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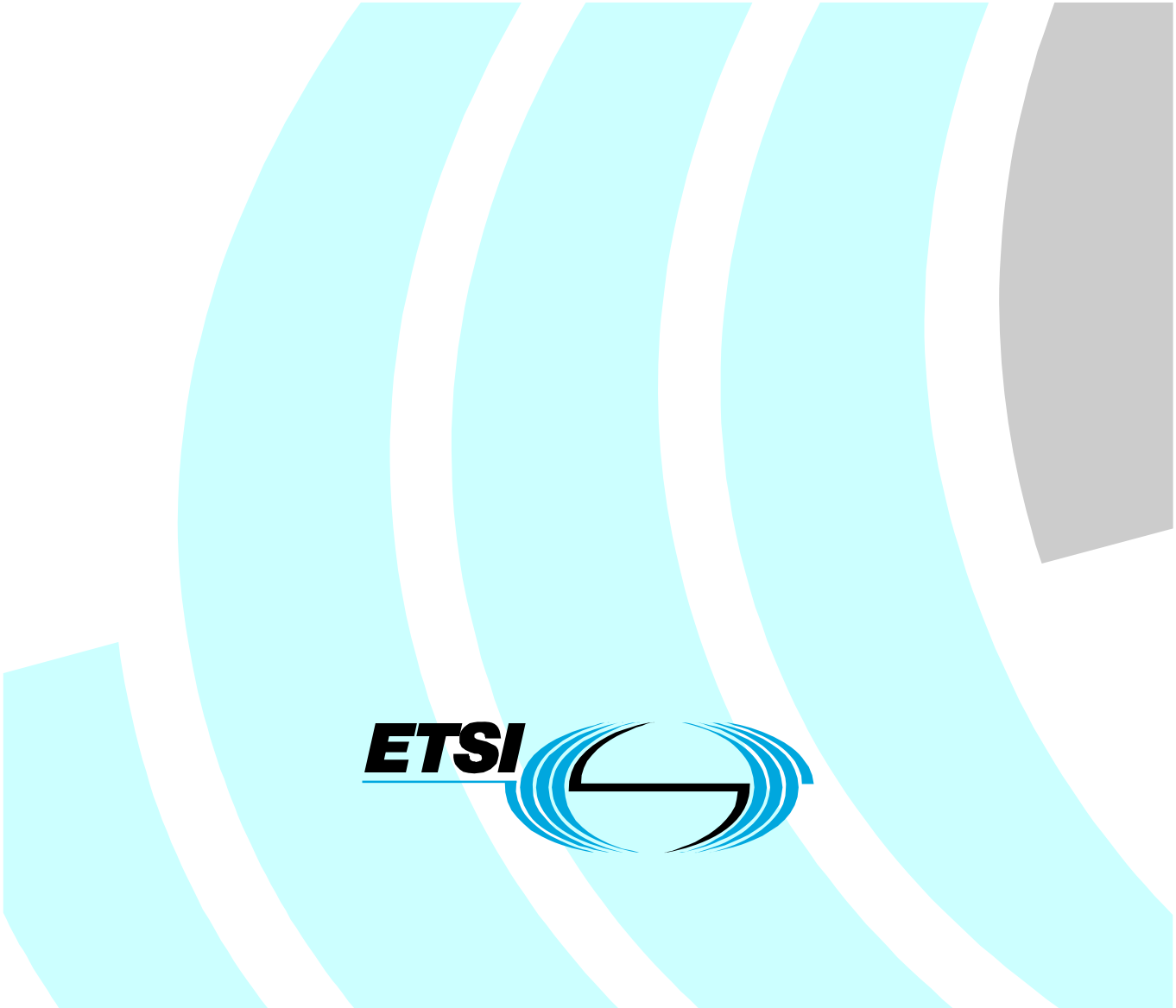
Technical Specification

Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service



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Contents

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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 3 of a multi-part deliverable covering Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications, as identified below:

Part 1: "Functional Requirements";

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

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

Part 4: "Operational Requirements".

Introduction

ITS use cases are distributed over multiple ITS stations. Co-operating ITS stations are interacting to provide a large diversity of customer services that satisfy different types of functional and operational requirements.

ETSI TC ITS has defined a Basic Set of Applications (BSA) [i.8] that can be deployed within a three-year time frame after the completion of their standardization. In this BSA, the Road Hazard Warning (RHW) application is composed of multiple use cases. ETSI TC ITS defines the decentralized environmental notification (DEN) basic service that supports the various RHW use cases. The specification of this basic service is the purpose of the present document.

The RHW application is an active road safety application that is distributed among vehicles ITS station and roadside ITS stations. The application execution is achieved through direct V2V / I2V communications.

Furthermore, this application broadcasts useful information that is related to road traffic conditions. Consequently, roadside ITS stations may collect the broadcasted information from vehicle ITS stations, process the information and forward the information to a central ITS station in order to improve the traffic efficiency and traffic management. In this case, the application execution can be achieved through V2V/I2V and/or other communications as defined in [6].

1 Scope

The present document provides the specification of the DEN basic service, which mainly supports the RHW application.

More specifically, the present document specifies the semantics of the Decentralized Environmental Notification Message (DENM) and the DENM handling.

A DENM transmission is triggered by a cooperative RHW use case to provide information about a specific driving environment event or traffic event to other ITS stations. The ITS station that receives the DENM is able to provide appropriate HMI information to the end user, who makes use of these information or takes actions in its driving and travelling.

The concept of the DEN basic service is derived from the functional requirements of BSA as defined in [i.4] and operational requirements of BSA as defined in [i.5].

Detailed specifications of the RHW use cases are out of scope of the present document.

The present document is based on DENM specifications defined in [i.1] and [i.2].

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

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

[2] Mobile.Info WG Automotive (March 2006): "TPEG TEC Application Specification V1.0".

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

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

NOTE: Available at: http://www.itu.int/ITU-T/studygroups/com17/languages/X.691-0207.pdf.

[5] Mobile.Info WG Automotive (March 2006): "TPEG-Automotive Protocol Location Container TAP-LOC V1.0".

[6] ETSI TS 102 636-3: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network architecture".

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] Car2Car Communication Consortium (August 2007): "Car2Car Communication Consortium Manifesto", Version 1.1.

NOTE: http://www.car-2-car.org.

[i.2] Car2Car Communication Consortium: "Message description: Decentralized Environmental Notification Message", Version 1.0.

[i.3] 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.4] ETSI TS 102 637-1: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 1: Functional Requirements".

[i.5] ETSI TS 102 637-4: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic set of applications; Part 4: Operational Requirements".

[i.6] ETSI TS 102 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[i.7] ETSI TS 102 636-4-1: "Intelligent Transport System (ITS); Vehicular communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Subpart 1: Media independent functionalities".

[i.8] ETSI TR 102 638: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions".

3 Definitions and abbreviations

3.1 Definitions

For the purpose of the present document, the terms and definitions given in EN 302 665 [3] and the following apply:

application support: subset of facilities, providing support elements for applications

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

NOTE: The basic set of applications can be deployed at a targeted time (day 1) after completion of their standards with the objective to serve societal and business objectives of private and public road transport stakeholders. The BSA is defined in [i.8].

communication support: subset of facilities, providing support for communications

DEN basic service: set of facilities and components to support RHW use cases, DENM management and DENM dissemination

DENM: ITS facility layer message providing RHW related information

destination area: geographical area for DENM dissemination

NOTE: The destination area is defined and specified by the ITS networking and transport layer.

event: road hazard situation, a driving environment situation, or a traffic condition situation

NOTE: An event potentially has an impact on the road safety, the traffic efficiency and/or the driving conditions.

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

NOTE: These functionalities, services and data are gathered in the ITS 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 for the 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 V2X-relevant image of the real world

NOTE: Applications can retrieve the data from the LDM by means of the LDM Management [i.3].

originator ITS station: In the context of the present document, the ITS station that generates and transmits the DENM

reference position: In the context of the present document, a geographical position that represents the event position

NOTE: The reference position is included in the DENM as a data frame.

reliability: In the context of the present document, the probability that a detected event is truly existent

relevance area: geographical area, one or several road section, or a traffic direction within which ITS stations are concerned by the event

V2I, I2V: direct vehicle to roadside infrastructure communication using a wireless local area network

V2V: direct vehicle(s) to vehicle(s) communication using a wireless local area network

NOTE: Other networks can be used for use case development. The selection of the optimal 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 abbreviations given in EN 302 665 [3] and the following apply:

ASN.1	Abstract Syntax Notation One
BER	Basic Encoding Rules
BSA	Basic Set of Applications
CAM	Cooperative Aware Message
CAN	Controller Area Network
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	DEN Message
DF	Data Frame
DSRC	Dedicated Short Range Communications
HMI	Human Machine Interface
ITS	Intelligent Transport System
LDM	Local Dynamic Map
OSI	Open System Interconnection
PDU	Protocol Data Unit
PER	Packed Encoding Rules
RHW	Road Hazard Warning
SAE	Society of Automotive Engineers
TEC	Traffic Event Compact
TPEG	Transport Protocol Experts Group
UTC	Coordinated Universal Time
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	V2V and/or V2I

4 Road hazard warning application general overview

4.1 Application overview

Decentralized Environmental Notification Messages (DENMs) are mainly used by the Cooperative Road Hazard Warning (RHW) application in order to alert road users of the detected events. The RHW application is an event-based application composed of multiple use cases. The general processing procedure of a RHW use case is as follows:

- Upon detection of an event that corresponds to a RHW use case, the ITS station immediately broadcasts a DENM to other ITS stations located inside a geographical area and which are concerned by the event.
- The transmission of a DENM is repeated with a certain frequency.
- This DENM broadcasting persists as long as the event is present.

