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

Reference

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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

The present document is part 3 of a multi-part deliverable covering Vehicular Communications; Basic Set of Applications, as identified below:

ETSI TS 102 637-1: "Functional Requirements";

ETSI EN 302 637-2: "Specification of Cooperative Awareness Basic Service";

ETSI EN 302 637-3: "Specifications of Decentralized Environmental Notification Basic Service".

The specification of the Decentralized Environmental Notification (DEN) basic service was initially developed in the European Car-to-Car Communication Consortium (C2C-CC) Manifesto [i.2] and in C2C-CC Message description: Decentralized Environmental Notification Message [i.3]. The service was evaluated by several initiatives, such as the C2C-CC demonstration in 2008, by ETSI Plugtest events and European projects including PRE-DRIVE C2X, DRIVE C2X, SafeSpot, CVIS, CoVeL, SCORE@F, simTD, etc. These evaluation efforts have provided feedback to ETSI TC ITS.

The present document replaces ETSI TS 102 637-3 [i.16] in whole. It includes improvements and enhancements of the DEN basic service specifications in ETSI TS 102 637-3 [i.16] according to the feedback provided by the various initiatives.

National transposition dates	
Date of adoption of this EN:	7 November 2018
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Date of withdrawal of any conflicting National Standard (dow):	31 January 2020

Modal verbs terminology

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Introduction

ITS use cases are distributed over multiple instances of ITS stations (ITS-S). ITS-Ss interact in the ITS networks to provide a large diversity of co-operating customer services that satisfy different types of functional and operational requirements.

ETSI TC ITS has defined a "Basic Set of Applications" (BSA) in ETSI TR 102 638 [i.1] that can be deployed within a three-year time frame after the completion of their standardization. In BSA, the Road Hazard Warning (RHW) application is composed of multiple use cases with the objective to improve road safety and traffic efficiency using vehicle-to-vehicle and vehicle-to-infrastructure communication technologies. ETSI TC ITS defines the decentralized environmental notification (DEN) basic service that supports the RHW application.

The DEN basic service is an application support facility provided by the facilities layer. It constructs, manages and processes the Decentralized Environmental Notification Message (DENM). The construction of a DENM is triggered by an ITS-S application. A DENM contains information related to a road hazard or an abnormal traffic conditions, such as its type and its position. The DEN basic service delivers the DENM as payload to the ITS networking & transport layer for the message dissemination. Typically for an ITS application, a DENM is disseminated to ITS-Ss that are located in a geographic area through communications among ITS stations. At the receiving side, the DEN basic service of an receiving ITS-S processes the received DENM and provides the DENM content to an ITS-S application. This ITS-S application may present the information to the driver if information of the road hazard or traffic condition is assessed to be relevant to the driver. The driver is then able to take appropriate actions to react to the situation accordingly.

1 Scope

The present document provides specification of the DEN basic service, which is in support of the RHW application.

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

The DEN basic service may be implemented in an vehicle ITS-S, a road side ITS-S, a personal ITS-S or a central ITS-S.

2 References

2.1 Normative references

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

- [1] SAE J2735 (2009-11-19): "Dedicated Short Range Communications (DSRC) Message Set Dictionary".

NOTE: Available at: http://standards.sae.org/j2735_200911/.

- [2] ETSI EN 302 665 (V1.1.1): "Intelligent Transport Systems (ITS); Communications Architecture".
- [3] ETSI TS 102 636-3 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network Architecture".
- [4] ETSI EN 302 931 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition".
- [5] ETSI TS 102 894-2 (V1.3.1): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary".
- [6] Recommendation ITU-T X.691/ISO/IEC 8825-2 (12-1997): "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)".
- [7] ETSI EN 302 637-2 (V1.4.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".
- [8] ETSI EN 302 636-2 (V1.2.1): "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 2: Scenarios".

2.2 Informative references

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

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI TR 102 638 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions".
 - [i.2] Car2Car Communication Consortium (2007-08): "Car2Car Communication Consortium Manifesto", Version 1.1.
- NOTE: Available at <http://www.car-2-car.org>.
- [i.3] Car2Car Communication Consortium: "Message description: Decentralized Environmental Notification Message", Version 1.0.
 - [i.4] ETSI TS 101 539-1: "Intelligent Transport Systems (ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification".
 - [i.5] ETSI TS 101 539-2: "Intelligent Transport Systems (ITS); V2X Applications; Part 2: Intersection Collision Risk Warning (ICRW) application requirements specification".
 - [i.6] ETSI TS 101 539-3: "Intelligent Transport Systems (ITS); V2X Applications; Part 3: Longitudinal Collision Risk Warning (LCRW) application requirements specification".
 - [i.7] ETSI EN 302 895: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Local Dynamic Map (LDM)".
 - [i.8] ETSI EN 302 636-4-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality".
 - [i.9] ETSI EN 302 636-5-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol".
 - [i.10] TISA specification TAWG11071 (2011-11-07, drafted to potentially become ISO/TS 21219 Part 15): "Intelligent Transport Systems (ITS) - Traffic and Travel Information (TTI) via Transport Protocol Experts Group, Generation 2 (TPEG2) - Part 15: Traffic Event Compact (TPEG2-TEC-3.1/001)".
 - [i.11] ISO EN 17419: "Intelligent Transport Systems - Cooperative Systems - Classification and management of ITS applications in a global context".
 - [i.12] ETSI TS 102 723-5: "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 5: Interface between management entity and facilities layer".
 - [i.13] ETSI TS 102 723-8: "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 8: Interface between security entity and network and transport layer".
 - [i.14] ETSI TS 102 723-11 (V1.1.1): "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 11: Interface between networking and transport layer and facilities layer".
 - [i.15] ISO 3779 (2011-07): "Road vehicles - Vehicle identification number (VIN) Content and structure".
 - [i.16] ETSI TS 102 637-3: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".
 - [i.17] ETSI TS 103 097 (V1.3.1): "Intelligent Transport Systems (ITS); Security; Security header and certificate formats".
 - [i.18] ETSI TR 102 965 (V1.1.1): "Intelligent Transport Systems (ITS); Application object identifier (ITS-AID); Registration list".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in SAE J2735 [1], ETSI EN 302 665 [2], ETSI EN 302 895 [i.7] and the following apply:

actionID: identifier of an detected event

à la carte container: container of DENM that includes information of the detected event in addition to management container, situation container and location container

NOTE: Due to coding constraints in programming language, the term "alacarte" is also used.

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

NOTE: The BSA is defined in ETSI TR 102 638 [i.1].

cancellation Decentralized Environmental Notification Message (DENM): DEN message type generated by the ITS-S, which originated the new DENM, indicating the event termination

Decentralized Environmental Notification (DEN) basic service: facility at the facilities layer to support ITS-S applications, DENM management and DENM dissemination

Decentralized Environmental Notification Message (DENM): ITS facilities layer PDU providing event information

Decentralized Environmental Notification Message (DENM) protocol: ITS facilities layer protocol that operates the DENM transmission, forwarding and reception

destination area: geographical area for DENM dissemination

NOTE: The destination area is specified in ETSI EN 302 931 [4].

downstream traffic: direction from the event position towards the departing traffic on the same carriageway

event: road hazard, driving environment, or traffic condition

facility: functionality, service or data provided by the ITS facilities layer

forwarding Intelligent Transport System Station (ITS-S): ITS-S that forwards DENMs and implements the DENM protocol

location container: container of DENM that includes location data of the detected event

management container: container of DENM that includes management data for DENM protocol

negation Decentralized Environmental Notification Message (DENM): DEN message type generated by an ITS-S other than the ITS-S, which originated the new DENM, indicating the event termination

new Decentralized Environmental Notification Message (DENM): DEN message type indicating that the event is detected for the first time

originating Intelligent Transport System Station (ITS-S): ITS-S that generates DENMs and implements the DENM protocol

receiving Intelligent Transport System Station (ITS-S): ITS-S that receives DENMs from the ITS networking & transport layer and implements the DENM protocol

relevance area: geographic area in which information concerning the event is identified as relevant for use or for further distribution

situation container: container of DENM that includes data related to the detected event

update Decentralized Environmental Notification Message (DENM): DEN message type indicating the evolution of the event

upstream traffic: direction from the event position towards the approaching traffic on the same carriageway

3.2 Symbols

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

actionID	Identifier of an event that is detected by an ITS-S
appDENM_trigger	Application request type to generate a new DENM for a newly detected event
appDENM_update	Application request type to generate an update DENM for an update of the event
appDENM_termination	Application request type to generate a cancellation or negation DENM for termination of the event
detectionTime	Timestamp at which an event or event update/termination is detected
IF.DEN1	Interface between the DEN basic service and ITS-S applications for DENM transmission
IF.DEN2	Interface between the DEN basic service and ITS-S applications for DENM reception
IF.Mng	Interface between the DEN basic service and the ITS management entity
IF.N&T	Interface between the DEN basic service and the ITS networking & transport layer
IF.SEC	Interface between the DEN basic service and the ITS security entity
referenceTime	Timestamp at which a new, update or cancellation DENM is generated by the DEN basic service

NOTE: A negation DENM contains the *referenceTime* of the DENM that is negated.

repetitionDuration	Duration of the DENM repetition
repetitionInterval	Time interval of the DENM repetition
stationID	Identifier of an ITS-S
T_F_VValidity	Timer that indicates the end of the DENM processing of one specific actionID of the forwarding ITS-S
T_Forwarding	Timer for the scheduling of the DENM forwarding by the forwarding ITS-S
T_O_VValidity	Timer that indicates the end of the DENM processing of one specific actionID of the originating ITS-S
T_R_VValidity	Timer that indicates the end of the DENM processing of one specific actionID of the receiving ITS-S
T_Repetition	Timer for the scheduling of the DENM repetition by the originating ITS-S
T_RepetitionDuration	Timer that indicates the end of the DENM repetition
termination	Parameter that indicates the termination of an event
transmissionInterval	Time interval for DENM transmission
validityDuration	Duration of the DENM validity

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 302 665 [2] and the following apply:

ABS	Anti-lock Braking System
AEB	Automatic Emergency Braking
API	Application Programming Interface
ASN.1	Abstract Syntax Notation One
BSA	Basic Set of Applications
BTP	Basic Transport Protocol
C2C-CC	Car to Car Communication Consortium
CA	Cooperative Awareness
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
DSRC	Dedicated Short Range Communications
EEBL	Electronic Emergency Break Light
ESP	Electronic Stability Program
FA-SAP	Facilities-Application Service Access Point
GN	GeoNetworking
HMI	Human Machine Interface

ISO	International Standardization Organization
ITS	Intelligent Transport System
ITS-AID	ITS-Application IDentifier
ITS-S	ITS Station
KAF	Keep Alive Forwarding
LDM	Local Dynamic Map
LSB	Least Significant Bit
MF-SAP	Management Facilities Service Access Point
MSB	Most Significant Bit
NF-SAP	Network Facilities Service Access Point
OSI	Open System Interconnection
PCI	Protocol Control Information
PDU	Protocol Data Unit
PER	Packed Encoding Rules
RHW	Road Hazard Warning
SAE	Society of Automotive Engineers
SF-SAP	Security Facilities Service Access Point
SSP	Service Specific Permissions
TEC	Traffic Event Compact
TISA	Traveller Information Services Association
TPEG™	Transport Protocol Experts Group
TS	Technical Specification
TTI	Traffic and Travel Information
VDS	Vehicle Descriptor Section
WMI	World Manufacturer Identifier

4 DEN basic service introduction

4.1 Background

Decentralized Environmental Notification Message (DENM) is a facilities layer message that is mainly used by ITS applications in order to alert road users of a detected event using ITS communication technologies. DENM is used to describe a variety of events that can be detected by ITS stations (ITS-S). A set of ITS applications are specified in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6], which includes multiple ITS use cases.

The exchange of DENM among ITS-Ss is operated by DENM protocol.

The general processing procedure of an ITS use case that is supported by the DENM protocol is as follows:

- Upon detection of an event, an ITS-S transmits a DENM in order to disseminate the information about this event to other ITS-Ss located inside an area of relevance. The ITS-S that transmits DENM is denoted as originating ITS-S.
- DENM transmission is initiated and terminated by an ITS-S application at the ITS application layer. Examples are provided in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6].
- The transmission of a DENM may be repeated.
- DENM transmission may persist as long as the event is present.
- An ITS-S may forward a DENM. This ITS-S is denoted as forwarding ITS-S.
- The termination of DENM transmission is either automatically achieved by the facilities layer, i.e. the DEN basic service of the originating ITS-S when a predefined expiry time is reached, or by an ITS-S application that requests the generation of a DENM to inform that the event has terminated.
- An ITS-S, which receives a DENM, processes the information and may decide to present an appropriate warning or information to user, as long as the information in the received DENM is relevant to the ITS-S. This ITS-S is denoted as receiving ITS-S.

A general inter-layer and inter-ITS-Ss dataflow for DENM exchange is provided in Figure 1.

