannot be determined the maximum allowed length shall be given and corresponding confidence value has to be provided (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity 0,01 m

StationWidth

The data element describes the maximum width of the station. It is given by the minimum passage width needed for a station with all factory installed equipment (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity 0,01 m

StreetName

Name of the referenced street (see TS 102 637-3 [2] ASN.1 notation of DENM).

Temperature

Any Temperature (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity 1 °C

TrafficLightPriority

Generalized term for priority treatment of certain traffic streams, usually PT or emergency vehicles (see TS 102 637-3 [2] ASN.1 notation of DENM).

TurnAdvice

Advice given by the navigation for the next turning manoeuvre (see TS 102 637-3 [2] ASN.1 notation of DENM).

TurnDirection

Direction of turn movement for signal description or vehicle manoeuvre (see TS 102 637-3 [2] ASN.1 notation of DENM).

VehicleSpeed

Speed of a single vehicle in direction of heading (see TS 102 637-3 [2] ASN.1 notation of DENM).

VehicleType

Characterization of a vehicle according to TPEG rtm01 (ISO-TS18234-4). E.g. 1: car (see TS 102 637-3 [2] ASN.1 notation of DENM).

WiperSystemFront

(see TS 102 637-3 [2] ASN.1 notation of DENM).

YawRate

Data element represents the signed change of the node heading (see TS 102 637-3 [2] ASN.1 notation of DENM).

Granularity 0,01°/s

Annex B (informative): CAM generation rules

CAMs are generated by the CAM Management and passed to lower layers when any of following rules apply:

- maximum time interval between CAM generations: 1 s;
- minimum time interval between CAM generations is 0,1 s. These rules are checked latest every 100 ms;
- generate CAM when absolute difference between current heading (towards North) and last CAM heading > 4°;
- generate CAM when distance between current position and last CAM position > 5 m;
- generate CAM when absolute difference between current speed and last CAM speed > 1 m/s;
- the generation rules are checked every 100 ms.

History

Document history		
V1.1.1	April 2010	Publication
V1.2.1	March 2011	Publication