NOTE 1: According to the type of the detected event, the DENM broadcasting can be realized by the same ITS station, temporarily realized by one or several ITS station(s), or relayed by one or several ITS station(s).

- The termination of the DENM broadcasting is either automatically achieved once the event disappears after a predefined expiry time, or by an ITS station that generates a special DENM to inform that the event has disappeared.
- ITS stations, which receive the DENMs, process the information and decide to present appropriate warnings or information to users, as long as the information in the DENM is relevant for the ITS station.

NOTE 2: A general use case procedure and DENM transmission data flow is provided in the annex C.

As defined in [i.8], the RHW application includes thirteen use cases. It is expected that further use cases will be added in the future.

Table 1 provides examples of the triggering and termination conditions of sending DENM.

Table 1: Triggering and termination conditions of DENM sending

Use case	Triggering condition	Terminating condition
Emergency electronic brake light	Hard breaking of a vehicle	Automatic after the expiry time
Wrong way driving warning	Detection of a wrong way driving by the vehicle being in wrong driving direction	Vehicle being in the wrong way has left the road section
Stationary vehicle - accident	e-Call triggering	Vehicle involved in the accident is removed from the road
Stationary vehicle - vehicle problem	Detection of a vehicle breakdown or stationary vehicle with activated warnings	Vehicle is removed from or has left the road
Traffic condition warning	Traffic jam detection	End of traffic jam
Signal violation warning	Detection of a vehicle being violating a signal	Signal violation corrected by the vehicle
Road-work warning	Signalled by a fix or moving roadside ITS station	End of the roadwork
Collision risk warning	Detection of a turning collision risk by a roadside ITS station	Elimination of the collision risk
	Detection of a crossing collision risk by a roadside ITS station	Elimination of the collision risk
	Detection of a merging collision risk by a roadside ITS station	Elimination of the collision risk
Hazardous location	Detection of a hazardous location	Automatic after the expiry time
Precipitation	Detection of a heavy rain or snow by a vehicle (activation of the windscreen wrappers)	Detection of the end of the heavy rain or snow situation
road adhesion	Detection of a slippery road condition (ESP activation)	Detection of the end of the slippery road condition
Visibility	Detection of a low visibility condition (activation of some lights or antifog)	Detection of the end of the low visibility condition
Wind	Detection of a strong wind condition (stability control of the vehicle)	Detection of the end of the strong wind condition

4.2 Concept of DEN basic service

Given the similarity of the different RHW use cases, a set of facilities and components have been defined and grouped into the DEN basic service. In particular, the DEN management domain facility is defined as the main facility to generate, update and terminate the transmission of DENM. Facilities and components belonging to the DEN basic service are presented in figure 1.

NOTE: The common and domain facilities are defined in [i.4].

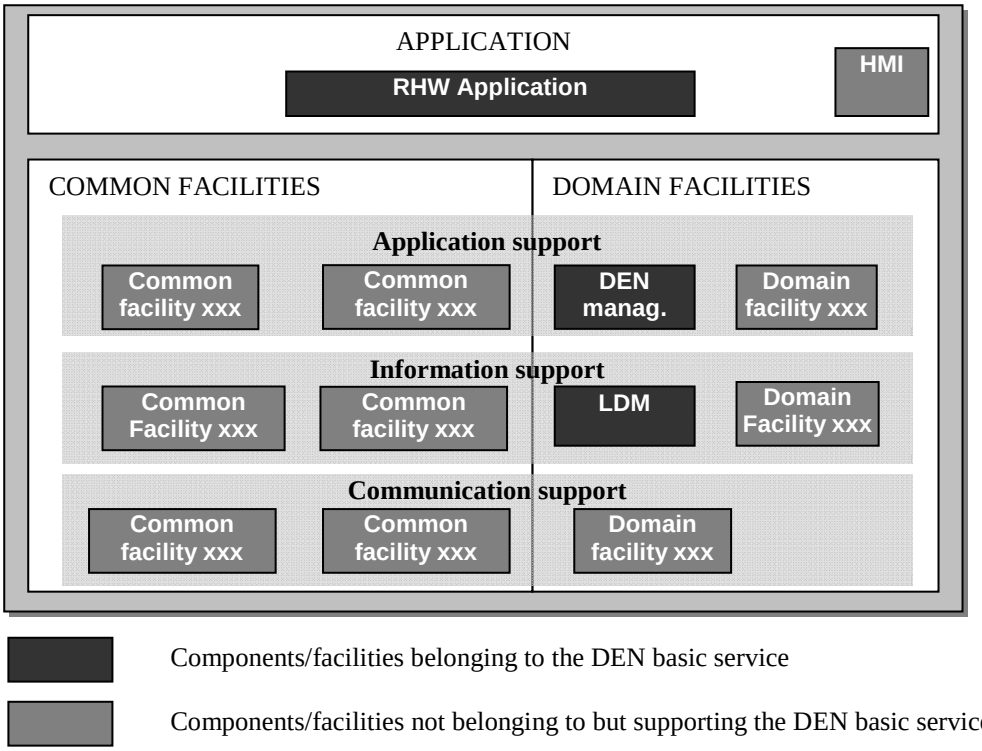

Figure 1: DEN basic service components

A DENM provides information related to an event that has a potential impact on road safety. Furthermore, a DENM can be used for traffic efficiency use cases. In such a situation, a use case may require the dissemination of a DENM over a long distance or to a central ITS station, such as for vehicle rerouting or traffic management.

In general, an event is characterized by an event type, a geographical position or an area, the detection time and a duration. These attributes may change over space and over time. A DENM, which concerns the same event, may be issued by multiple originator ITS stations at different positions and persists even after the originator ITS stations have passed by. Therefore, the detected event can be independent from the originator ITS stations. Furthermore, the reliability of the provided information related to the same event may vary at different originator ITS stations, depending on the detection capability of that ITS station.

5 DEN basic service

5.1 Functional components

As presented in figure 1, the main functional components that belong to the DEN basic service are the DEN management facility, the LDM and the RHW application. Other facilities may be required to exchange information with these DEN basic service components. Detailed information exchange differs from use case to use case

5.1.1 DEN management

The DEN management provides the following functionalities:

- DENM format management

  The DEN management holds information related to the DENM formats and semantic of DENM, a protocol version number is attached to each version of DENM format. Therefore, the DENM management also manages the update of DENM protocol.

- Generation of DENM

  The DEN management provides interfaces to the corresponding RHW application and other facilities in order to collect the needed information for DENM construction and updates.

  When the originator ITS station detects the event evolution, the DEN management constructs new DENM including the updated information. A data version number is assigned to DENM to indicate the event evolution.

- Management of DENM and information dispatching in the ITS station

  In case multiple DENMs are received by an ITS station, the DEN management provides functionalities to manage DENMs. This includes, not exhaustively:

  - the deletion of DENMs with outdated information;
  - the invalidation of outdated information;
  - the dispatching of event information included in the DENM to the LDM, to the ITS application layer and to other facilities for further processing;
  - the correlation of information from multiply received DENMs, in order to judge whether different DENMs sent from the same originator ITS station or from different originating ITS stations are concerned by the same event.

  NOTE: This functionality should be supported by the LDM as defined in [i.3].

- Delivery of the relevant communication parameters to the ITS networking and transport layer for DENM dissemination

5.1.2 Local Dynamic Map (LDM)

The LDM is updated based on received DENMs.

NOTE: The detailed specification of LDM [i.3] is out of scope of the present document.

5.1.3 RHW application

A RHW application is a component that initiates the broadcasting of a DENM and triggers the termination of DENM dissemination concerning the same event.

NOTE 1: The detailed specifications of the RHW application are out of the scope of the present document.

A non-exhaustive list of information that the RHW application should provide to the facilities layer for DENM construction and DEN management includes:

- Event type: the type of the detected event. An identifier is assigned to each specific event as cause code and/or sub cause code.
- Event position: the position of the detected event. In case the event covers an area, the event position may be described by a reference position or a geographical description of the event area.

NOTE 2: The detailed specifications of the event position is use case specific, therefore is out of the scope of the present document. Examples of the reference position of events are illustrated in annex D.

- Location referencing information for the event position.
- Detection time: time at which the event is detected.
- Event expiry time: time at which the event is expected to be terminated. In case that the originator ITS station is not able to detect the event expiry time, an estimated expiry time may be provided by the RHW application at the originator ITS station. The expiry time can be updated, terminated or dynamically extended if an event evolution is detected.

- Relevance area: a geographical area or road sections in which ITS stations are concerned by the event.
- DENM transmission frequency: the nominal time interval between two consecutive DENMs issued by the same ITS station.

5.2 DENM dissemination

5.2.1 Dissemination requirements

A DENM shall be disseminated to as many ITS stations as possible located within the relevance area. This includes ITS stations entering the destination area until the expiry time and ITS stations that have no connectivity to the originator ITS station when the DENM was issued. A list of DENM dissemination requirements are defined by the RHW application.