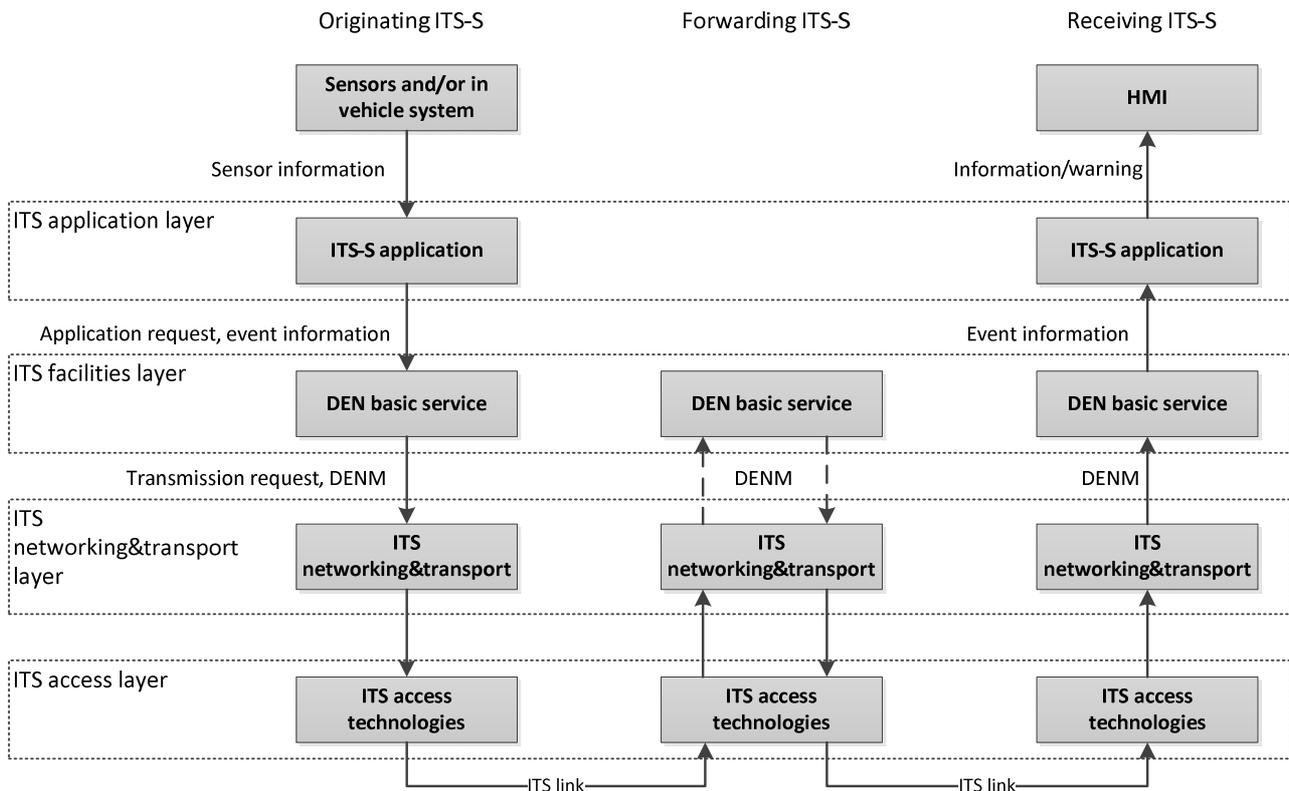


Figure 1: General data flow for ITS-S application supported by the DEN basic service

The solid lines illustrate the dataflow that is mandatory for all ITS applications using the DENM protocol. The dotted lines illustrate the dataflow that may apply only in certain situations.

NOTE: A DENM may be forwarded by intermediate ITS-Ss in order to disseminate DENM from the originating ITS-S to the receiving ITS-S, if the receiving ITS-S is not located in the direct communication range of the originating ITS-S. This forwarding is realized by the ITS networking & transport layer. In addition, the DEN basic service may provide forwarding functionality at the facilities layer, in order to maintain the DENM retransmission in certain situations, for example when the originating ITS-S has lost the capability to repeat DENM transmission. This optional facilities layer forwarding functionality is illustrated as dotted lines in Figure 1.

4.2 Services provided by the DEN basic service

The DEN basic service is a facilities layer entity that operates the DENM protocol. It provides services to entities at the ITS application layer. At the originating ITS-S, an ITS-S application may trigger, update and terminate the transmission of DENMs. At the receiving ITS-S, the DEN basic service processes received DENMs and makes the information available for usage in ITS-S applications process. Optionally, the DEN basic service may also provide forwarding functionality.

The DEN basic service uses the services provided by the protocol entities of the ITS networking & transport layer to disseminate DENM.

NOTE 1: Typically, for road safety ITS applications as specified in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6], the destination of a DENM transmission is ITS-Ss that are located in a pre-defined geographic area close to the detected event position.

NOTE 2: A DENM may also be disseminated over a long distance or to a central ITS-S, such as for vehicle rerouting or road traffic management purposes.

A DENM contains information related to an event that has potential impact on road safety or traffic condition. An event is characterized by an event type, an event position, a detection time and a time duration. These attributes may change over space and over time.

In some situations, the originating ITS-S transmits a DENM of an event caused by the ITS-S itself, such as electronic brake light event. The originating ITS-S manages the transmission and the termination of the DENM for this event. However, in some other situations, DENMs related to the same event may be transmitted by more than one originating ITS-Ss. In addition, in case the originating ITS-S is mobile (e.g. vehicle ITS-S or personal ITS-S), an event may persist even after the originating ITS-S has moved to a position far from the event position. For example, multiple vehicle ITS-Ss may detect black ice on the road surface and transmit DENMs. These DENMs are relayed by other ITS-Ss even after the detecting vehicle ITS-Ss have left the black ice location. Therefore, the DENM transmission is independent from the originating ITS-S in this example. The DENM protocol is designed to manage these situations.

The following DENM types are defined:

- **New DENM:** A DENM generated by the DEN basic service when an event is detected by an originating ITS-S for the first time. Each new DENM is assigned with a new identifier, denoted as *actionID*. A new DENM provides event attributes, such as event position, event type, event detection time, and other attributes as defined in clause 7.
- **Update DENM:** A DENM generated by the DEN basic service that includes update information of an event. An update DENM is transmitted by the same originating ITS-S, which had generated the new DENM for the same event.
- **Cancellation DENM:** A DENM that informs the termination of an event. A cancellation DENM is transmitted by the same originating ITS-S which has generated the new DENM for the same event.
- **Negation DENM:** A DENM that informs the termination of an event for which the new DENM has been received by the originating ITS-S from another ITS-S. A negation DENM may be used to announce the termination of an event if the originating ITS-S has the capacity to detect the termination of an event which has been previously announced by other ITS-Ss. As example, the originating ITS-S of a new DENM indicating black ice has left the event position, some time later, another ITS-S receiving this new DENM reaches the indicated black ice position and detects that the back ice has disappeared. The latter ITS-S may in this case generate a negation DENM for this event.

NOTE 3: Whether a negation DENM is transmitted may depend on the application requirements and the deployment requirement. Therefore, definition of conditions under which the generation and transmission of negation DENM is allowed is out of scope of the present document.

The DEN basic service of the originating ITS-S shall be able to construct above DENMs types. ITS-S application of the originating ITS-S sends an application request to the DEN basic service in order to trigger the generation of DENMs. The type of the DENM to be generated depends on the type of the application request.

Due to the different detection capabilities of ITS-Ss, the quality of the provided information in a DENM may vary. However, predefined conditions are to be satisfied by an ITS-S in order to initiate and terminate the transmission of DENMs for a specific event. These conditions are specified as ITS application requirements in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6].

5 DEN basic service functional description

5.1 Introduction

The DEN basic service features several functionalities which are specified hereafter. The present clause is organized as following:

- Clause 5.2 introduces the DEN basic service.
- Clause 5.3 defines functionalities of the DEN basic service.
- Clause 5.4 defines interfaces of the DEN basic service.

5.2 DEN basic service in the ITS architecture

The DEN basic service is a facilities layer entity that implements the DENM protocol. It interfaces with ITS-S applications in order to receive the application request for DENM transmission and to provide the received DENM content to the ITS-S applications. Furthermore, the DEN basic service may interact with other facilities layer entities, in particular the Local Dynamic Map (LDM) as defined in ETSI EN 302 895 [i.7], which is a facilities layer database. At the receiving ITS-S, the LDM may be updated with a received DENM and ITS-S applications may retrieve event related information from the LDM database for further processing.

NOTE 1: The specification of the LDM is out of scope of the present document.

Figure 2 presents the DEN basic service in the ITS-S architecture as defined in ETSI EN 302 665 [2] as well as its logical interfaces with other entities and layers.

NOTE 2: The DEN basic service may exchange information with additional facilities layer entities for the purpose of construction, transmission, forwarding and reception of DENM. For simplicity reason, these interfaces are not illustrated in Figure 2.

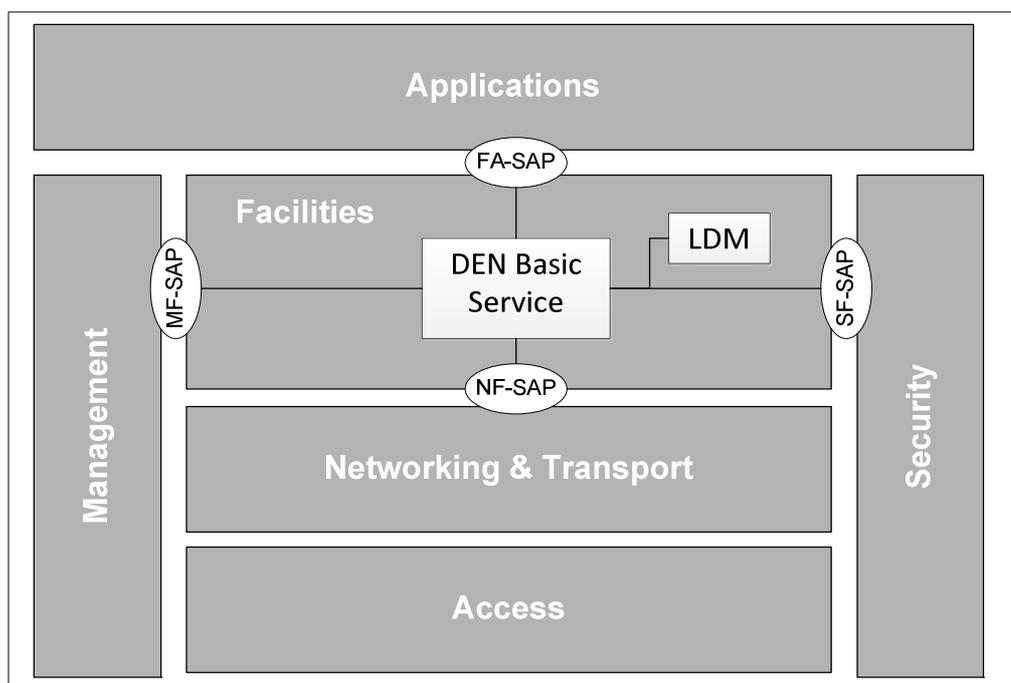


Figure 2: DEN basic service and logical interfaces

5.3 DEN basic service functional architecture

The DEN basic service shall provide the following sub-functions:

- Encode DENM:
 - This sub-function constructs a DENM according to the format specified in Annex A of the present document.
- Decode DENM:
 - This sub-function decodes a received DENM.
- DENM transmission management:
 - This sub-function implements the DENM protocol operation of the originating ITS-S as specified in clause 8.2, including in particular:
 - The generation of a new DENM as requested by the ITS-S applications at the originating ITS-S.

- The generation of an update DENM as requested by the ITS-S applications at the originating ITS-S.
- The termination of the DENM transmission as requested by the ITS-S applications at the originating ITS-S.

NOTE 1: DENM termination refers to the generation of a cancellation DENM or a negation DENM as defined in clause 4.2.

- The repetitive transmission of DENMs.
- DENM reception management:
 - This sub-function implements the DENM protocol operation of the receiving ITS-S as specified in clause 8.4, including in particular:
 - The update of the receiving ITS-S message table as defined in clause 8.4.1.
 - The discarding of received invalid DENMs.
 - The provisioning of received DENM data to ITS-S applications and/or to other facilities layer entities of the receiving ITS-S.
- DENM Keep Alive Forwarding (KAF):
 - This sub-function implements the DENM protocol operation of the forwarding ITS-S. In one possible KAF protocol, the KAF stores a received DENM during its validity duration, and forwards the DENM when applicable as specified in clause 8.3.
 - This sub-function is optional. The usage conditions of the KAF may either be defined by the ITS applications requirements or by a cross-layer functionality of the management entity.

NOTE 2: The conditions to enable KAF are beyond the scope of the present document.

Figure 3 illustrates sub-functions and interfaces of the DEN basic service in a component diagram.

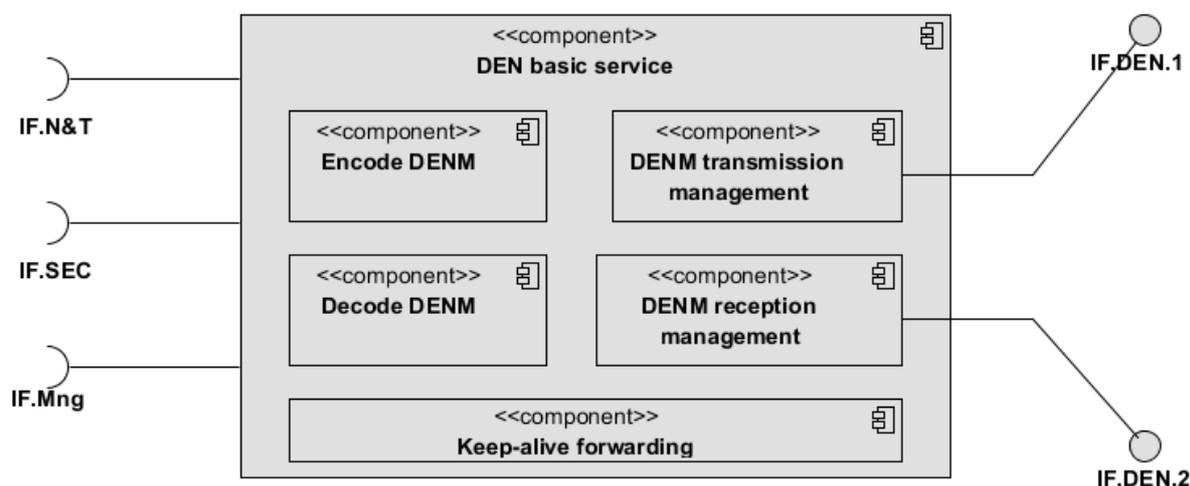


Figure 3: DEN basic service component diagram

5.4 Interfaces of the DEN basic service

5.4.1 Interfaces to the ITS application layer

5.4.1.1 Introduction

An ITS-S application is the ITS application layer entity that implements the application logic of one or more ITS use cases. It requests the generation of different types of DENM as specified in clause 4.2, according to pre-defined conditions, for example as specified in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6].