- DENM transmission frequency: the time interval between two consecutive DENMs sent out by the same ITS station.
- Required DENM transmission latency: the time interval between the time when a DENM is delivered by the facilities layer to the ITS networking and transport layer at the originator ITS station and the time when the DENM is delivered by the ITS networking and transport layer to the facilities layer of the receiving ITS station.
- DENM priority: DENM priority is defined by the RHW application and assigned as specified in [i.5].

NOTE 1: The dissemination requirements may be combined into one traffic class that represents the QoS requirement of a DENM. The concept of the traffic class is defined in [i.5].

- Destination area: geographical area that DENMs are required to be disseminated.

NOTE 2: The destination area description is as specified in [i.7]. In case the relevance area and the destination area is not identical, the DEN management should be able to convert the relevance area to the destination area before delivering to the ITS networking and transport layer.

The DENM dissemination shall rely on the functionalities of the ITS networking and transport layer, in particular on GeoNetworking functionalities as defined in [6].

5.3 Termination of the event

The termination of the event can be indicated in two ways:

- A cancellation DENM is sent by the originator ITS station when the event termination is detected. The cancellation message is regarded as a DENM with a special data version.
- A negation DENM is sent by one or several third party ITS stations that have received DENM earlier. When such third party ITS stations detect that the event does not exist anymore, it generates a DENM to negate the event. A negation flag is included in the DENM. The third party ITS stations that initiate the event negation shall be an authorized ITS station.

Once cancellation or negation DENM are verified to be trustworthy by the receiving ITS stations. All previously received DENMs concerning the same event shall be cancelled from the DEN management. Information included in those DENMs should be set as invalid inside the receiving ITS stations.

Once a cancellation or negation DENM is transmitted by an ITS station, it shall be repeated for a certain duration defined by the RHW application.

5.4 General confidence constraints

A DENM provides a qualitative description of a detected event. Special constraints may apply to some attributes provided within the event description. DENMs include information about the reliability level to be associated to the event (isNegation, reliability).

Position confidence level constraints is use case specific. Detailed specifications are out of scope of the present document.

5.5 General security constraints

Security-related information is not included in DENM.

NOTE: The detailed specifications of DENM security mechanism will be defined by the WG5 of ETSI ITS TC.

5.6 General priority constraints

The DENM priority is defined by the RHW use case as specified in [i.5].

Priority information is transmitted by lower layers and is therefore not included in the DENM.

6 Message format specification

6.1 General structure

A DENM PDU is composed of a common ITS PDU header and a DENM. The header inclues basic information including the protocol version, the message type (CAM or DENM) and the generation time of the message. A DENM consists of three fixed order parts: the management container, the situation container and the location container. The general structure of a DENM is illustrated in figure 2. Each container is composed of a sequence of data elements (DE) and data frames (DF). A DE and a DF is either optional or mandatory. If not specified as optional in the present document, a DE or DF is considered as mandatory.

NOTE: A DF is composed of a fixed sequence of at least two DEs.

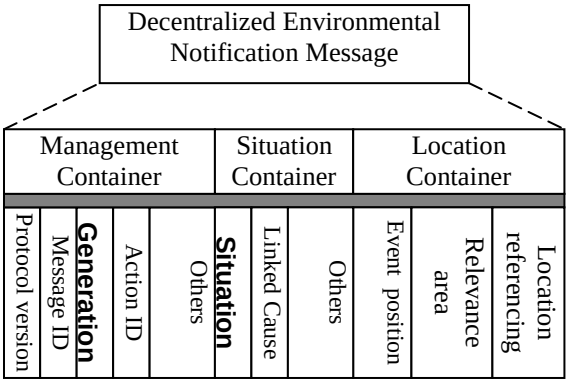

Figure 2: General structure of the DENM

6.1.1 DENM management container

The management container holds management information of a DENM. Specific DEs are included in the management container to indicate the reliability level, the event evolution and the event termination. The reliability level is expressed by the DE reliability, the event evolution is indicated by the data version, and the event termination can be indicated by a special data version number or a negation flag DE.

Information included in the management container shall allow ITS station to distinguish different originator ITS stations and different events without ambiguity.

6.1.2 DENM situation container

The situation container includes information that describes the detected event as well as its potential impact to the road safety and traffic flow. The situation container is composed of the following DEs and DFs:

- Traffic flow effect: this DE provides traffic flow status caused by the event. That is, whether the event has caused a traffic jam, dense traffic, or does not have impact on the traffic flow.
- The information may require specific jam detection means at the originator ITS station. The DE is optional.
- Cause code: this DE provides a description of the direct cause for the event.
- Sub cause code: this DE is used to provide more detailed information for the direct cause. For example, extreme weather conditions being the direct cause, strong wind, precipitation or strong snow are specified in the sub cause.
- The sub cause DE can be set to unknown if the originator ITS station does not have the required detection capability. In this case, this DE is set to "0".
- Direct cause DE and sub cause DE are combined into the situation DF.
- Linked cause: this DF provides description of another event that are related to or being the cause to the direct cause. For example, an accident is detected caused by the low road adhesion situation. Accident is defined as the direct cause, while low road adhesion is assigned as linked clause.
- Linked cause is described by the situation DF. This DF is optional. The originator ITS station should determine whether to add a linked cause in DENM, depending on its detection capability,
- Severity: this DE provides a severity level of the event to the overall traffic. Various events are classified into four severity levels, with 1 for relatively low safety impact and 4 for high safety critically events. Detailed specifications of severity shall be as specified in [2].
- Basic event characteristics: This DF is used to provide basic characteristics of the event in order to facilitate the collision risk estimation and/or better understanding of the event natures at the receiving ITS station. These characteristics specify:
  - event mobility: whether the detected event is static or in mobility;
  - cause type: whether the detected event is caused by an ITS station in danger, or is a location or a road section that cause the danger;
  - relevant: whether the detected event is physically relevant to the received ITS stations (accident) or describes difficult driving conditions (strong wind on the road);
  - time criticality: whether the detected event is time critical and requires high attention from the driver (hard brake vehicle) or provide some traffic information (traffic jam).

- Others: supplementary information related to the event may be included in the situation container if such information is known and available at the originator ITS station. These supplementary information can be different depending on the detected event. For example, for the slow vehicle, further information for the vehicle type, vehicle size and vehicle speed limit can be provided. As another example of the traffic condition warning, supplementary information can be needed to indicate the restrictive vehicle type, if the traffic condition is only dedicated to a specific vehicle type.

  These supplementary information is provided as optional data within the situation container. Vehicle common parameters and profile parameters as defined in [1] can be used.

Considering the RHW use cases, assigned cause code and sub cause code is presented in the table 2. If not specified within table 6.1, specifications on direct cause and sub cause shall be as specified in [2].

Table 2: Cause description and cause code assignment for RHW use case

Use case	Direct cause code	Direct cause	Sub cause code	Sub cause
Emergency electronic brake lights	101	Dangerous Driving	1	Hard brake vehicle
Wrong way driving warning	*	Wrong way driving	0	
Signal violation warning	102	Intersection violation	1	Stop sign violation
			2	Traffic light violation
			3	Turning regulation violation
Stationary vehicle - accident	*	Accident	0	
Stationary vehicle - vehicle problem	103	Vehicle problems	1	Break down vehicle
			2	Vehicle speed reduced with safety lights on.
Slow vehicle warning	*	Slow vehicle	0	
Traffic condition warning	*	Traffic jam	0	
Roadwork warning	*	Road work	0	
Collision risk warning	104	Intersection collision	1	Left turn collision risk
			2	Right turn collision risk
			3	Crossing collision risk
			4	Merging collision risk
Hazardous location	105	Hazardous location	1	Dangerous curve
			2	Obstacle on the road
Precipitation	*	Precipitation	*	Heavy rain
			*	Heavy snow
Wind	*	Extreme weather condition	0	
Road adhesion	*	Slippery Road	*	Low road adhesion
			*	Black ice
Visibility	*	Visibility reduced	*	Bad visibility due to frost
			*	Bad visibility due to storm
Emergency vehicle approaching	*	Rescue on the way	*	Emergency vehicle

6.1.3 DENM location container

The location container consists mainly of three DFs: the event position, the location referencing and the relevance area.

6.1.3.1 Event position

The event position describes the geographical position of the detected event. The event position can be represented as a geographical position or as an event area.

- The exact event position: When the event is located at a specific geographical position (e.g. the current position of a vehicle ITS station in accident event), the geographical coordinates of this position are provided and augmented with speed and moving direction.

- Event reference position: When the event covers a geographical area or cannot be precisely detected by the originator ITS station, an event reference position DF can be defined and used as the event position. For example, the reference position could be the border point position of a road hazard area, which is closest to the relevance area, or the current position of the originator ITS station of the DENM. Detailed definition of the event reference position is use case specific. In case the detected event is in mobility, further information such as speed, moving direction are included as optional information in the event reference position.

  The event reference position and the exact event position are described in a DF RefPosition.

- Event area: In another way to describe the event position when the event covers an area, the geometrical description of the event area can be provided in a event area DF. The event area DF may be coded with combination of one or several RefPosition DFs or other DEs, such as length, road segment identifier etc.

NOTE: Detailed specifications of the event area DF may be as specified in [5].

6.1.3.2 Relevance area

The relevance area describes a geometrical area, a road topology area and/or a specific traffic direction that the ITS stations located within such area are concerned by the event. The relevance area indicates the minimum area where the DENMs should be disseminated and the transmission direction of the DENMs along the road traffic. DENM according to the selected traffic class shall be disseminated to as many ITS stations as possible located in or entering into the relevance area. Receiving ITS station makes use of the relevance information to realize the relevance check and to manage the information related to the event. The relevance area DF is included in DENM.

NOTE 1: The relevance area is defined by the RHW use case, a sample text description of the relevance area for the RHW use cases are provided in the annex D of the present document.

According to the use case requirements, the relevance area DF can be described in several ways:

- Geographical area: The relevance area DF is described by a geometric shape. In this case, the DF is combined by one or several geographical point DFs or other DEs such as distance. For example, for a road accident on a motorway, the relevance area of the DENM related to the vehicle accident is a certain distance from the accident position.

- Road topology: The relevance area DF is described by one or several road segments identifiers. For example, for roadwork, the relevance area of the DENM related to the roadwork is one or multiple road sections that are influenced by the roadwork.

- Dissemination traffic direction: The relevance area DF is described by a traffic direction along which DENM is disseminated. For example, for a traffic jam on a motorway, the relevance area of the DENM related to the traffic jam is the upstream direction of the traffic jam.

According to [i.7], the destination area can be defined by geometrical shapes of different size. Three shapes are currently defined:

- circular shape;

- rectangular shape;

- elliptical shape.

The relevance area is not necessarily identical with the destination area used at the ITS networking and transport layer as defined in [i.7]. However, the destination area shall cover the relevance area.

In case the relevance area description is different from the destination area description, the DEN management shall convert the relevance area to the destination area as specified in [i.7].

NOTE 2: Detailed specifications of the relevance area DF are use case specific and out of the scope of the present document.

Examples for the relationship and the difference among the event position, the relevance area and the destination area are provided in figures 3 and 4.

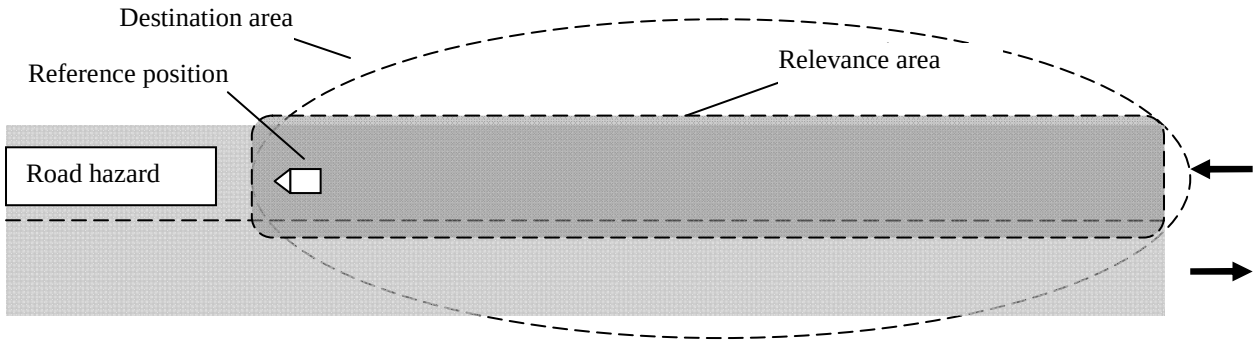

Figure 3: Example of the event reference position, the relevance area and the destination area, highway scenario

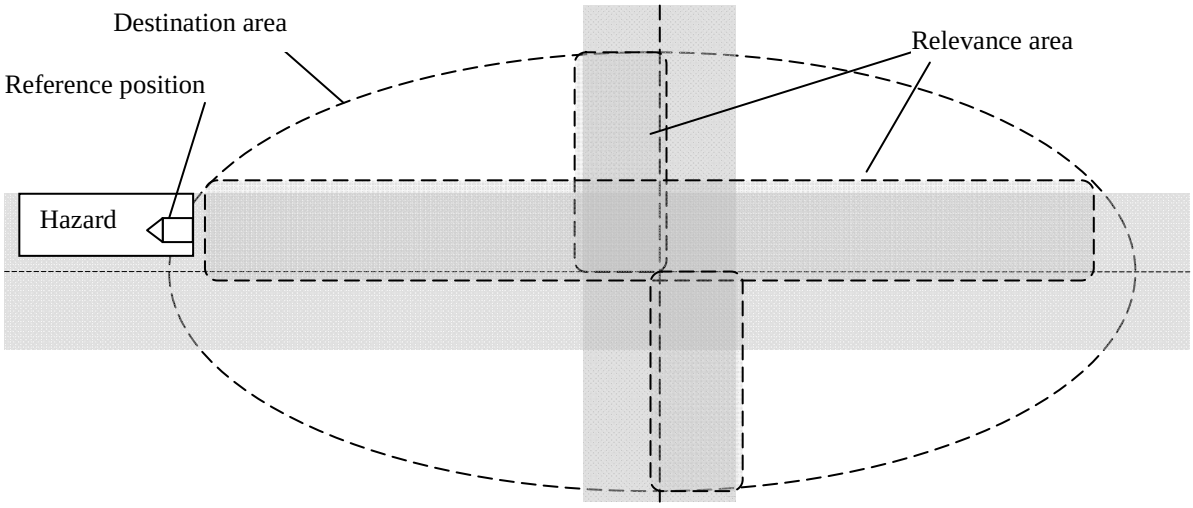

Figure 4: Example of the event reference position, the relevance area and the destination area, intersection scenario

6.1.3.3 Location referencing

This DF provides location referencing information of the event position. Multiple location referencing mechanisms may be used depending on the use case requirements. One location referencing mechanism that can be used for RHW use cases is the trace location referencing.

The trace location referencing provides a list of waypoint positions that lead towards the event position. One trace contains several waypoints that forms an itinerary approaching to the event position. Multiple traces can be included in this location referencing for an event, if ITS stations can encounter the detected event from different road sections or from different traffic flows.

Trace location referencing is defined and provided by the originator ITS station.

The selection of the optimal location referencing mechanism to be used as well as the detailed specifications of the location referencing are out of the scope of the present document.

6.2 Detailed DENM format

The following clauses define the DENMs DE and DF.

6.2.1 Format definition of DENM

The present clause shows the DENM format in a semantic representation. Data presentation shall be as determined in clause 6.2.4.

The entries referring to "Byte Position" in the table 5 are therefore arbitrary and listed to aid the understanding of the semantic representation only. The real position of the element in the data-stream is defined by the ASN.1 definition in clauses 6.2.3, 6.2.4 and 6.2.5.

NOTE: The ASN.1 presentation of DEs and DFs is presented in annex B of the present document.

6.2.2 Data presentation of DENM

The DENM format is presented in ASN.1. Unaligned packed encoding rules (PER) as defined in ISO/IEC 8825-2 [4] shall be used for encoding and decoding.

NOTE: A general description of ASN.1 PER is presented in annex A of the present document.

The DENM shall be sent in the sequence defined in the clauses 6.2.4, 6.2.5 and 6.2.6. Figure 5 provides the order of bits and bytes in the DENM.

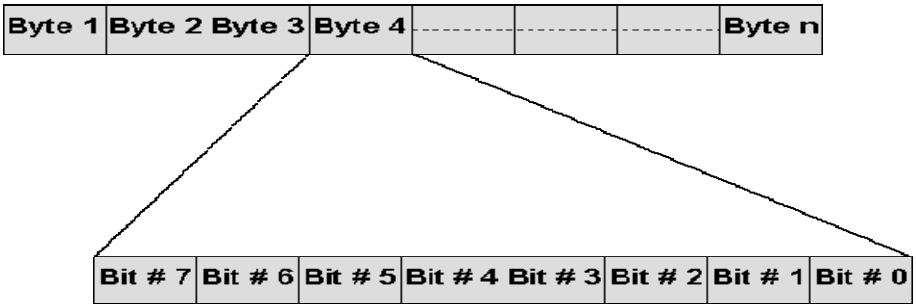

Figure 5: Bits and bytes in DENM

6.2.3 Content of DENM

For illustration purposes, table 3 provides an example summary of the content and the format of a DENM.

Table 3: Content and format of a DENM

Container	Block #	Name	Byte Position		Type	Unit	O/M	Description
			First	Last				
ITS PDU header	1	Protocol Version	1	1	Integer		M	Indicates the current version of the protocol being used at the management container level
	2	Message ID	2	2	Integer		M	Message type identifier associated to DENM
	3	Generation Time	3	8	Integer	UTC millisec	M	Timestamp when the DENM is generated, milliseconds elapsed since midnight January 1st , 1970 UTC
Management	4 Action ID :	Originator ID	9	12	Integer		M	ITS station identifier
		Sequence Number	13	14	Integer		M	Sequence number provided by the originator when an event is detected for the first time.
	5	Data version	15	15	Integer		M	Data version indicating an update of the event evolution. Set to 255 for cancellation message
	6	Expiry Time	16	21	Integer	UTC millisec	M	Timestamp of event expiry, milliseconds elapsed since midnight January 1st, 1970 UTC
	7	Frequency	21	21	Integer		O	Transmission frequency of DENM as defined by the originator ITS station.
	8	Reliability	22	22	Integer		M	Probability for the event information to be true. Bit 7 to bit 1 of the byte 22
	9	IsNegation	22	22	Boolean		M	Bit 0 of byte 22 when "1" negates the existence of the event
Situation	10	CauseCode	23	23	Integer		M	Identifier of the event direct cause as specified in table 1
	10	SubCauseCode	24	24	Integer		M	Sub cause as provided in table 1
	11	Severity	25	25	Integer		M	Severity value of the event