The DEN basic service provides APIs to ITS-S applications for the processing of the DENM protocol of the originating ITS-S, the forwarding ITS-S and the receiving ITS-S. As illustrated in Figure 3, the interface IF.DEN.1 is the API for DENM transmission and the interface IF.DEN.2 is the API for DENM reception. Data is exchanged between the DEN basic service and ITS-S applications via these APIs.

In one possible implementation, these APIs may be implemented as FA-SAP.

NOTE: Specifications of the FA-SAP and the corresponding protocols are out of the scope of the present document.

At the originating ITS-S, the ITS-S application sends a request to the DEN basic service to generate DENM and to start the DENM transmission. Three types of application request are defined:

- *AppDENM_trigger*: The originating ITS-S detects a new event and triggers the transmission of a new DENM.
- *AppDENM_update*: The originating ITS-S detects the evolution of a detected event and requests the transmission of an update DENM with update information.
- *AppDENM_termination*: The originating ITS-S detects the termination of an event and requests the transmission of a cancellation DENM or a negation DENM to inform other ITS-Ss of the event termination.

According to the application request type, a DENM of a specific type as defined in clause 4.2 is generated and transmitted by the DEN basic service. Table 1 defines the mapping between the application request types and generated DENM types.

Table 1: Mapping between application request types and DENM types

Application request type	DENM type to be generated
AppDENM_trigger	New DENM
AppDENM_update	Update DENM
AppDENM_termination	Cancellation DENM if the originating ITS-S has generated the new DENM or Negation DENM otherwise

Clause 5.4.1.2 to clause 5.4.1.5 provide examples of data being passed via the interfaces IF.DEN.1 and IF.DEN.2. For the sake of the presentation clearness, the data is categorized into data passed from the ITS-S application to the DEN basic service and data returned from the DEN basic service to the requesting ITS-S application.

5.4.1.2 Data passed via interface IF.DEN.1 for the request type *AppDENM_trigger*

For the application request type *AppDENM_trigger*, Table 2 presents data being exchanged via the interface IF.DEN.1.

Table 2: Data passed via the interface IF.DEN.1 for *AppDENM_trigger*

Category	Data	Definition (see note 9)	Remarks
Data passed from ITS-S application to DEN basic service	Event detection time	{ <i>DENM.denm.management.detectionTime</i> } as specified in Annex A.	
	Event position	{ <i>DENM.denm.management.eventPosition</i> } as specified in Annex A.	
	Event validity duration	{ <i>DENM.denm.management.validityDuration</i> } as specified in Annex A.	Optional (see note 1)
	Repetition duration	Duration of the DENM repetition in units of milliseconds, denoted as <i>repetitionDuration</i> .	Optional (see note 2)
	Transmission interval	{ <i>DENM.denm.management.transmissionInterval</i> } as specified in Annex A.	Optional (see note 3)
	Repetition interval	Interval of DENM repetition in units of milliseconds, denoted as <i>repetitionInterval</i> .	Optional (see note 2)
	Information contained in the situation container	{ <i>DENM.denm.situation</i> } as specified in Annex A.	Optional (see note 4)
	Information contained in the location container	{ <i>DENM.denm.location</i> } as specified in Annex A.	Optional (see note 4)
	Information contained in the à la carte container	{ <i>DENM.denm.alacarte</i> } as specified in Annex A.	Optional (see note 5)
	Relevance area of the event	{ <i>DENM.denm.management.relevanceDistance</i> } and { <i>DENM.denm.management.relevanceTrafficDirection</i> } as specified in Annex A.	Optional (see note 6)
	Destination area	Destination area for DENM dissemination as specified in ETSI EN 302 931 [4].	
	Traffic class	GN traffic class of the DENM as defined in ETSI EN 302 636-4-1 [i.8], if GeoNetworking/BTP is used.	
Data returned from DEN basic service to the requesting ITS-S application	actionID or other applicable identifier (see note 7)	{ <i>DENM.denm.management.actionID</i> } as specified in Annex A. The DEN basic service returns the <i>actionID</i> or other applicable identifier created by the DEN basic service to the requesting ITS-S application, in case the request was successfully handled.	
	Failure notification	The DEN basic service returns a failure notification to the requesting application under the condition as specified in clause 8.	Optional (see note 8)
<p>NOTE 1: Applicable if the ITS-S application detects or estimates the event expiration time.</p> <p>NOTE 2: Applicable if the ITS-S application requests the DENM repetition.</p> <p>NOTE 3: Applicable if the ITS-S application requests the KAF for the DENM.</p> <p>NOTE 4: As alternative of providing data via IF.DEN.1, the requesting ITS-S application may request DEN basic service to collect data from other facilities of the facilities layer.</p> <p>NOTE 5: Applicable if the ITS-S application requests the transmission of an à la carte container.</p> <p>NOTE 6: Applicable if the ITS-S application has the knowledge of the relevance area.</p> <p>NOTE 7: An applicable identifier is associated to the <i>actionID</i> as created by the DEN basic service, it may be used for the interaction between the ITS-S application and the DEN basic service.</p> <p>NOTE 8: Applicable as specified in clause 8.</p> <p>NOTE 9: Data format is up to implementation.</p>			

5.4.1.3 Data passed via interface IF.DEN.1 for the request type *AppDENM_update*

For the application request type *AppDENM_update*, Table 3 defines data being exchanged via the interface IF.DEN.1.

Table 3: Data passed via the interface IF.DEN.1 for *AppDENM_update*

Category	Data	Definition (see note 7)	Remarks
Data passed from application to DEN basic service	<i>actionID</i> or other applicable identifier	<i>ActionID</i> or other applicable identifier for which the update is detected (see note 1). <i>{DENM.denm.management.actionID}</i> as specified in Annex A.	
	Event update detection time	<i>{DENM.denm.management.detectionTime}</i> as specified in Annex A.	
	Event position	<i>{DENM.denm.management.eventPosition}</i> as specified in Annex A.	
	Event validity duration	<i>{DENM.denm.management.validityDuration}</i> as specified in Annex A.	Optional (see note 2)
	Repetition duration	Duration of the DENM repetition in units of milliseconds, denoted as <i>repetitionDuration</i> .	Optional (see note 2 and note 3)
	Transmission interval	<i>{DENM.denm.management.transmissionInterval}</i> as specified in Annex A.	Optional (see note 2 and note 4)
	Repetition interval	Interval of DENM repetition in units of milliseconds, denoted as <i>repetitionInterval</i> .	Optional (see note 2 and note 3)
	Information contained in the situation container	<i>{DENM.denm.situation}</i> as specified in Annex A.	Optional (see note 2)
	Information contained in the location container	<i>{DENM.denm.location}</i> as specified in Annex A.	Optional (see note 2)
	Information contained in the à la carte container	<i>{DENM.denm.alacarte}</i> as specified in Annex A.	Optional (see note 2)
	Relevance area of the event	<i>{DENM.denm.management.relevanceDistance}</i> and <i>{DENM.denm.management.relevanceTrafficDirection}</i> as specified in Annex A.	Optional (see note 2 and note 5)
	Destination area	Destination area for DENM dissemination as specified in ETSI EN 302 931 [4]	
	Traffic class	GN traffic class of the DENM as defined in ETSI EN 302 636-4-1 [i.8], if GeoNetworking/BTP is used.	Optional (see note 2)
Data returned from DEN basic service to the requesting application	<i>actionID</i> or other applicable identifier (see note 1)	<i>{DENM.denm.management.actionID}</i> as specified in Annex A. The DEN basic service returns the <i>actionID</i> or other applicable identifier created by the DEN basic service to the requesting ITS-S application.	
	Failure notification	The DEN basic service returns a failure notification to the requesting application under the condition as specified in clause 8.	Optional (see note 6)
NOTE 1: An applicable identifier is associated to the <i>actionID</i> as created by the DEN basic service, it may be used for the interaction between the ITS-S application and DEN basic service.			
NOTE 2: Applicable if an update of the data is detected.			
NOTE 3: Applicable if the ITS-S application requests the DENM repetition.			
NOTE 4: Applicable if the ITS-S application requests the KAF for the DENM.			
NOTE 5: Applicable if the ITS-S application has the knowledge of the relevance area.			
NOTE 6: Applicable as specified in clause 8.			
NOTE 7: Data format is up to implementation.			

5.4.1.4 Data passed via interface IF.DEN.1 for the request type *AppDENM_termination*

For the application request type *AppDENM_termination*, Table 4 defines data being exchanged via the interface IF.DEN.1.

Table 4: Data passed via the interface IF.DEN.1 for *AppDENM_termination*

Category	Data	Definition (see note 7)	Remarks
Data passed from application to DEN basic service:	<i>actionID</i> or other applicable identifier	<i>actionID</i> or other applicable identifier for which the termination is detected (see note 1). { <i>DENM.denm.management.actionID</i> } as specified in Annex A.	
	Event termination detection time	{ <i>DENM.denm.management.detectionTime</i> } as specified in the Annex A.	
	Event position	Position at which the event termination is detected. { <i>DENM.denm.management.eventPosition</i> } as specified in Annex A.	
	Event validity duration	Validity of the event termination information. { <i>DENM.denm.management.validityDuration</i> } as specified in Annex A.	Optional (see note 2)
	Repetition duration	Duration of the DENM repetition in units of milliseconds, denoted as <i>repetitionDuration</i> .	Optional (see note 3)
	Transmission interval	{ <i>DENM.denm.management.transmissionInterval</i> } as specified in Annex A.	Optional (see note 4)
	Repetition interval	Interval of DENM repetition in units of milliseconds, denoted as <i>repetitionInterval</i> .	Optional (see note 3)
	Relevance area of the event	{ <i>DENM.denm.management.relevanceDistance</i> } and { <i>DENM.denm.management.relevanceTrafficDirection</i> } as specified in Annex A.	Optional (see note 5)
	Destination area	Destination area for DENM dissemination as specified in ETSI EN 302 931 [4]	
	Traffic class	GN traffic class of the DENM as defined in ETSI EN 302 636-4-1 [i.8], if GeoNetworking/BTP is used.	
Data returned from DEN basic service to the requesting application	<i>actionID</i> or other applicable identifier (see note 1)	{ <i>DENM.denm.management.actionID</i> } as specified in Annex A. The DEN basic service returns the <i>actionID</i> or other applicable identifier created by the DEN basic service to the requesting ITS-S application.	
	Failure notification	The DEN basic service returns a failure notification to the requesting application under the condition as specified in clause 8.	Optional (see note 6)
NOTE 1: An applicable identifier is associated to the <i>actionID</i> as created by the DEN basic service, it may be used for the interaction between the ITS-S application and DEN basic service.			
NOTE 2: Applicable if the application detects the event termination information expiry time.			
NOTE 3: Applicable if the application requests the DENM repetition.			
NOTE 4: Applicable if the ITS-S application requests the KAF for the DENM.			
NOTE 5: Applicable if the ITS-S application has the knowledge of the relevance area.			
NOTE 6: Applicable as specified in clause 8.			
NOTE 7: Data format is up to implementation.			

5.4.1.5 Data passed via interface IF.DEN.2 for received DENM

At the receiving ITS-S, the DEN basic service may provide the received DENM content in whole or in part to ITS-S applications via the interface IF.DEN.2. The list of data passed via the interface IF.DEN.2 from the DEN basic service may vary depending to the ITS application needs.

Alternatively, ITS-S applications may receive DENM information via the LDM database as described in clause 5.2.

Table 5 provides an example of data passed via IF.DEN.2.

Table 5: Data passed via the interface IF.DEN.2

Category	Data	Definition (see note 2)	Remarks
Data passed from DEN basic service to ITS-S applications	DENM	{ <i>denm</i> } in whole or in part as specified in Annex A.	Optional (see note 1)
NOTE 1: Applicable if ITS-S application of the receiving ITS-S requests the content of received DENM.			
NOTE 2: Data format is up to implementation.			

5.4.1.6 Methods for data exchanges between DEN basic service and ITS application layer

In one possible implementation of IF.DEN.2, DENM content is provided directly by the DEN basic service to the ITS-S application when a DENM is received (push mode), or on demand when an ITS-S application requests specific DENM content to the DEN basic service (pull mode). In another possible implementation, both - push and pull - modes may be implemented.

Similar data exchange method may also be used for the implementation of the interface IF.DEN.1. When the ITS-S application sends a request to the DEN basic service, data is pushed from the application to the DEN basic service. DEN basic service returns data as specified in clauses 5.4.1.2, 5.4.1.3 and 5.4.1.4 to the ITS-S application.

NOTE: It is out of the scope of the present document to specify data exchange method of the interfaces between the DEN basic service and the ITS-S application.

5.4.2 Interface to the ITS networking & transport layer

5.4.2.1 General requirements

The DEN basic service exchanges information with the ITS networking & transport layer via the interface IF.N&T (Figure 3). The interface IF.N&T may be realized as NF-SAP ETSI TS 102 723-11 [i.14].