Container	Block #	Name	Byte Position		Type	Unit	O/M	Description
Location container	12	RefPosition_Situation Latitude	26	29		1/10 micro degree	M	Latitude of the event reference position
	13	RefPosition_Situation Longitude	30	33	Integer	1/10 micro degree	M	Longitude of the event reference position
	14	RefPosition_Situation Altitude	34	35	Integer	1/10 meter	M	Altitude of the event reference position
	15	Accuracy	36	39	String		M	Event position accuracy
	16	Other DEs and DFs for the relevance area and the location referencing	40	n			M	This block is defined and specified by the RHW application with variable sizes

6.2.4 DENM format

The ASN.1 representation of the DENM is represented in figure 6.

```
-- ASN1START


DENM-PDU-Descriptions {
 itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) ts (102637) denm (3) version2 (2)
}
DEFINITIONS AUTOMATIC TAGS ::=


BEGIN
DenmPdu ::= SEQUENCE {
    header                  ItsPduHeader,
    denm                    DecentralizedEnvironmentalNotificationMessage
}


DecentralizedEnvironmentalNotificationMessage ::= SEQUENCE {
    management              DecentralizedSituationManagement
                                                    -- container with DEN management and version control
    situation               DecentralizedSituation  -- container with event description, incl. type, severity
    location                DecentralizedSituationLocation
                                                    -- container with event location, location referencing
                                                    with more detailed location description and the
                                                    relevance area

    ...
}
```

```
DecentralizedSituationManagement::= SEQUENCE {
    -- unique identifier about an event from one originator ITS station, combination of node ID and a sequence number
    actionID                ActionID,           -- 6 byte
    -- version of the DENM indicating updates from the same originator ITS station; value of 255 is used for the cancellation message sent from the originator ITS station
    dataVersion             DataVersion,        -- 1 byte
    -- time when the DENM is deleted from the DEN management and the information related to the event is set as invalid.. If it is not provided, it indicates that the expiry time is unkown by the originator ITS station
    expiryTime              TimeStamp           OPTIONAL,   -- 6 byte
    frequency               INTEGER (0..255)    OPTIONAL,   --units in 0.1Hz
    -- probability of the detected event to  be true, varies  from 0 to 100, with maximum value as full reliability
    reliability             INTEGER(0..100),    -- 7 bits
    -- negates the existence of an event at the event position by a third part ITS station that have received DENMs previously.
    isNegation              BOOLEAN             -- 1 bit
}

    -- event description derived from [2]
DecentralizedSituation::= SEQUENCE {
    -- traffic status near the event position, defined based on [2], TPEG table tec001
    trafficFlowEffect       TrafficFlowEffect       OPTIONAL,  -- 1 byte.
    -- event direct cause and sub cause description as defined in tab6.1 and in [2]
    situation               Situation,
    -- linked cause if information is available.
    linkedCause             Situation               OPTIONAL,  -- 2 Byte,
    -- severity value of the event, defined in [2], TPEG table tec003
    severity                Severity,               -- 1 byte
    -- characteristics of the event
    eventCharact            SEQUENCE                -- EventCharact 1 byte
    {
                            -- event mobility description, set to TRUE if the event is in mobility
                            eventmobility   BOOLEAN,
                            -- whether the event is caused by the originator ITS station
                            causeType       ENUMERATED { itsStation, geographicalRegion },
```

```
                    -- whether the event is physicalling relevant to the  receiving ITS station
                    relevance       ENUMERATED {physicallyRelevant, difficultDrivingConditions },
                    -- whether the event is time critical road safety event, set to TRUE if it is the case.
                    timeCriticality  BOOLEAN,
                    -- more characteristics may be added.
                    ...
    } OPTIONAL,

    vehicleCommonParameters VehicleCommonParameters OPTIONAL,
    profile                 ProfileParameters       OPTIONAL
}

DecentralizedSituationLocation::= SEQUENCE {
    -- description of the event position.
    eventPosition           CHOICE      {
                    -- the geographical position of the event reference position
                    eventPositionCurrentDefinition      EventPosition,
                    ...
    },
    -- description of  the relevance area for the  DENM dissemination

    -- location referencing of the event position
    locationRef             CHOICE {
                    -- consequence position of the trace location referencing mechanism
                    trace           TraceLocData,
                    -- more location referencing mechanism to be added
                    ...
    },
    ...
}

EventPosition ::= SEQUENCE {
    refPosition             ReferencePosition,
    -- event speed, either equal to or different from the vehicle speed
```

```
    eventSpeed              Speed          OPTIONAL
}

ActionID ::= SEQUENCE {
    stationID               StationID,     -- a 4 byte value
    sequenceNo              SequenceNo     -- a 2 byte value
}

Elevation ::= INTEGER (-10000..16767215) -          - multiples of 0.1 m

ItsPduHeader ::= SEQUENCE {
    -- protocolVersion fixed to 0
    protocolVersion         INTEGER(0..255),
    -- message type ID associated to CAM = 0, DENM=1
    messageID               INTEGER(0..255),
    -- milliseconds elapsed since midnight January 1st, 1970 UTC
    generationTime          TimeStamp
}

Latitude ::= SEQUENCE {
    hemisphere              ENUMERATED { north (0), south (1) },
    degree                  INTEGER (0..900000000)  -- multiples of 0.1 microdegree
}

Longitude ::= SEQUENCE {
    hemisphere              ENUMERATED { east (0), west (1) },
    degree                   INTEGER (0..1800000000)     -- multiples of 0.1 microdegree
}

ReferencePosition ::= SEQUENCE {
  longitude                 Longitude,
  latitude                  Latitude,
  elevation                 Elevation,
  heading                   Direction      OPTIONAL,          --present if mobileItsStation flag is TRUE
```

```
    streetName              StreetName      OPTIONAL,
    positionConfidence      Confidence      OPTIONAL,       --present if mobileItsStation flag is TRUE
    elevationConfidence     Confidence      OPTIONAL,       --present if mobileItsStation flag is TRUE
    roadSegmentID RoadSegmentID             OPTIONAL
}

SequenceNo ::=INTEGER (0..65535)            -- increased by 1 each time a new event is detected by the same ITS station.

DataVersion ::= INTEGER {firstVersion(0),secondVersion(1),cancellation(255) } (0..255)

TrafficFlowEffect ::= INTEGER(0..7)         -- values as specified in [2], set to 1 when the traffic flow effect is unknown,

Situation ::= SEQUENCE {
    cause                   CauseCode,      -- 1 byte
    subCause                SubCauseCode -- 1 byte
}

-- 1 to 100 indicates causecode defined within [2]
-- 101 to 255 indicates causecode without being defined by [2]
CauseCode::=INTEGER{
    reserved                (0),
    dangerousDriving        (101),
    intersectionViolation   (102),
    vehicleProblem          (103),
    intersectionCollision   (104),
    hazardousLocation       (105)
} (0..255)

SubCauseCode ::= INTEGER {unknown(0)} (0..255)

Severity ::= ENUMERATED     -- 1 byte
{
    informative             (1),
```

```
    -- Text example: <Attention, there is a dangerous obstruction due to fog>
    obstacles               (2),        --danger level 1
    -- Text example: <Attention, there a danger due to fog>
    danger                  (3),        --danger level 2
    -- Text example: <Attention, highest danger due to fog>
    highestDanger           (4)         --danger level 3
}

Speed ::= INTEGER (-32765..32765)       -- multiples of 0.01 m/s
StationID ::=   INTEGER(0..4294967295)

TraceLocData ::=            SEQUENCE {
    --3 bits, identifier of the trace
    traceID                 INTEGER(0 .. 7),
    --5 bits, number of waypoint positions included in the trace
    waypoints               SEQUENCE (SIZE(0..31)) OF Waypoint
}

TimeStamp ::=               INTEGER (0.. 281474976710655)   -- units of milliseconds, 6 byte

Waypoint  ::=SEQUENCE{
    --  waypoint positions included in the trace.
    ptLat                   Latitude,   --a 4 bytes value
    ptLong                  Longitude,  --a 4 bytes value
    ptAlt                   Elevation,
    ...
}

-- common and profile dependent parameter definitions follow
ProfileParameters ::= CHOICE {
    basicVehicle            BasicVehicle,
    emergencyVehicle        EmergencyVehicle,
    publicTransportVehicle  PublicTransportVehicle,
  ...
```

```
}

VehicleCommonParameters ::= SEQUENCE {
    vehicleType                 VehicleType,
    stationLength               StationLength,
    stationLengthConfidence     Confidence      OPTIONAL,
    stationWidth                StationWidth,
    stationWidthConfidence      Confidence      OPTIONAL,
    vehicleSpeed                VehicleSpeed,
    vehicleSpeedConfidence      Confidence,
    longAcceleration            LongAcceleration,
    longAccelerationConfidence                  Confidence,
    accelerationControl         AccelerationControl,
    yawRate                     YawRate,
    yawRateConfidence           Confidence,
    exteriorLights              ExteriorLights,
    turnAdvice                  TurnAdvice      OPTIONAL,
    distanceToStopLine          DistanceToStopLine          OPTIONAL,
    occupancy                   Occupancy       OPTIONAL,
    doorOpen                    DoorOpen        OPTIONAL,
    posConfidenceEllipse        PosConfidenceEllipse,
    curvature                   Curvature,
    curvatureChange             CurvatureChange             OPTIONAL,
    curvatureConfidence         Confidence,
    crashStatus                 CrashStatus     OPTIONAL,
    headingConfidence           Confidence,
    dangerousGoods              DangerousGoods              OPTIONAL,
    ...
}

BasicVehicle ::= SEQUENCE {
    ...
}
```

```
EmergencyVehicle ::= SEQUENCE {
    lightBarInUse               LightBarInUse  OPTIONAL,
    sireneInUse                 SireneInUse    OPTIONAL,
    emergencyResponseType       EmergencyResponseType,
    ...
}

PublicTransportVehicle ::= SEQUENCE {
    publicVehicleType           PublicVehicleType,
    pTLineDescription           PTLineDescription OPTIONAL,
    scheduleDeviation           ScheduleDeviation OPTIONAL,
    trafficLightPriority        TrafficLightPriority OPTIONAL,
    ...
}

AccelerationControl ::= BIT STRING {
 brakePedal    (0),
 throttlePedal (1),
 cruiseControl (2),
 acc           (3),
 limiter       (4),
 brakeAssist   (5)
}

AmbientAirTemperature ::= Temperature


Confidence ::= INTEGER (0..15)

CourseOfJourney ::= IA5String(SIZE(0..32))

CrashStatus ::= BOOLEAN

Curvature ::= INTEGER (-32765..32765)
```

```
CurvatureChange ::= INTEGER (-1023..1023)

DataReference ::= IA5String(SIZE(1..128))

DangerousGoods ::= INTEGER (0..8191)

Dimension ::= INTEGER (0..16383)

Direction ::= INTEGER{north(0), east(7200), south(14400), west(21600)} (0..28799)

Distance ::= INTEGER (0..65535) -- multiples of 1.0m

DistanceToStopLine ::= Distance

DoorOpen ::= BIT STRING {
 driver (0),
 passenger (1), -- any passenger door
 maintenance (2), -- hood, other access to engine, or similar
 luggage (3)
}

EmergencyResponseType ::= ENUMERATED {
 none        (0),
 staticSafeguard (1),   -- e.g. at accident spot
 movingSafeguard (2),   -- e.g. convoy or abnormal load
 rightOfWay      (3),   -- claiming right of way
 ...
}

ExteriorLights ::= BIT STRING {
 lowBeamHeadlightsOn     (0),
 highBeamHeadlightsOn    (1),
 leftTurnSignalOn        (2),
```

```
    rightTurnSignalOn       (3),
    automaticLightControlOn (4),
    daytimeRunningLightsOn  (5),
    fogLightOn              (6),
    parkingLightsOn         (7)
    }

LightBarInUse ::= SimpleSystemState

LineRef ::= IA5String(SIZE(0..32))

LongAcceleration ::= INTEGER (-2000..2000)  -- multiples of 0.01 m/s^2

Occupancy ::= INTEGER (0..255)

PosConfidenceEllipse ::= SEQUENCE {
    semiMajorConfidence     Confidence,     -- confidence of the ellipse's major semi-axes
    semiMinorConfidence     Confidence,     -- confidence of the ellipse's minor semi-axes
    semiMajorOrientation    Direction
}

Priority ::= INTEGER(0..7)

PTLineDescription ::= SEQUENCE {
    courseOfJourney         CourseOfJourney,
     lineRef                LineRef,
    routeRef                RouteRef
}

PublicVehicleType ::= INTEGER(0..255)

RoadSegmentID ::= INTEGER (0..99999999)

RouteRef ::= IA5String(SIZE(0..32))
```

```
ScheduleDeviation ::= INTEGER (-900..3600)  -- seconds, positiv delay; negative ahead of schedule

SimpleSystemState ::= ENUMERATED {
  unavailable  (0), -- not equipped or out of order
  disabled  (1), -- switched off by user or due to driving situation, e.g. ACC below minimum speed
  enabled   (2), -- switched on but no action, e.g. ESP in normal operation, limiter below limit speed
  engaged   (3)  -- switched on and in action, e.g. light bar flashing, limiter limiting speed
}

SireneInUse ::= SimpleSystemState

StationLength ::= Dimension

StationWidth ::= Dimension

StreetName ::= IA5String(SIZE(1..32))

Temperature ::= INTEGER (-40..215)

TrafficLightPriority ::= Priority

TurnAdvice ::= SEQUENCE {
  direction    TurnDirection,
  distance     Distance
}

TurnDirection ::= BIT STRING {
  uTurn       (0),
  sharpRight  (1),
  right       (2),
  slightRight (3),
  straight    (4),
  slightLeft  (5),
```

```
  left        (6),
  sharpLeft   (7)
}

VehicleSpeed ::= Speed

VehicleType ::= INTEGER (0..255)

WiperSystemFront ::= ENUMERATED {
  idle        (0),
  interval    (1),
  normal      (2),
  fast        (3),
  washerActive (4)
}

YawRate ::= SEQUENCE {
  yawDirection ENUMERATED { left (0), right (1) },
  yawRateValue  INTEGER (0..32765)                    -- multiples of 0.01deg/s
}

END

-- ASN1STOP
```