For ITS applications specified in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6], point-to-multipoint communication as defined in ETSI EN 302 636-2 [8] and ETSI TS 102 636-3 [3] shall be used for the dissemination of DENM.

At the originating ITS-S, the DEN basic service delivers a DENM to the ITS networking & transport layer. The DEN basic service shall provide at least the protocol control information (PCI) specified in Table 6 to the ITS networking & transport layer. At receiving ITS-S, if the receiving ITS-S is considered as the destination of the DENM dissemination, the ITS networking & transport layer delivers the received DENM to the DEN basic service.

Table 6 provides minimum data being passed between the DEN basic service and ITS networking & transport layer for the originating and receiving ITS-S.

Table 6: Data passed between the DEN basic service and the ITS networking & transport layer

Category	Data	Definition (see note 3)	Remarks
Data passed from DEN basic service to the ITS networking & transport layer	DENM	{denm} as specified in Annex A.	
	Destination area	Destination area for DENM dissemination. The definition of DENM destination area shall be as specified in ETSI EN 302 931 [4].	
	Repetition interval	In units of milliseconds.	Optional (see note 1)
Data passed from the ITS networking & transport layer	Received DENM	{denm} as specified in Annex A.	Optional (see note 2)
NOTE 1: Applicable if the ITS-S application requests the DENM repetition by the ITS networking & transport layer. The repetition may also be performed by the DEN basic service at the facility layer as described in clause 5.4.1.			
NOTE 2: Applicable if the receiving ITS-S is considered by the ITS networking & transport layer as inside the destination area.			
NOTE 3: Data format is up to implementation.			

5.4.2.2 Interface to the GeoNetworking/BTP stack

A DENM may rely on services provided by the GeoNetworking/BTP stack to disseminate a DENM to a geographic destination area. For ITS applications specified in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6], BTP header type B and GeoBroadcast protocol shall be used for the DENM dissemination.

Data being passed between the DEN basic service and the GeoNetworking/BTP stack shall be as specified in Table 6 and as specified in Table 7.

Table 7: Data passed from DEN basic service to GeoNetworking/BTP at the originating ITS-S

Category	Data	Requirement (see note 3)	Remarks
Data passed from the DEN basic service to GeoNetworking/BTP	BTP type	BTP header type B (ETSI EN 302 636-5-1 [i.9], clause 7.2.2).	Optional (see note 1)
	Destination port	As specified in ETSI EN 302 636-5-1 [i.9] (see note 2).	Optional (see note 1)
	Destination port info	As specified in ETSI EN 302 636-5-1 [i.9].	Optional (see note 1)
	GN Packet transport type	GeoNetworking GeoBroadcast protocol.	Optional (see note 1)
	GN Destination address	Specified as Destination area in Table 6.	
	GN communication profile	Unspecified, ITS G5 or LTE-V2X.	Optional (see note 1)
	GN security profile	SECURED or UNSECURED.	Optional (see note 1)
	Traffic class	As defined in ETSI EN 302 636-4-1 [i.8].	
	GN Maximum packet lifetime	Shall not exceed <i>validityDuration</i> .	Optional (see note 1)
	GN Hoplimit		Optional (see note 1)
Length	Length of the DENM.		
NOTE 1: Applicable if the value is not provided or different from the ITS-S configuration.			
NOTE 2: When a global registration authority for ITS application ISO EN 17419 [i.11] is operational, the BTP destination port registered with this authority should be used.			
NOTE 3: Data format is up to implementation.			

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

A DENM may rely on the IPv6 stack or the combined IPv6/GeoNetworking stack as defined in ETSI TS 102 636-3 [3] for DENM dissemination.

NOTE: The specifications of the interface between the DEN basic service and the IPv6 stack is out of scope of the present document.

When the DENM dissemination makes use of the combined IPv6/GeoNetworking stack, the interface between the DEN basic service and the combined IPv6/GeoNetworking stack may be identical to the interface between the DEN basic service and IPv6 stack.

5.4.3 Interface to the ITS management entity

The DEN basic service may exchange information with the ITS management entity via the interface IF.Mng (Figure 3). The interface IF.Mng may be realized as the MF-SAP ETSI TS 102 723-5 [i.12].

5.4.4 Interface to the ITS security entity

The DEN basic service may exchange information with the ITS security entity via the interface IF.SEC (Figure 3).

NOTE 1: The interface IF.SEC may be realized using the SF-SAP or using the NF-SAP ETSI TS 102 723-11 [i.14] and SN-SAP ETSI TS 102 723-8 [i.13].

NOTE 2: In case the NF-SAP and SN-SAP are used for the realization of IF.SEC. The DENM payload is passed through NF-SAP to SN-SAP.

6 DENM dissemination

6.1 DENM dissemination concepts

6.1.1 Event identification

6.1.1.1 *actionID*

The event identification is enabled by the parameter *actionID*. Each time a new DENM is generated upon an application request, a new *actionID* value shall be assigned.

The *actionID* shall be the combination of an ITS-S ID and a sequence number. The ITS-S ID corresponds to *stationID* of the originating ITS-S that detects an event for the first time. The sequence number is assigned to the *actionID* for each new DENM.

For each new DENM, an un-used value shall be assigned to sequence number.

An *actionID* is linked to one originating ITS-S. In case multiple originating ITS-Ss detect the same event for the first time, the assigned *actionID* should be different in each originating ITS-S.

The *actionID* is used in originating, forwarding and receiving ITS-S for the DENM protocol operation. An *actionID* may enable an ITS-S to distinguish DENMs transmitted from different originating ITS-Ss and DENMs transmitted by the same originating ITS-S for different events.

6.1.1.2 *stationID* update and *actionID* management

An ITS-S may implement security functionalities that assigns temporal *stationID* (pseudonym) to be used at the facilities layer and to be included in a generated *actionID*. This *stationID* may change over time.

When the DEN basic service generates an *actionID* for a new DENM, a valid value of *stationID* shall be used. When the *stationID* is updated, all *actionID* and *stationID* values in the DENM header that are generated and stored in the originating ITS-S shall be updated.

6.1.2 Trigger, update, repetition and termination of DENM

6.1.2.1 DENM trigger

DENM trigger refers to the process of the generation and transmission of a DENM when the DEN basic service of the originating ITS-S receives an application request with the type *AppDENM_trigger*. A new DENM shall be generated.

For DENM trigger, an unused *actionID* value shall be created by the DEN basic service.

6.1.2.2 DENM update

The originating ITS-S may detect the evolution of an event some time after the DENM trigger. The ITS-S application provides the update information to the DEN basic service using the application request *AppDENM_update*. The DEN basic service shall then generate an update DENM. This process is denoted as DENM update.

The parameter *referenceTime* is the identifier for DENM update referring to a specific *actionID*. The *referenceTime* represents the time at which a DENM is generated by the DEN basic service, after receiving the application request. For each DENM update, the *referenceTime* shall be updated and the value shall be greater than the *referenceTime* value of the previous DENM update for the same *actionID*.

The *actionID* shall remain unchanged for DENM update, as long as the *stationID* of the originating ITS-S remains unchanged.

The *actionID* shall remain unchanged when the *validityDuration* is updated, as long as the *stationID* of the originating ITS-S remains unchanged.

6.1.2.3 DENM repetition

In between two consequent DENM updates, a DENM may be repeated by the DEN basic service of the originating ITS-S at a pre-defined repetition interval, in order that new ITS-Ss entering the destination area during the event validity duration may also receive the DENM. This process is referred to as DENM repetition.

The DENM repetition shall be activated under the request from the ITS-S application. If ITS-S application at the originating ITS-S requires the repetition of DENM, it shall provide following data in the application request as specified in clause 5.4.1:

- *repetitionInterval*.
- *repetitionDuration*.

If any of the above data are not provided by the ITS-S application, the DEN basic service shall not execute the DENM repetition. At the reception of the application request, the DENM repetition scheduling shall start from the *referenceTime*, corresponding to the time at which DENM is generated.

For one particular *actionID*, DENM repetition should apply to the most updated DENM.

6.1.2.4 DENM termination

The DENM termination indicates the end of the detected event. A DENM termination is either a cancellation or a negation. Cancellation DENM can only be transmitted by the originating ITS-S that originally requested the DENM trigger. Negation DENM can be transmitted by other ITS-Ss.

- DENM termination by the originating ITS-S that requested the DENM trigger:
 - For originating ITS-S that requested the DENM trigger, the DEN basic service shall stop the DENM repetition automatically at the end of the *repetitionDuration*. The *repetitionDuration* may be updated by the ITS-S application of the originating ITS-S.

- Moreover, before the expiration of the *validityDuration*, the originating ITS-S may detect the termination of the event. In this case, the DEN basic service shall generate a cancellation DENM as defined in clause 4.2. The parameter *termination* is used for the cancellation DENM. For the generation of a cancellation DENM, *termination* shall be set to *isCancellation*.
- For the generation of a cancellation DENM, the *actionID* value shall be identical to the *actionID* as set for the application request *appDENM_trigger*, as long as the *stationID* remains unchanged.

NOTE 1: In a cancellation DENM, the *stationID* value included in the *actionID* is identical to the *stationID* of the originating ITS-S.

- DENM termination by an originating ITS-S that has not requested the DENM trigger, i.e. that has not created *actionID* of the event for which the DENM termination is intended:
 - If an ITS-S has received a DENM from other ITS-S regarding an event, passes the indicated event position when the received DENM is still valid (i.e. *validityDuration* is not expired), and detects that the event has terminated, then the ITS-S application at this ITS-S may send a *AppDENM_termination* request to the DEN basic service, upon which the DEN basic service shall generate a negation DENM as defined in clause 4.2.
 - The parameter *termination* is used for the negation DENM. For the generation of a negation DENM, *termination* shall be set to *isNegation*.
 - For the generation of a negation DENM, the *actionID* shall be set to the *actionID* of the event for which the DENM negation refers to. The *referenceTime* shall be set to the value of the latest received DENM of the same *actionID* from the originating ITS, in order that the receiving ITS-S is able to match to which DENM the negation is reported by the negation DENM.

NOTE 2: In a negation DENM, the *stationID* value included in the *actionID* is not identical to the *stationID* value in the *itsPduHeader* (defined in Annex A) of the originating ITS-S that constructs the negation DENM.

NOTE 3: The ITS-S that initiates the negation DENM satisfies some predefined conditions as defined by ITS applications in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6].

For the cancellation DENM and negation DENM, the *detectionTime* shall be set as the time at which the event termination is detected by the originating ITS-S. Once the DENM is expired, the corresponding entry might be detected and the corresponding *actionID* may be used for future new DENM generation.

Once a cancellation DENM or a negation DENM is verified to be trustworthy by the receiving ITS-S, all information related to the previously received DENMs concerning the same *actionID* may be considered as not valid any more, the DEN basic service may notify ITS-S applications of the event termination.

A cancellation DENM or negation DENM shall be transmitted at least once by the originating ITS-S per application request. It may be repeated by the DEN basic service of the originating ITS-S.

6.1.3 Relevance area, location referencing and destination area

6.1.3.1 DENM relevance area

A DENM should be disseminated to as many ITS-Ss as possible located in an area of relevance, denoted as relevance area. This includes ITS-Ss entering the relevance area until the *validityDuration* and ITS-Ss that have no connectivity to the originating ITS-S when the DENM is transmitted.

The relevance area is set by the ITS-S application of the originating ITS-S and shall be included in the DENM when the information is available. A receiving ITS-S may make use of the relevance area information to realize the relevance check.

According to the event type and the event location, the size and the shape of the relevance area varies. In the present document, following information shall be used as the relevance area information:

- *relevanceDistance*: The distance within which the event is considered relevant to the receiving ITS-S.

- *relevanceTrafficDirection*: The traffic direction along which the receiving ITS-Ss may encounter the event. Therefore, it is also the direction along which the DENM should be disseminated. As an example, for an accident on a motorway, the relevant traffic direction of a DENM related to the event may be the upstream direction of the accident location. While for the accident occurred in rural two-way roads, the *relevanceTrafficDirection* may be both traffic directions (including also the opposite carriageway).

The *relevanceDistance* and the *relevanceTrafficDirection* shall be as specified in Annex A.

6.1.3.2 Location referencing

Complementary to the relevance area, a DENM provides location referencing information of the event position. In the present document, the location referencing used by DENM is denoted as *traces*.

A trace contains a list of well-ordered waypoints that forms an itinerary approaching towards the event position.

NOTE 1: The present document specifies the data formatting rules for waypoints and traces to be included in DENM, as specified in Annex A. However, the total length covered by a trace or density of waypoints in a trace may vary depending on ITS application needs.

NOTE 2: Details of waypoints setting rules and the usage of traces at receiving ITS-Ss are out of scope of the present document.

A DENM shall include at least one trace. Multiple traces may be included in DENM, e.g. in case there are more than one possible paths in which a detected event may be approached, e.g. in an intersection area.

The *traces* location referencing is defined and provided by the ITS-S application of the originating ITS-S and shall be included in DENM.

A receiving ITS-S may compare its own itinerary with the trace in order to realize the relevance check.

The *traces* shall be as specified in Annex A.

6.1.3.3 DENM destination area

The destination area is used by the ITS networking & transport layer for the DENM transmission. According to ETSI EN 302 931 [4], three geometric shapes are defined, each shape being represented by the combination of one or several geographical point and distance information:

- circular shape;
- rectangular shape;
- elliptical shape.

The DEN basic service of the originating ITS-S shall provide the destination area information to the ITS networking & transport layer.

The size and the shape of the relevance area are not necessarily identical to the destination area. The DEN basic service shall provide the destination area in the format compliant to the one as specified in ETSI EN 302 931 [4] to the ITS networking & transport layer.

6.1.4 DENM forwarding

6.1.4.1 Packet centric forwarding

DENM forwarding may be realized by the ITS networking & transport layer or the facilities layer.

The packet centric forwarding function refers to the ITS networking & transport layer functionality that forwards a DENM from the originating ITS-S to the destination area.

NOTE: The specification of this function is out of scope of the present document. When GeoNetworking/BTP stack is used, this functionality is specified in ETSI EN 302 636-4-1 [i.8].

6.1.4.2 Keep-alive forwarding

The keep-alive forwarding (KAF) functionality is optional for the DEN basic service.

The KAF refers to the ITS facilities layer forwarding scheme, represented as a sub-function of DEN basic service in Figure 3. The main objective of KAF is to store a received DENM in the DEN basic service and to forward it to other ITS-Ss when necessary.

The KAF may be triggered by the DEN basic service or by an ITS application for one or several *actionIDs*. Once triggered, the KAF may store the received DENM of the relevant *actionID* as long as all the below conditions are met:

- the validity duration of the received DENM is not expired;
- the ITS-S is located within the destination area or the relevance area of the received DENM;
- the event is not cancelled by the originating ITS-S;
- the event is not negated by any originating ITS-S.

The KAF may redeliver a DENM being stored in the DEN basic service to the ITS networking & transport layer if necessary. In one possible forwarding protocol, the KAF may forward a DENM if the DEN basic service has received neither DENM of the same *actionID* forwarded by any other ITS-S nor DENM of the same *actionID* transmitted from the originating ITS-S within a certain period of time. Only DENMs with the most recent *referenceTime* will be forwarded by the KAF.

KAF and packet centric forwarding functions may be complementary with each other. The KAF is able to maintain the dissemination of most updated DENM in the relevance area or in the destination area before the *validityDuration* expires, even though the originating ITS-S has lost the capacity to transmit the DENM by itself. For example, if the originating ITS-S is a break down vehicle, it may stop transmitting DENM unexpectedly due to the failed operation of the vehicle ITS-S. In this case, KAF function of an ITS-S may be used to continue the transmission of DENM that it has received before.

The operation of one possible KAF protocol is specified in clause 8.3.

6.2 DENM dissemination constraints

6.2.1 General confidence constraints

Special data confidence constraints may apply to some data provided in the DENM, depending on the detection capabilities of the ITS-S, such as position accuracy constraint, time accuracy constraint and event detection quality constraint.

These confidence constraints are presented in the data element and data frame definitions as specified in Annex A of the present document and in ETSI TS 102 894-2 [5].

NOTE: According to the requirements of specific ITS-S application, data contained in a DENM may be obtained from different sources, e.g. from the in vehicle network or from ITS-S users via specific Human Machine Interface (HMI). Corresponding requirements are defined in ITS applications specifications such as ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6].

6.2.2 General security constraints

6.2.2.1 Introduction

The security mechanisms for ITS consider the authentication of messages transferred between ITS-Ss with certificates. A certificate indicates its holder's permissions, i.e. what statements the holder is allowed to make or privileges it is allowed to assert in a message signed by that certificate. The format for the certificates is specified in ETSI TS 103 097 [i.17]. Permissions are indicated by a pair of identifiers within the certificate, the ITS-AID and the SSP.

The ITS-Application Identifier (ITS-AID) as given in ETSI TR 102 965 [i.18] indicates the overall type of permissions being granted: for example, there is an ITS-AID that indicates that the originating ITS-S is entitled to send DENMs.

The Service Specific Permissions (SSP) is a field that indicates specific sets of permissions within the overall permissions indicated by the ITS-AID: for example, there may be an SSP value associated with the ITS-AID for DENM that indicates the originating ITS-S is entitled to send DENMs with a *causeCode* (defined in clause 7.1.4) set.

ITS-S provides SSP information in its certificate for all generated, signed DENMs. This applies to new DENM, update DENM, cancellation DENM, and negation DENM. A received signed DENM is accepted by the receiving ITS-S if the DENM is consistent with the ITS-AID and SSP in its certificate.

6.2.2.2 Service Specific Permissions (SSP)

The octet scheme allows the SSP format to accommodate current and future versions of the present document. The octet scheme for DENM SSP is constructed out of four octets as illustrated in Figure 4.

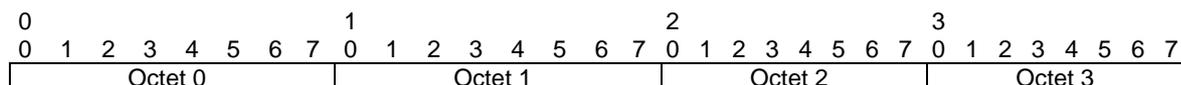


Figure 4: Format for the Octets

EXAMPLE of bit order: The decimal value 199 shall be represented as shown in Figure 5.

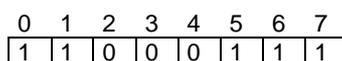


Figure 5: Example of octet presentation

For each octet, the most significant bit (MSB) shall be the leftmost bit. The transmission order shall always be the MSB first. The first octet (octet 0 in Figure 4) shall control the SSP version and be interpreted in the following way:

- 0: No version, length 1 octet; the value shall only be used for testing purposes.
- 1: First version, length 4 octets.
- 2 to 255: Reserved for Future Usage.

The SSP has a maximum length as specified in ETSI TS 103 097 [i.17]. The first octet shall reflect the version of the present document. As future versions of the present document are published, the first octet shall be accordingly incremented. The second to fourth octet (octet 1 to octet 3 in Figure 4) is based on the *causeCode* types described in the clause 7.1.4.

Length of SSP is the length of the Octet String. Table 8 presents the octet scheme for DENM SSPs.

When the ITS Application Identifier (ITS-AID) is set for the DEN basic service, the permissions shall be as defined in Table 9.

Table 8: Octet Scheme for DENM SSPs

Octet #	Description
0	SSP version control
1 to 3	Service-specific parameter
4 to 30	Reserved for Future Usage

Table 9: SSP Definitions for DENM

Octet Position	Bit Position	CauseCodeType / Container	Bit Value
1	0 (80h) (MSBit)	trafficCondition(1)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	1 (40h)	accident(2)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	2 (20h)	roadworks(3)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	3 (10h)	adverseWeatherCondition-Adhesion(6)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	4 (08h)	hazardousLocation-SurfaceCondition(9)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	5 (04h)	hazardousLocation-ObstacleOnTheRoad(10)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	6 (02h)	hazardousLocation-AnimalOnTheRoad(11)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	7 (01h) (LSBit)	humanPresenceOnTheRoad(12)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	0 (80h) (MSBit)	wrongWayDriving(14)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	1 (40h)	rescueAndRecoveryWorkInProgress(15)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	2 (20h)	adverseWeatherCondition-ExtremeWeatherCondition(17)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	3 (10h)	adverseWeatherCondition-Visibility(18)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	4 (08h)	adverseWeatherCondition-Precipitation(19)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	5 (04h)	slowVehicle(26)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	6 (02h)	dangerousEndOfQueue(27)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	7 (01h) (LSBit)	vehicleBreakdown(91)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	0 (80h) (MSBit)	postCrash(92)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	1 (40h)	humanProblem(93)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	2 (20h)	stationaryVehicle(94)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	3 (10h)	emergencyVehicleApproaching(95)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	4 (08h)	hazardousLocation-DangerousCurve(96)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	5 (04h)	collisionRisk(97)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	6 (02h)	signalViolation(98)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	7 (01h) (LSBit)	dangerousSituation(99)	0: certificate not allowed to sign
			1: certificate allowed to sign

NOTE: Bit position corresponds to numerical value for *CauseCodeType* assigned in ETSI TS 102 894-2 [5].

NOTE 1: The setting of the subCauseCode and the related triggering conditions are out of scope of the SSP.

NOTE 2: From security point of view, enabling one *causeCode* type by setting the corresponding SSP bit automatically enables all corresponding *subCauseCode* types. However, the triggering conditions of the *subCauseCode* type setting are defined by ITS application requirements. As consequence, if the SSP for a *causeCode* type is set to 1, it does not imply that the ITS-S is able to detect all events of the corresponding *subCauseCode* types.

EXAMPLE: The application Electronic Emergency Break Light (EEBL) requires the SSP bit for dangerousSituation(99) to be set because emergencyElectronicBrakeEngaged(1) is part of DangerousSituationSubCauseCode. However, this does not mean that aebEngaged(5) can be detected.

6.2.3 General priority constraints

The DENM priority is defined by the related use case as specified in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6].

Priority information is provided in the PCI across the OSI layers and/or transmitted by lower layers as specified as Traffic Class in ETSI EN 302 636-4-1 [i.8]. Therefore, it is not included in a DENM.

7 DENM format specification

7.1 DENM structure

7.1.1 General structure of a DENM

A DENM is composed of a common ITS PDU header and multiple containers, which constitutes the DENM payload.

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

The DENM payload consists of four fixed order parts: the management container, the situation container, the location container and the à la carte container:

- The management container contains information related to the DENM management and the DENM protocol.
- The situation container contains information related to the type of the detected event.
- The location container contains information of the event location, and the location referencing.
- The à la carte container contains information specific to the use case which requires the transmission of additional information that is not included in the three previous containers.

For all types of DENM, the ITS PDU header and the management container shall always be present. The situation container, the location container and the à la carte container are optional containers. For a cancellation DENM or a negation DENM, the situation container, location container and à la carte container shall not be present. If the situation container is present, the location container shall be present as well. The à la carte container is present only when applicable as specified in application specification standards, such as ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6].

The general structure of a DENM is illustrated in Figure 6. Each container is composed of a sequence of data elements (DE) and/or 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.

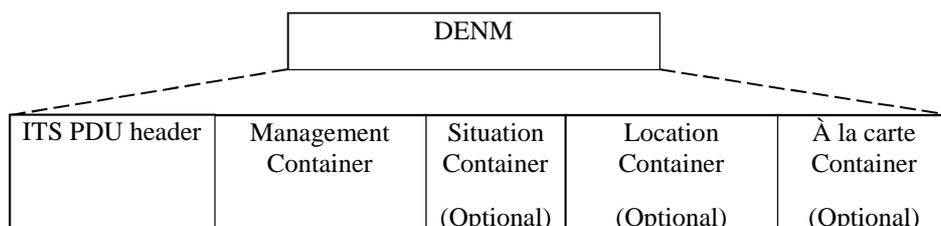


Figure 6: General structure of a DENM

7.1.2 ITS PDU header

The ITS PDU header shall be as specified in ETSI TS 102 894-2 [5]. Detailed data presentation rules of the ITS PDU header in the context of DENM shall be as specified in clause B.1.

7.1.3 DENM management container

The management container shall include the following information:

- *actionID*: Shall be as defined in clauses 6.1.1 and B.7.
- *detectionTime*: Shall be as defined in clause B.11.
- *referenceTime*: Shall be as defined in clause B.37.
- *termination*: Shall be as defined in clauses 6.1.2 and B.50. This DE is optional, it shall be present for *cancellation DENM* and *negation DENM*.
- *eventPosition*: The event position is use case specific and provided by the ITS-S application to the DEN basic service, it shall be as defined in clause B.14.
- *relevanceDistance*: As specified in clauses 6.1.3.1 and B.38. This DE is optional. If the ITS application of the originator ITS-S provides such information to the DEN basic service, the *relevanceDistance* shall be present.
- *relevanceTrafficDirection*: As specified in clauses 6.1.3.1 and B.39. If the ITS application of the originator ITS-S provides such information to the DEN basic service, the *relevanceTrafficDirection* shall be present.
- *validityDuration*: Shall be as defined in clause B.55. This DE is optional. If this information is provided by the application layer, the *validityDuration* shall be present. The *validityDuration* value may be updated or extended by the ITS-S application of the originating ITS-S. At the end of this *validityDuration*, the event is regarded as terminated, and all information related to the event may be deleted by the DEN basic service.
- *transmissionInterval*: Shall be as defined in clause B.53. This DE is optional. If the ITS application of the originator ITS-S provides such information to the DEN basic service, the *transmissionInterval* shall be present.
- *stationType*: Shall be as specified in clause B.49.

7.1.4 DENM situation container

The situation container includes information that describes the detected event. It shall include at least *informationQuality* DE and *eventType* DF, and may include *linkedCause* DF and *eventHistory* DF, as follows:

- *informationQuality*: Shall be as defined in clause B.23. The value ranges from lowest (1) to highest (7). The *informationQuality* value shall be provided by the application layer of the originating ITS-S. The value 0 shall be set when the information is unavailable.
- *eventType*: This DF provides a description of the event type being detected. It shall be as defined in clause B.17. For each specific event type, a unique code shall be used. The *eventType* is composed of two DEs, namely the *causeCode* and *subCauseCode*:
 - *causeCode*: the direct cause code provides a high level description of the detected event type. The value of the *causeCode* is based on the TPEG TEC specification as defined in TISA TAWG11071 [i.10].
 - *subCauseCode*: This DE is used to provide more detailed information of the event related to the *causeCode*. The value of the sub cause code is based on the TPEG TEC specification as defined in TISA TAWG11071 [i.10]. The *subCauseCode* shall be set to 0 if no specific information of the *subCauseCode* is available.
- *linkedCause*: This DF indicates an event which may be linked with the *eventType*. It shall be as defined in clause B.26. The *linkedCause* is an optional DF. It shall be present in the situation container, if the application provides such information to the DEN basic service.

NOTE 1: In many cases, the traffic events are the combination of more than one situation, for example, accident due to the bad weather conditions, break down vehicle resulting the people on the road situation. Therefore, the *linkedCause* information is added.