Figure 6: ASN.1 notation of the DENM

Annex A (informative): Packed encoding rule

Packed encoding rules (PER) are ASN.1 encoding rules for producing a compact transfer syntax for data structures described in ASN.1. It provides a more compact encoding based on the data type to generate much more compact representations than Basic Encoding Rules (BER). PER specifications are defined by ITU-T (ITU-T Recommendation X.691) and adopted by ISO standards (ISO/IEC 8825-2) [4].

In BER encoding rules, a common form of encoding commonly known as Tag-Length-Value is used. Each item is encoded as a tag, indicating what type it is, a length indicating the size of the object, and a value, which contains the actual contents of the object.

PER uses additional information from the ASN.1 specification to represent the data units using the minimum number of bits. However, the compactness requires that the decoder knows the complete abstract syntax of the data structure to be decoded.

PER only generates tags when they are needed to prevent ambiguity. Lengths are only generated by PER when the size of an object can vary. Even then, PER tries to represent the lengths in the most compact form possible.

There are two variations of packed encoding rules: unaligned and aligned. With the unaligned encoding, the bits are packed with no regard for octet (byte) boundaries. With aligned encoding, certain types of data structures are aligned on octet boundaries, which may result in some number of wasted bits. Unaligned encoding uses the least number of bits by allowing values such as Booleans and small integers to be compacted together in one byte, but presumably at some cost in processing time.

The presence of optional elements in a sequence is indicated by a list of single bit flags placed at the start of a sequence if the bit is set, then the option is present.

Annex B (normative): ASN.1 presentation for data elements and data frames

A DENM carries the following data elements (DE) and data frames (DF).

B.1 DE_protocolVersion

Purpose	Version identifier for the underlying protocol specification. It shall be used to select the appropriate protocol decoder at the receiver ITS station.
Notes	This DE enables separate versioning of this message type. For the present standard, this protocol version is set to 0.

B.2 DE_messageID

Purpose	Message type identifier assigned to the DENM.
Notes	This DE should be harmonized with other V2X message identifier definition. For DENM, the messageId is set to 1.

B.3 DE_generationTime

Purpose	Time at which the DENM was generated. It denotes the time difference in milliseconds since a well-defined start time - here milliseconds since 1.1.1970 00:00:00.000.
Notes	This DE should be harmonized with the general V2X message timestamp definition.

B.4 DF_actionID

Purpose	Identifier generated each time an ITS station detects an event at a specific position for the first time. The actionID value is composed of an ITS station identifier and a sequence number. The sequence number is increased by 1 each time a new event is detected by the ITS station. The actionID differs from all actionIDs generated by other ITS stations and from the actionIDs generated by the same ITS station for other detected events while the original DENM is valid. It is used to allow receiving ITS stations to process information for DENMs that are multiply received.
Notes	For the event covering an area, a moving vehicle ITS station may detect the persistence of the same event at different positions. The actionID should be maintained by the originator ITS station and remain the same if this originator ITS generates multiple DENMs regarding the same event. The station ID should be harmonized with general station ID definition. A temporary station ID (e.g. pseudonyms) can be used.

B.5 DE_dataVersion

Purpose	Data version that indicates an update of information related to an event described by a previous DENM from the same originator ITS station. For the 1st DENM generated by the originator ITS station, this DE is set to 0. With each update it is increased by one. The maximum value of 255 indicates a cancellation, i.e. the node indicates that the event described with the same actionID does not exist anymore. This dataVersion number is in correspondence with the evolution of the event, (e.g. the position of black ice changes). The updating rate (i.e. the rate of dataVersion value changes) depends on the dynamism of the detected event itself and is determined by the originator ITS station. However, between two updates, the DENM might be repeatedly sent to other ITS stations.
Notes	The actionID shall remain unchanged while dataVersion is increased. However, if the data version is used up from 0 to 254, then a new DENM with a new actionID should be generated with a data version set to 0.