- *eventHistory*: This DF indicates the list of positions that a plain event has been detected prior to the *eventPosition*. It shall be as defined in clause B.13. The *eventHistory* is an optional DF. It shall be present in the situation container, if the application provides such information to the DEN basic service.

Table 10 lists the *causeCode* and *subCauseCode* values for all ITS use cases as defined in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6] that make use of the DEN basic service.

NOTE 2: ETSI TC ITS harmonizes *causeCode* and *subCauseCode* values with the TISA TAWG11071 [i.10].

For the event types that have been assigned with the *causeCode* and *subCauseCode* values in TISA TAWG11071 [i.10], the same values are used. For events types, for which the *causeCode* and *subCauseCode* values are not assigned in TISA TAWG11071 [i.10], a value is assigned by ETSI TC ITS.

In Table 10, references to TISA TAWG11071 [i.10] cause codes and related sub cause codes are indicated when applicable.

Table 10: Cause description and cause code assignment for ETSI use case

Cause code description	Direct cause code	Mapping with TPEG-TEC	Sub cause code	Sub cause description
Traffic condition	1	Specified as traffic congestion in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1	As specified in <i>tec101</i> of clause 9.11 in TISA TAWG11071 [i.10]
			2	Traffic jam slowly increasing, as specified in clause 5.3.8 in ETSI TS 101 539-1 [i.4], not specified in TISA TAWG11071 [i.10]
			3	Traffic jam increasing, as specified in clause 5.3.8 in ETSI TS 101 539-1 [i.4], not specified in TISA TAWG11071 [i.10]
			4	Traffic jam strongly increasing, as specified in clause 5.3.8 in ETSI TS 101 539-1 [i.4], not specified in TISA TAWG11071 [i.10]
			5	Traffic stationary, as specified in clause 5.3.8 in ETSI TS 101 539-1 [i.4], not specified in TISA TAWG11071 [i.10]
			6	Traffic jam slightly decreasing, as specified in clause 5.3.8 in ETSI TS 101 539-1 [i.4], not specified in TISA TAWG11071 [i.10]
			7	Traffic jam decreasing, as specified in clause 5.3.8 in ETSI TS 101 539-1 [i.4], not specified in TISA TAWG11071 [i.10]
			8	Traffic jam strongly decreasing, as specified in clause 5.3.8 in ETSI TS 101 539-1 [i.4], not specified in TISA TAWG11071 [i.10]

Cause code description	Direct cause code	Mapping with TPEG-TEC	Sub cause code	Sub cause description
Accident	2	Specified as accidents in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 7	As specified in <i>tec102</i> of clause 9.12 in TISA TAWG11071 [i.10]
			8	Assistance requested (e-call)
Roadworks	3	Specified as road works in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 3	As specified in <i>tec103</i> of clause 9.13 in TISA TAWG11071 [i.10]
			4	Short-term stationary roadWorks
			5	Street cleaning
			6	Winter service
Adverse weather condition - adhesion	6	Specified as slippery road in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 10	As specified in <i>tec106</i> of clause 9.16 in TISA TAWG11071 [i.10]
Hazardous location - Surface condition	9	Specified as hazardous driving conditions in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 9	As specified in <i>tec109</i> of clause 9.18 in TISA TAWG11071 [i.10]
Hazardous location - Obstacle on the road	10	Specified as objects on the road in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 7	As specified in <i>tec110</i> of clause 9.19 in TISA TAWG11071 [i.10]
Hazardous location - Animal on the road	11	Specified as animals on the road in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 4	As specified in <i>tec111</i> of clause 9.20 in TISA TAWG11071 [i.10]
Human presence on the road	12	Specified as people on roadway in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 3	As specified in <i>tec112</i> of clause 9.21 in TISA TAWG11071 [i.10]
Wrong way driving	14	Specified as vehicle on wrong carriageway in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1	Vehicle driving in wrong lane
			2	Vehicle driving in wrong driving direction
Rescue and recovery work in progress	15	Specified as Rescue and recovery work in progress in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 5	As specified in <i>tec115</i> of clause 9.23 in TISA TAWG11071 [i.10]
Adverse weather condition - extreme weather condition	17	Specified as extreme weather condition in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 6	As specified in <i>tec117</i> of clause 9.25 in TISA TAWG11071 [i.10]
Adverse weather condition - visibility	18	Specified as visibility reduced in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 8	As specified in <i>tec118</i> of clause 9.26 in TISA TAWG11071 [i.10]
Adverse weather condition -Precipitation	19	Precipitation as defined in TISA TAWG11071 [i.10], clause 8.3.2	0	Unavailable
			1 to 3	As defined in <i>tec119</i> of clause 9.27 in TISA TAWG11071 [i.10]
Slow vehicle	26	Specified as slow moving vehicles in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 8	As defined in <i>tec126</i> of clause 9.32 in TISA TAWG11071 [i.10]

Cause code description	Direct cause code	Mapping with TPEG-TEC	Sub cause code	Sub cause description
Dangerous end of queue	27	Specified as dangerous end of Queue in <i>tec002</i> of clause 9.2 in TISA TAWG11071 [i.10]	0	Unavailable
			1 to 4	As defined in <i>tec127</i> of clause 9.33 in TISA TAWG11071 [i.10]
Vehicle breakdown	91	Values are assigned referring to ETSI TS 101 539-1 [i.4], clause 6.3.3	0	Unavailable
			1	Lack of fuel
			2	Lack of battery
			3	Engine problem
			4	Transmission problem
			5	Engine cooling problem
			6	Braking system problem
			7	Steering problem
Post crash	92	Values are assigned referring to ETSI TS 101 539-1 [i.4], clause 6.3.3	0	Unavailable
			1	Accident without e-Call triggered
			2	Accident with e-Call manually triggered
			3	Accident with e-Call automatically triggered
			4	Accident with e-Call triggered without a possible access to a cell network.
Human problem	93	Values are assigned referring to ETSI TS 101 539-1 [i.4], clause 6.3.3	0	Unavailable
			1	Glycaemia problem
			2	Heart problem
Stationary vehicle	94	Not specified in TISA TAWG11071 [i.10] Values are assigned referring to ETSI TS 101 539-1 [i.4], clause 6.3.3	0	Unavailable
			1	Human Problem
			2	Vehicle breakdown
			3	Post crash
			4	Public transport stop
			5	Carrying dangerous goods
Emergency vehicle approaching	95	Not specified in TISA TAWG11071 [i.10] Values are assigned referring to ETSI TS 101 539-1 [i.4], clause 6.3.1	0	Unavailable
			1	Emergency vehicle approaching
			2	Prioritized vehicle approaching

Cause code description	Direct cause code	Mapping with TPEG-TEC	Sub cause code	Sub cause description
Hazardous location indication - Dangerous Curve	96	Not specified in TISA TAWG11071 [i.10] Values are assigned referring to ETSI TS 101 539-1 [i.4], clause 6.3.7	0	Unavailable
			1	Dangerous left turn curve
			2	Dangerous right turn curve
			3	Multiple curves starting with unknown turning direction
			4	Multiple curves starting with left turn,
			5	Multiple curves starting with right turn
Collision risk	97	Intersection collision Not specified in TISA TAWG11071 [i.10] Values are assigned referring to ETSI TS 101 539-2 [i.5]	0	Unavailable
			1	Longitudinal collision risk
			2	Crossing collision risk
			3	lateral collision risk
			4	Collision risk involving vulnerable road user
Signal violation	98	Intersection violation	0	Unavailable
			1	Stop sign violation
			2	Traffic light violation
			3	Turning regulation violation
Dangerous situation	99	Not specified in TISA TAWG11071 [i.10] Values are assigned referring to ETSI TS 101 539-1 [i.4], clause 6.3.4	0	Unavailable
			1	Emergency electronic brake lights
			2	Pre-crash system activated
			3	ESP(Electronic Stability Program) activated
			4	ABS (Anti-lock braking system) activated
			5	AEB (Automatic Emergency Braking) activated
			6	Brake warning activated
			7	Collision risk warning activated

7.1.5 DENM location container

The location container describes the location of the detected event. It shall include *traces* DF and may include *eventSpeed*, *eventPositionHeading*, and *roadType* DE and DFs, as follows:

- *eventSpeed*: Shall be defined in clause B.16. This DF is optional, it shall be present if the information is provided by the ITS-S application to the DEN basic service of the originating ITS-S.
- *eventPositionHeading*: Shall be as defined in clause B.15. This DF is optional, it shall be present if the information is provided by the ITS application layer to the DEN basic service of the originator ITS-S.
- *traces*: Shall be as specified in clauses 6.1.3.2 and B.51.
- *roadType*: Shall be defined in clause B.42. This DE is optional, it shall be present if the information is provided by the ITS application layer to the DEN basic service of the originator ITS-S.

7.1.6 DENM à la carte container

The à la carte container contains additional information that is not provided by other containers. This container provides the possibility for ITS-S application to include application specific data in a DENM.

All information included in the à la carte container is optional. They shall be present when the data is provided by the ITS-S application.

The present document includes the à la carte container specification for use cases as specified in ETSI TS 101 539-1 [i.4], ETSI TS 101 539-2 [i.5] and ETSI TS 101 539-3 [i.6]. It includes the following use case specific container:

- *lanePosition*: This information may be added to indicate the corresponding lane position of the event position. It shall be as defined in clause B.24.
- *impactReduction*: This container may be added when potential collision is detected. It includes vehicle data for the collision mitigation. It shall be as defined in clause B.21.
- *externalTemperature*: This information may be added for the adverse weather condition use case as specified in ETSI TS 101 539-1 [i.4]. It indicates the ambient temperature at the event position. It shall be as defined in clause B.18.
- *roadWorks*: This container may be added for the roadwork use case as specified in ETSI TS 101 539-1 [i.4]. It includes information of the roadwork zone and specific access conditions. It shall be as defined in clause B.43.
- *positioningSolution*: This information may be added for the emergency vehicle approaching, slow vehicle and stationary vehicle use cases as specified in ETSI TS 101 539-1 [i.4]. It indicates the type of positioning solution being used for the resolution of the event position. It shall be as defined in clause B.30.
- *stationaryVehicle*: This container may be added for the stationary vehicle use case as specified in ETSI TS 101 539-1 [i.4]. It shall be as defined in clause B.48.

7.2 DENM format and decoding rules

7.2.1 Common data dictionary

The DENM format makes use of the common data dictionary as defined in ETSI TS 102 894-2 [5].

Where applicable, DEs and DFs that are not defined in the present document shall be imported from the common data dictionary as specified in ETSI TS 102 894-2 [5].

Detailed descriptions of all DEs and DFs in the context of DENM are presented in the normative Annex B of the present document.

7.2.2 DENM data presentation

The DENM format is presented in ASN.1. Unaligned packed encoding rules (PER) as defined in Recommendation ITU-T X.691/ISO/IEC 8825-2 [6] shall be used for DENM encoding and decoding.

The ASN.1 representation of DENM shall be as specified in Annex A of the present document.

8 Protocol operation of the DEN basic service

8.1 Introduction

This clause specifies the protocol operations of the DEN basic service for three main roles:

- Originating ITS-S operation (clause 8.2);
- Forwarding ITS-S operation (clause 8.3); and
- Receiving ITS-S operation (clause 8.4).

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

- 1) Protocol data setting rules specify the setting of the relevant parameters used by the protocol.
- 2) The general protocol operation specifies the sequence of protocol operations.
- 3) Exception handling specifies additional protocol operations that extend the general protocol operation. They are applied when special conditions, referred to exceptions (for example inconsistent data) occur.

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

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

8.2 Originating ITS-S operation

8.2.1 Protocol data setting rules

8.2.1.1 General requirements

The data setting for the originating ITS-S operation shall be as specified in Annex B and shall follow the rules defined in this clause.

8.2.1.2 *actionID*

For the application request type *AppDENM_trigger*, a new *actionID* shall be assigned to an unused value. The *sequenceNumber* in the *actionID* shall be set to a next unused value each time a new event is detected by the originating ITS-S.

For the application request type *AppDENM_update*, the application may pass *actionID* to the DEN basic service in the application request. For update DENM, the *actionID* shall remain unchanged, as long as the originating ITS-S *stationID* is unchanged.

For the application request type *AppDENM_termination*, the application may pass *actionID* to the DEN basic service in the application request. For cancellation DENM, the *actionID* shall remain unchanged, as long as the originating ITS-S *stationID* is unchanged. For negation DENM, the *actionID* shall be set to the *actionID* for which the negation DENM refers to.

In case ITS application requests the DENM repetition, the *actionID* shall remain unchanged during DENM repetition, as long as the originating ITS-S *stationID* is unchanged.

8.2.1.3 *referenceTime*

For the application request type *AppDENM_trigger*, the *referenceTime* shall be set to the time at which the new DENM is generated by the DEN basic service.

For the application request type *AppDENM_update*, the *referenceTime* shall be set to the time at which update DENM is generated by the DEN basic service for each update.

For the application request type *AppDENM_termination*, DEN basic service shall generate a cancellation DENM if the originating ITS-S message table as defined in clause 8.2.1.6 contains a DENM of the same *actionID*. The DEN basic service shall generate a negation DENM if the receiving ITS-S message table as defined in clause 8.4.1.6 contains a DENM of the same *actionID*. Otherwise, the DEN basic service shall ignore the application request and sends a failure notification to the ITS-S application. For cancellation DENM, the *referenceTime* shall be set to the time at which cancellation DENM is generated. For negation DENM, the *referenceTime* shall be set to the latest value of the DENM of the same *actionID* in the receiving ITS-S message table. This is to enable receiving ITS-Ss to match to which event update the negation DENM is referring to (see clause 6.1.2.4).