B.6 DE_expiryTime

Purpose	Time when the information becomes invalid and the DENM should be deleted from the DEN management. The expiry time is set by the originator ITS station. Therefore it is only an estimation of how long the event may persist. It implies the duration over which the DENM should be kept at the application layer of the receiving ITS station and the DENM dissemination be maintained in the relevance area, until the expiryTime or until a cancellation or a negation DENM is received. This DE is optional. When it is not provided by the originator ITS station, it indicates that the expiry time is "unknown".
Notes	In order to keep the DENM alive in the relevance area during this time, it can be either managed at the originator ITS station by sending periodically DENMs or at a receiving ITS station by forwarding or delaying the DENMs to other ITS stations entering into the relevance area. For the latter situation, packet-centric store-and-forward at the ITS networking and transport layer or information centric forwarding at the ITS facility layer can be used. This DE is optional, In case the expiry time of the event cannot be estimated at the originator ITS station, either this expiry time is not provided, either a default value can be set by the originator ITS station. Expiry time can be renewed by the originator ITS station or an authorized ITS station relaying the DENM, if the pre-set expiry time has reached to 70 % of its limit and the event persistence is detected. The ActionID shall be remained unchanged when the expiry time is renewed. However, the data version should be increased by one when the expiry time is renewed.

B.7 DE_frequency

Purpose	Sending frequency of the DENM as defined by the originator ITS station. This DE informs receiving ITS stations the intended transmission frequency of DENM. It can be used in situation when the originator ITS station has lost the capability of sending DENMs (e.g. accident vehicle battery down) and the DENM is relayed by a third part ITS station (e.g. roadside ITS station). This third part ITS station shall be an authorized ITS station.
Notes	This DE is optional, the originator ITS station should determines whether to add this DE.

B.8 DE_reliability

Purpose	The probability of the event to be truly existent at the event position. An initial value is set by the originating ITS station in accordance to the used sensor data and detection means.
Notes	0 is set to indicate the unknown probability and 100 to indicate maximum reliability.

B.9 DE_isNegation

Purpose	Flag DE that indicates the event described by a previously received DENM from other ITS stations does not exist. DENMs with this flag set to be true are generated after the event was announced by another ITS station previously. It is used to announce a third part termination.
Notes	When it is set to true, information described in the DENM is not detected by the originator ITS station. As example a vehicle ITS station negates a traffic jam that was announced previously by another ITS station when it passes the corresponding road section with normal speed.

B.10 DE_trafficfloweffect

Purpose	Traffic flow situation where the event is detected.
Notes	This DE definition shall be as specified in [2]. When the traffic flow effect is unknown, it is set to 1.

B.11 DF_situation

Purpose	Description for the event type, including direct cause and sub cause. A causeCode may be combined with a subcauseCode that further describes the event.
Notes	The definition of cause and subCause shall be as specified in [2] and in table 1 of the present document.

B.12 DF_linkedCause

Purpose	The description of the linked causes related to the event if such linked event is detected at the originator ITS station. This DF is optional. The definition is the same as the situation DF.
Notes	The originator ITS station that has the capacity to detect the linked cause should determine whether to add this DF. The cause definition shall be as specified in [2] and in table 1 of the present document.

B.13 DE_severity

Purpose	Severity level of the event to the road safety.
Notes	The severity level is set to 1 if the detected event has low impact on the road safety, it is set to 4 if the detected event is a safety critical event.

B.14 DF_eventCharacteristics

Purpose	Basic characteristics of the detected events. This DF is optional.
Notes	More event characteristics may be defined and added.

B.15 DF_eventPosition

Purpose	Geographical position of the event position. The position of the event is determined by the RHW application at the originator ITS station. If the position is the position of a vehicle ITS position, then the reference position of the vehicle is given as specified in [1]. Optionally, when the event is moving, a speed can be given.
Notes	The event position may be described as an event area DF, by a geographical area (i.e. geometric shape) or by other DEs, e.g. the road segment identifier, in case the originator ITS station is able to detect the event area. The event area DF may be as specified in [5].

B.16 DF_ refPosition

Purpose	The reference position of the event, when the originator ITS station is a vehicle ITS station. The reference position is the provided by the vehicle reference position as specified in [1].
Notes	

B.17 DE_longitude

Purpose	Absolute geographical longitude in a WGS84 co-ordinate system, range limited to 0,84° approx 50 km at 50° Latitude. *Granularity* 0,1 microdegree.
Notes	The direction flag is used to save the bandwidth for aligned PER. *Reference SAE J2735* Compliant to SAE J2735 DE_Longitude in [1]. *Reference TPEG* Longitude in TPEG-LOC in 10 micro-degrees units in [2].

B.18 DE_latitude

Purpose	Absolute geographical latitude in a WGS84 coordinate system. *Granularity* 0,1 microdegree.
Notes	The direction flag is used to save the bandwidth for aligned PER. *Reference SAE J2735* Compliant to SAE J2735 DE_Latitude in [1]. *Reference TPEG* Latitude in TPEG-LOC in 10 micro-degrees units in [2].

B.19 DE_elevation

Purpose	Altitude in a WGS84 co-ordinate system. *Granularity* 0,1 m.
Notes	*Reference SAE J2735* Compliant to SAE J2735 DE_ Elevation in [1].

B.20 DE_heading

Purpose	Orientation of the detected event, if the detected event has an orientation. *Granularity* 0,0125 degrees from North.
Notes	This DE is optional and only present if the originator ITS station is able to detect the direction of the event.

B.21 DE_positionConfidence

Purpose	Provides the position confidence level of the 2D positioning.
Notes	Detailed specifications can be as defined in [1].

B.22 DE_elevationConfidence

Purpose	Provides the confidence level of the elevation.
Notes	Detailed specifications can be as defined in [1].

B.23 DE_eventSpeed

Purpose	Speed of the detected event when the detected event is mobile. Any speed. Negative values imply the vehicle is moving in reverse. *Granularity* 0,01 m / s.
Notes	This DE is optional and only present if the originator ITS station is able to detect the speed of the detected event.

B.24 DF_traceLocData

Purpose	Trace location referencing that describes a set of consecutive waypoint positions leading to the event position. ITS stations located near to or inside this trace positions can be concerned by the event. Multiple traces can be defined in case multiple road sections or traffic flows are leading to the event position. For each trace, multiple waypoint positions are provided to describe the trace. Definition of waypoints is specific to the RHW use case.
Notes	

Annex C (informative): General use case procedure and data flow

RHW use cases follow a common general procedure and data flow:

- Road hazard detection
- Use case triggering/terminating
- DENM construction and transmission
- Dissemination and updating
- DENM reception and handling
- HMI warning

The general data flow is illustrated in figure C.1. The originator ITS station detects, generates and transmits a DENM via the ITS network. At the receiver ITS station, the DENM is processed and the information is checked. If necessary, a warning is provided to the user.

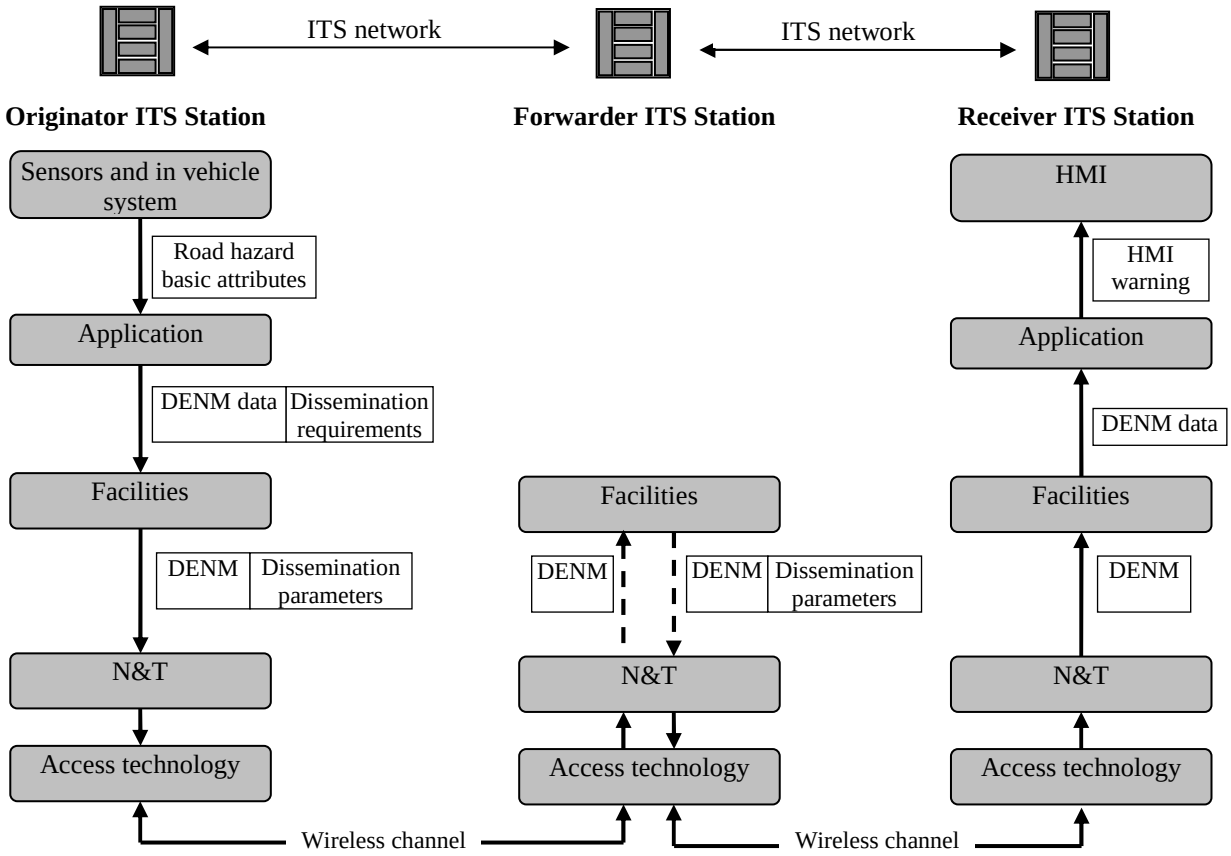

Figure C.1: General inter layer dataflow for road hazard warning application and DENM

C.1 Road hazard detection

The RHW is based on the detection of the corresponding event. The RHW application is triggered only when the ITS station is capable of detecting the corresponding event with a minimum reliability. For a vehicle ITS station, the detection capabilities may require access to vehicle electronic functions, e.g. to engine/power train, ESP, speed control system, yaw rate, steering wheel angle or in vehicle sensor data such as tire pressure sensor, temperature, another via in-vehicle communication network, e.g. CAN. For a roadside ITS station, specific sensors may be required for the detection. Furthermore, sensor data fusion may be required to achieve the detection goal and improve the detection reliability.