In case application requests the DENM repetition, the *referenceTime* shall remain unchanged during the DENM repetition.

8.2.1.4 *termination*

For the application request type *AppDENM_trigger*, the *termination* DE shall not be included in DENM.

For the application request type *AppDENM_update*, the *termination* DE may be present, depending on the DENM type for which the update is requested by the ITS-S application.

For the application request type *AppDENM_termination*, the *termination* shall be set to 1 if a negation DENM is to be generated. The *termination* shall be set to 0 if a cancellation DENM is to be generated.

8.2.1.5 *T_O_Validity*, *T_RepetitionDuration* and *T_Repetition*

The timer *T_O_Validity* is the time that indicates the end of the DENM validity for the originating ITS-S protocol operation. Its expiration time shall be set to:

- the offset of the *validityDuration* starting from the *detectionTime*, if the *validityDuration* is provided by the application;
- the default offset of 600 s starting from the *detectionTime*, if the *validityDuration* is not provided by the application.

The timer *T_RepetitionDuration* is the time that indicates the end of the DENM repetition by the DEN basic service of the originating ITS-S. Its expiration time shall be set to:

- the offset of the *repetitionDuration* starting from the *referenceTime*, if the *repetitionDuration* is provided by the application;
- an invalid value, if the *repetitionDuration* is not provided by the application.

NOTE 1: *repetitionDuration* is not included in DENM.

The timer *T_Repetition* schedules the DENM repetition. Its timeout value shall be set to:

- the *repetitionInterval*, if the parameter is provided by the ITS-S application;
- an invalid value, if the *repetitionInterval* is not provided by the ITS-S application.

NOTE 2: If the *T_Repetition* is set to invalid, the DENM is transmitted only once.

NOTE 3: *repetitionInterval* is not included in DENM.

For all application request types, the *T_Repetition* and *T_RepetitionDuration* shall not be greater than the *validityDuration*.

8.2.1.6 Originating ITS-S message table

The DEN basic service shall maintain at least all data as defined in the present clause in the originating ITS-S message table.

At a point in time, any DENM entry in the originating ITS-S message table may be associated with one of three states:

- ACTIVE state: The *termination* data is not set for DENM entry of the *actionID*.
- CANCELLED state: The *termination* value is set to 0 for DENM entry of the *actionID*.
- NEGATED state: The *termination* value is set to 1 for DENM entry of the *actionID*.

The state of a DENM indicates the most updated status of a DENM entry of the same *actionID*.

NOTE: For application that requests the DENM repetition, the DENM is stored in the originating ITS-S message table.

8.2.2 General protocol operation

Upon reception of a request from ITS-S application via the interface IF.DEN.1, the DEN basic service shall execute the following operations:

For application request type *appDENM_trigger*:

- 1) Calculate expiration time for timer *T_O_Validity* (clause 8.2.1.5):
 - a. If expiration time of timer *T_O_Validity* is in the past, send a failure notification to the ITS-S application and omit the execution of further steps.
 - b. Otherwise, continue the operation.
- 2) Assign unused *actionID* value (clause 8.2.1.2).
- 3) If *transmissionInterval* is provided by the application request:
 - a. Set *transmissionInterval*.
 - b. Otherwise, continue the operation.
- 4) Set other fields of DENM management container, situation container, location container and à la carte container (Annex A).
- 5) Set *referenceTime* to the current time.
- 6) Construct DENM.
- 7) Pass the DENM to the ITS networking & transport layer.
- 8) Create an entry in the originating ITS-S message table and set the state to ACTIVE.
- 9) Start/restart timer *T_O_Validity*.
- 10) If *repetitionDuration* > 0 and *repetitionInterval* > 0:
 - a. Calculate and start timer *T_RepetitionDuration* and *T_Repetition*.
 - b. Otherwise, continue the operation.
- 11) Send *actionID* to the requesting ITS-S application.
- 12) End.

For application request type *appDENM_update*:

- 1) Calculate expiration time for timer *T_O_VValidity* (clause 8.2.1.5):
 - a. If expiration time of timer *T_O_VValidity* is in the past, send a failure notification to the ITS-S application and omit the execution of further steps.
 - b. Otherwise, continue the operation.
- 2) Compare *actionID* in the application request with entries in the originating ITS-S message table:
 - a. If *actionID* provided by the ITS-S application request does not exist in the originating ITS-S message table, send a failure notification to the ITS-S application and omit the execution of further steps.
 - b. Otherwise, continue the operation.
- 3) Stop *T_O_VValidity*, *T_RepetitionDuration* and *T_Repetition* if applicable.
- 4) If *transmissionInterval* is provided by the application request:
 - a. Set *transmissionInterval*.
 - b. Otherwise, continue the operation.
- 5) Set other fields of DENM management container, situation container, location container and à la carte container (Annex A).
- 6) Set *referenceTime* to the current time.
- 7) Construct DENM.
- 8) Pass the DENM to the ITS networking & transport layer.
- 9) Update the entry in the originating ITS-S message table.
- 10) Start/restart timer *T_O_VValidity*.
- 11) If *repetitionDuration* > 0 and *repetitionInterval* > 0:
 - a. Calculate and restart timer *T_RepetitionDuration* and *T_Repetition*.
 - b. Otherwise, continue the operation.
- 12) Send *actionID* to the requesting ITS-S application.
- 13) End.

For application request type *appDENM_termination*:

- 4) Set expiration time for timer *T_O_VValidity* (clause 8.2.1.5):
 - a. If expiration time of timer *T_O_VValidity* is in the past, send a failure notification to the ITS-S application and omit the execution of further steps.
 - b. Otherwise, continue the operation.
- 5) Compare *actionID* in the application request with entries in the originating ITS-S message table and the receiving ITS-S message table:
 - a. If *actionID* exists in the originating ITS-S message table and the entry state is ACTIVE, then set *termination* to *isCancellation*.
 - b. If *actionID* exists in the receiving ITS-S message table and, if applicable, the SSP is valid for that *CauseCode*; the entry state is ACTIVE, then set *termination* to *isNegation*.
 - c. Otherwise, send a failure notification to the ITS-S application and omit the execution of further steps.

- 6) Set *referenceTime*:
 - a. If *termination* is set to 0, set *referenceTime* to the current time.
 - b. If *termination* is set to 1, set *referenceTime* to the *referenceTime* value of receiving ITS-S message table DENM entry.
- 7) Stop *T_O_Validity*, *T_RepetitionDuration* and *T_Repetition* if applicable.
- 8) If *transmissionInterval* is provided by the application request:
 - a. Set *transmissionInterval*.
 - b. Otherwise, continue the operation.
- 9) Set other fields of the DENM management container (Annex A).
- 10) Construct DENM.
- 11) Pass the DENM to the ITS networking & transport layer.
- 12) Update the entry:
 - a. If *termination* is set to 0, update the entry in the originating ITS-S message table and set the state to CANCELLED.
 - b. If *termination* is set to 1, create an entry in the originating ITS-S message table and set the state to NEGATED.
- 13) Start/restart timer *T_O_Validity*.
- 14) If *repetitionDuration* > 0 and *repetitionInterval* > 0:
 - a. Calculate and restart timer *T_RepetitionDuration* and *T_Repetition*.
 - b. Otherwise, continue the operation.
- 15) Send *actionID* to the requesting ITS-S application.
- 16) End.

When the timer *T_O_Validity* expires, the DEN basic service shall execute the following operations:

- 1) Stop timer *T_Repetition* if exists.
- 2) Stop timer *T_RepetitionDuration* if exists.
- 3) Discard the expired DENM entry from the originating ITS-S message table.

When the timer *T_RepetitionDuration* expires, DEN basic service shall execute the following operations:

- 1) Stop timer *T_Repetition*.

When the timer *T_Repetition* expires, DEN basic service shall execute the following operations:

- 2) Pass the DENM to ITS networking & transport layer.
- 3) Restart timer *T_Repetition*.

The protocol operation is illustrated in Figure 7, Figure 8, Figure 9 and Figure 10.