However, in some situation, a RHW application can decide not to trigger a DENM even if an event is detected. This can be the case when the ITS station has already received DENMs concerning the same event from other ITS stations.

Regardless of the types and performance of the detection means, basic attributes related to the event including the event type, detection time, event position should always be provided to the RHW application.

C.2 Use case triggering and termination

In this procedure, RHW application corresponding to the detected event is triggered at the originator ITS station. The main sub-procedure of this procedure include:

C.2.1 Application data provision

A RHW application determines and provides information either from the detection means or according to predefined rules to the facilities layer for the construction of a DENM. For information related to the event that cannot be detected or provided by the detection means, e.g. the duration of the situation, specific algorithm can be used in order to define an estimated value.

All event related information as defined in clause 5.1.3 is provided to the DEN management domain facility for the construction of the DENM.

This sub-procedure is realized by the RHW application under the support of relevant facilities and detection means.

C.2.2 Communication requirement definitions

The RHW application defines and provides the relevance area information to the DEN management. The DEN management further converts the relevance area to the destination area as specified by the ITS networking and transport layer. Then the facilities layer provides the destination area to the ITS networking and transport layer as dissemination requirements. Furthermore, the ITS facilities layer provides others dissemination requirement such as DENM transmission frequency and DENM transmission latency to the ITS networking and transport layer.

This sub-procedure is realized by the DEN Management under the support of the RHW application and communication support facilities.

C.2.3 DENM construction

This sub-procedure constructs and encodes a DENM and provides it to the ITS networking and transport layer as payload. If an event evolution is detected by the originator ITS station, updated information is added to a new DENM with a new data version number by the originator ITS station. The actionID remains unchanged.

This sub-procedure is realized by the DEN management and communication support facilities.

C.2.4 Termination

A RWH application should stop sending and forwarding the DENM when the event terminates. In a situation where the termination cannot be detected or predicted by the originator ITS station when generating a DENM, the DENM dissemination is terminated in one of the following means:

- a DENM cancellation message is sent from the originator ITS station if the event termination in detected. The cancellation message is constructed as a specific version (dataversion set to 255) of DENMs;
- a DENM negation message is sent from a third party ITS station in order to indicate the event termination related to a previously received DENM. A negation message carries a isNegation flag set to true.

C.3 Dissemination and updating

The transmission of DENM happens when:

- the scheduled time of sending DENM is reached based on the required transmission frequency;
- an evolution of the event is detected and an updated DENM is constructed by the DEN management;
- a cancellation message is constructed;
- the expiry time is not achieved.

The communication system forwards a DENM to the required destination area. Forwarding can be done either directly at ITS networking and transport layer, or at the ITS facilities layer. ITS Facilities layer forwarding is realized by the information-centric forwarding. It can be used to keep only updated DENMs alive within the destination area. Information-centric forwarding also maintains the updated DENMs in the forwarding buffer by deleting duplicate received DENMs and outdated DENMs.

DENM forwarding may follow the following rules:

- The ITS networking and transport layer dissemination is used to disseminate the DENMs to the required destination area. The ITS facilities layer does not participate to this forwarding.
- When a receiving ITS station of a DENM is located in the destination area, the DENM is forwarded to the ITS facilities layer. The ITS facilities layer performs the information-centric forwarding in order to keep the DENM alive during the whole event duration within the relevance area.
    - For multiply received DENMs with the same action ID, the DENMs including more recent data version and higher reliability are kept for forwarding.
    - For multiply received DENMs with different action IDs, the DEN management checks with the support of the LDM and other facilities in order to correlate the information related to the event. This correlation allows the ITS station to judge whether the previously received DENMs concern the same event. If yes, DENMs that carries the most updated event information and/or higher reliability are selected for forwarding.
    - Selected DENMs based on the above two rules are maintained in the forwarding buffer at the ITS facilities layer as long the information is still valid and as long as the ITS station is still located inside or within the communication range of the relevance area.
    - If new ITS stations are detected to enter the relevance area (e.g. known by receiving a CAM from a new ITS station), the ITS facilities layer at the ITS station that performs the information-centric forwarding can decide to relay the DENM to this new ITS stations.

C.4 DENM handling

At the originator ITS station, a DENM should include a reliability value that describes the probability of the information included in DENM being true.

At the receiver ITS station, upon reception of a DENM, the DEN management can decide whether the information in the DENM is redundant to other previously received DENMs. Redundancy may refer to the same DENM that has been repetitively sent from the originator ITS station, or a different DENM that describes the same event, either transmitted by the same originator ITS station, or by other ITS stations. Redundant and outdated DENM will be discarded by the DEN management. Afterwards, valid DENM information is delivered to other facilities and to the ITS application layer.

The RHW application at the receiving ITS station interacts with the LDM and other facilities in order to check the relevance of the event with regards to itself. The receiving ITS station furthermore estimates the risk level. Based on the estimated risk level, the RHW application decides to deliver an HMI warning to user.

C.5 Information-centric forwarding

Information-centric forwarding is a potentially advanced functionality that can be provided by the facilities layer.

Information-centric forwarding is based on ITS stations that relay a received DENM to other incoming ITS stations as long as the event information included in DENM is still valid. The forwarding decision is made at the ITS facilities layer.

Information-centric forwarding requires an ITS station to physically keep the received DENMs at the ITS facilities layer during the event duration time and within the relevance area. Information-centric forwarding can be activated by the DEN management. Information-centric forwarding is illustrated in figure C.1 by the dashed line. For such purpose, the DEN management provides the following functionalities:

- Facilities layer forwarding decision: the DEN management at a receiver ITS station should make a decision whether the received DENM need to be further forwarded.
- DENM suppression: the DEN management deletes the redundant and outdated DENMs and provides updated or reliable DENMs for forwarding.
- Third party delaying: in case the originator ITS station looses the capacity to broadcast DENMs, it may request an authorized third party ITS station to relay the DENMs. This third party ITS station is an authorized ITS station. This third part ITS station is not necessarily located in the relevance area.

NOTE: Information centric forwarding is different from the store-and-forward functionality as defined in the ITS networking and transport layer.

C.6 HMI warning

This procedure requires HMI device to display appropriate HMI warnings to the driver or other road users based on the risk estimation for a received DENM. An HMI warning is required to be provided at a time that allows the driver to make manoeuvring for collision avoidance.

Annex D (informative): Text description of an example relevance area

Table D.1 provides an example of text description of the event reference position, the relevance area, and the destination area.

Table D.1: Example relevance position, relevance area and destination area text description

Event	Reference Position	Relevance area	Destination area
Emergency electronic brake lights	Vehicle current position	Certain distance within the upstream traffic of the vehicle position	Rectangle covering road topology
Wrong way driving warning	Vehicle current position	Road section of the wrong way driving and the linked road sections	Circle covering all concerned road sections
Stationary vehicle - accident	Accident vehicle position	Certain distance within the upstream traffic of the vehicle position	Rectangle covering road topology
Stationary vehicle - vehicle problem	Stationary vehicle position	Certain distance within the upstream traffic of the vehicle position	Rectangle covering road topology
Traffic condition warning	Position of the downstream end of the traffic jam	Certain distance within the upstream traffic of the upstream end of the traffic jam	Rectangle covering road topology
Signal violation warning	Position of vehicle violating the signal	Intersection road sections	Ellipse covering the intersection area
Roadwork warning	Downstream end position of the road work zone	Certain distance within the upstream traffic of the upstream end position of the roadwork section	Rectangle covering road topology
Collision risk warning	Estimated collision position	Intersection area	Ellipse covering the intersection area
Hazardous location	Downstream end position of the hazardous location	Certain distance from the hazardous location position	Circle covering road sections towards hazard location
Precipitations	Downstream end position of the precipitation	Certain distance from the precipitations area	Circle covering road sections towards hazard location
Road adhesion	Downstream end position of the low road adhesion area	Certain distance from the low adhesion area	Circle covering road sections towards hazard location
Visibility	Downstream end position of the low visibility area	Certain distance from the low adhesion area	Circle covering road sections towards hazard location
Wind	Downstream end position of the strong wind area	Certain distance from the strong wind area	Circle covering road sections towards hazard location

Annex E (informative): Bibliography

- ISO 17572-3 (2008): "Intelligent transport systems (ITS) -- Location referencing for geographic databases".
- SAE J2266: "Location Referencing Message Specification (LRMS)".
- PREparation for DRIVing implementation and evaluation of C-2-X communication technology: "PRE-DRIVE C2X deliverable D 4.1; Detailed description of selected applications and corresponding technical requirements".

History

Document history		
V1.1.1	September 2010	Publication