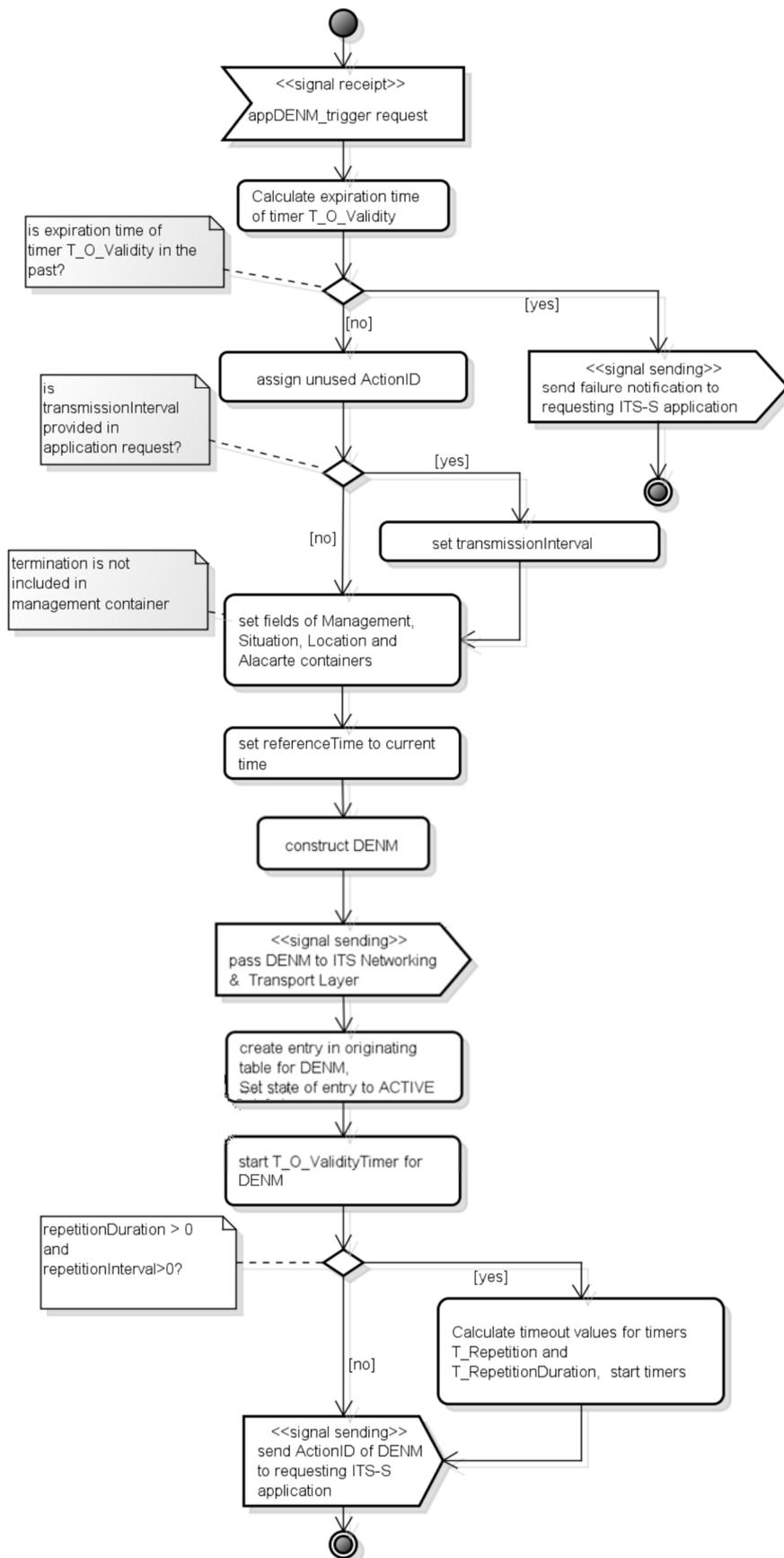


Figure 7: Originating ITS-S activity diagram: appDENM_trigger request

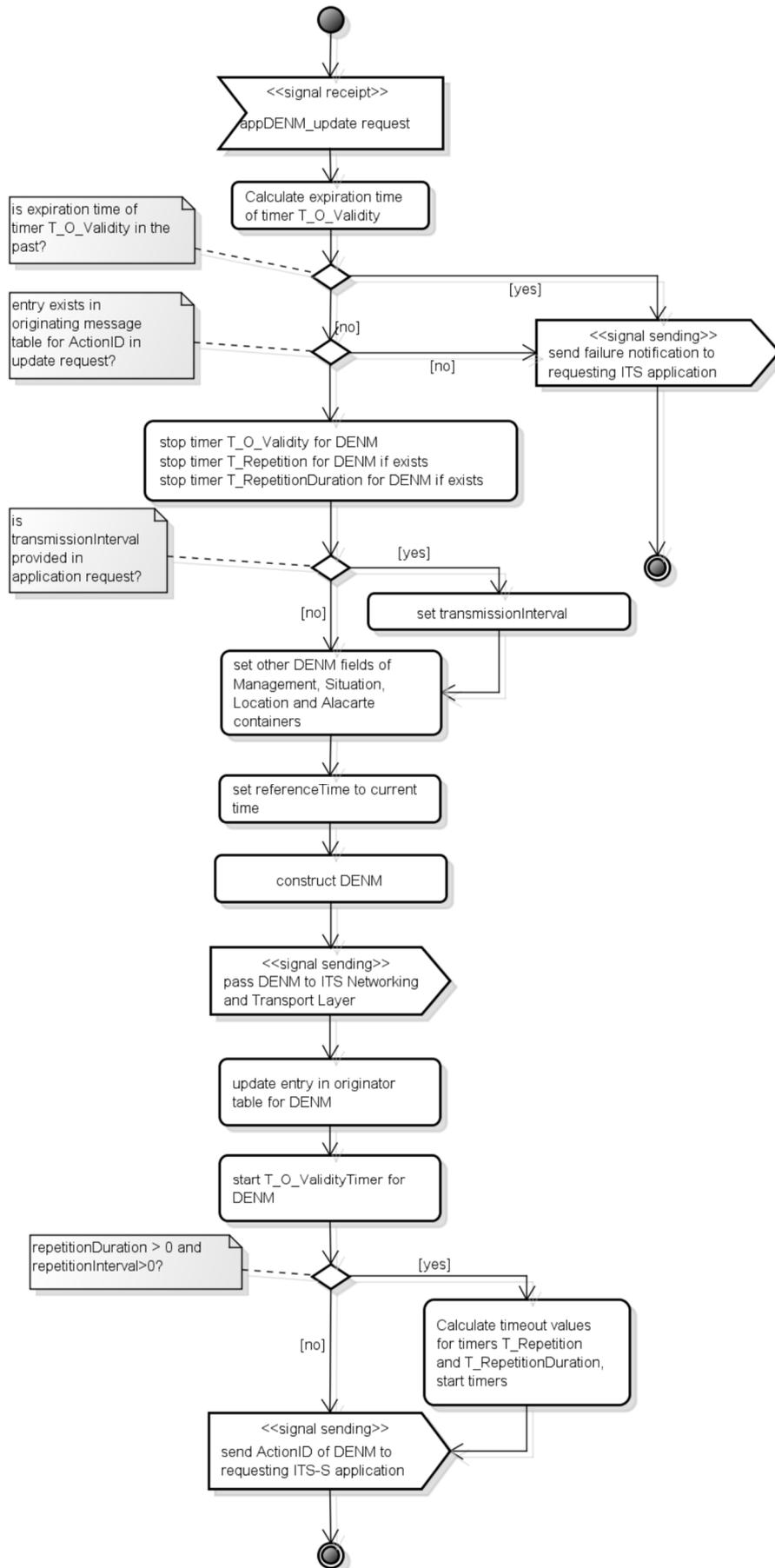


Figure 8: Originating ITS-S activity diagram: appDENM_update request

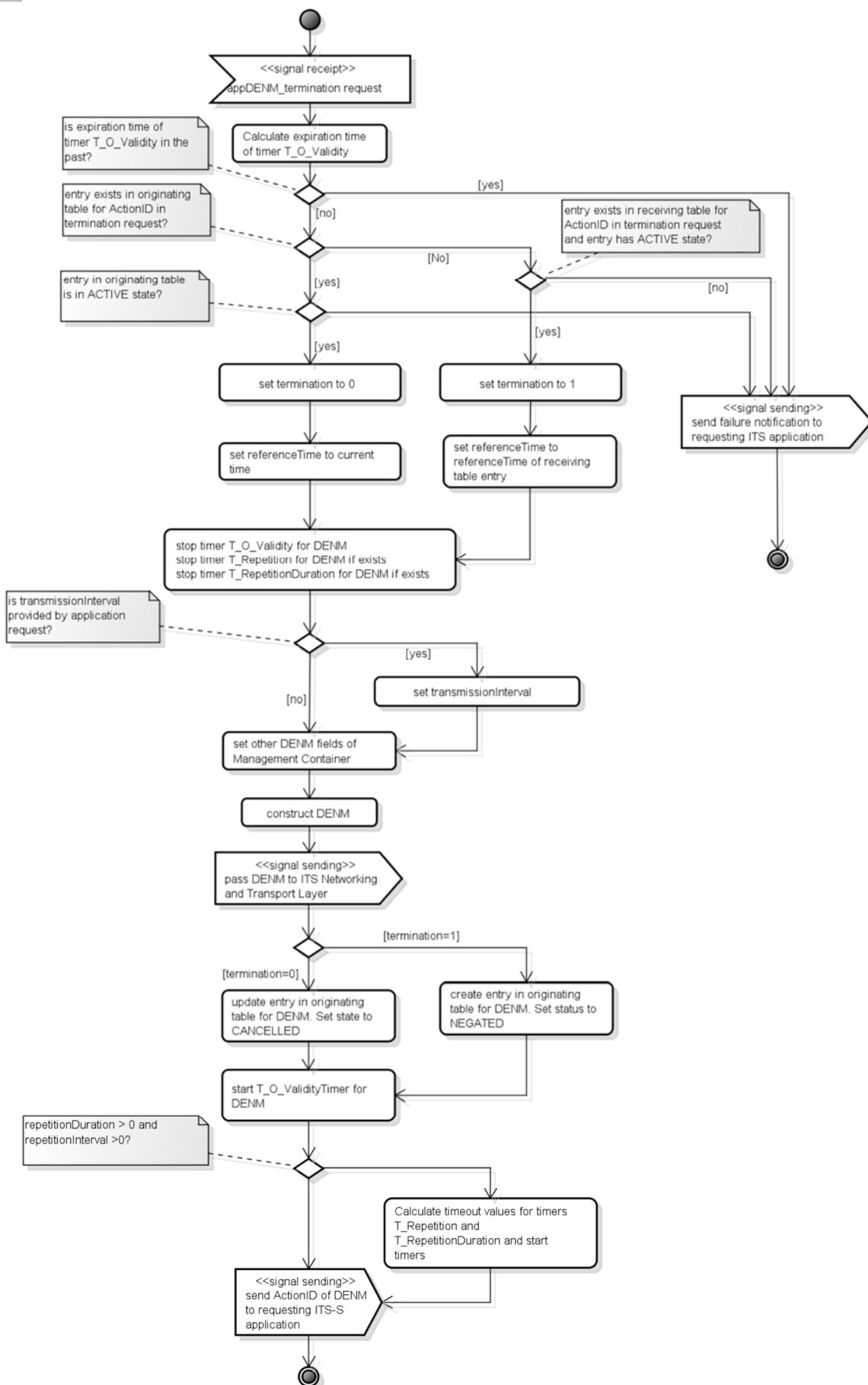


Figure 9: Originating ITS-S activity diagram: appDENM_termination request

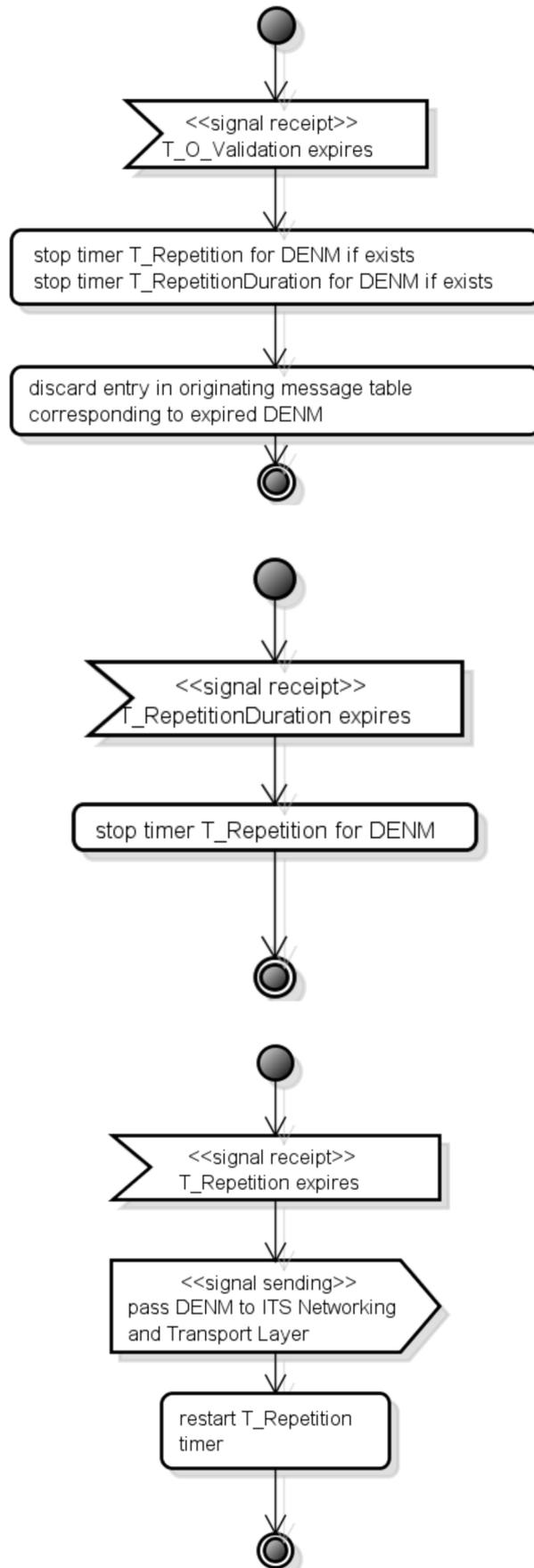


Figure 10: Originating ITS-S activity diagram: timeout management

8.2.3 Exception handling

8.2.3.1 General requirements

The originating ITS-S shall apply the exception handling rules specified in this clause.

8.2.3.2 DENM construction exception

If the DEN basic service cannot construct a DENM successfully, the DEN basic service shall send a failure notification to the ITS-S application.

NOTE 1: This exception is valid for all application request types.

NOTE 2: The failure of the DENM construction may happen, if the DEN basic service was not able to collect all required data for the DENM construction, or the collected data are not compliant to the DENM format as specified in Annex A (e.g. the value of a data is out of authorized range of the ASN.1 definition).

8.2.3.3 *actionID* non-existence exception

This exception applies to the application request types *AppDENM_update* and *AppDENM_termination*.

For the application request type *AppDENM_update*, if the corresponding *actionID* does not exist in the originating ITS-S message table, the DEN basic service shall send a failure notification to the ITS-S application.

For the application request type *AppDENM_termination*, if the corresponding *actionID* exists neither in the originating ITS-S message table (defined in clause 8.2.1.6), nor in the receiving ITS-S message table (defined in clause 8.4.1.6), the DEN basic service shall send a failure notification to the ITS-S application.

8.2.3.4 Time operation exception

If the expiration time of the timer *T_O_Validity* lies in the past when the application request is processed, the DEN basic service shall send a failure notification to the ITS-S application.

NOTE: This may happen, if the DEN basic service is not able to process the application request in time, due to the processing delay of the ITS-S system.

8.3 Forwarding ITS-S operation

8.3.1 Introduction

The following clauses describe the protocol operation of a one possible KAF protocol as introduced in clause 6.1.4.2. The KAF is a sub-function of the DEN basic service that forwards a received DENM from the facilities layer to the ITS networking & transport layer when necessary. This sub-function is optional. It may be deactivated either by the ITS-S application, the ITS-S configuration, the management layer or the DEN basic service itself.

NOTE: The triggering of the KAF may be useful for some applications or some event types. This means that among the received DENM, it can be the case that only DENMs with certain *actionIDs* will be forwarded by the KAF protocol. An ITS-S may also deactivate the KAF protocol for all DENMs.

8.3.2 Protocol data setting rules

8.3.2.1 General requirements

The data setting for the forwarding ITS-S operation shall be as specified in Annex B and shall follow the rules defined in this clause.

8.3.2.2 *actionID*

The forwarding ITS-S shall not set the *actionID*.

8.3.2.3 *referenceTime*

The forwarding ITS-S shall not set the *referenceTime*.

8.3.2.4 *termination*

The forwarding ITS-S shall not set the *termination*.

8.3.2.5 *T_F Validity* and *T_{Forwarding}*

The timer *T_F Validity* schedules the end of the DENM validity for the KAF protocol operation. Its expiration time shall be set to:

- the offset of the *validityDuration* starting from the *detectionTime*, if the *validityDuration* is included in the received DENM;
- an invalid value, if the *validityDuration* is not included in the received DENM.

NOTE 1: If the timer *T_F Validity* is set to an invalid value, the DENM is not forwarded and the KAF is deactivated.

The timer *T_{Forwarding}* schedules the DENM forwarding from the DEN basic service to the ITS networking & transport layer. Its timeout value shall be set to:

- two times of the received *transmissionInterval* plus a random delay in the range of 0 ms to 150 ms, if the *transmissionInterval* and *validityDuration* are present in the received DENM and the resulting timeout value is not greater than the *validityDuration*;

NOTE 2: The random delay addresses the potential synchronization of the keep-alive forwarding functionality among multiple ITS-S.

- *validityDuration*, if *transmissionInterval* and *validityDuration* are present in the received DENM and two times of the *transmissionInterval* plus a random delay in the range 0 ms to 150 ms is greater than the *validityDuration*;
- an invalid value, if the *transmissionInterval* is not present in the received DENM;
- an invalid value, if the timeout of the timer *T_F Validity* is set to an invalid value.

NOTE 3: If the timer *T_F Validity* is set to an invalid value, the DENM is not forwarded. Therefore there is no need to set the timeout value and start/stop the timer *T_{Forwarding}*.

NOTE 4: If the *transmissionInterval* is not present in the DENM, the originating ITS-S does not require the DENM to be kept alive and to be forwarded by an intermediate ITS-S.

8.3.2.6 Forwarding ITS-S message table

The DEN basic service shall maintain a forwarding ITS-S message table. This message table shall at least store the DENMs for which the KAF is activated. The forwarding ITS-S message table shall store the received DENM payload.

The update of the forwarding ITS-S message table shall follow the rules as defined in the receiving ITS-S operation specified in clause 8.4.

NOTE: The update of the forwarding ITS-S message table allows forwarding of the latest update DENM.

8.3.2.7 DENM reconstruction

When a DENM is being forwarded, the DEN basic service shall reconstruct the DENM before forwarding it to the ITS networking & transport layer. For this reconstruction, the management container, situation container, location container and à la carte container of the DENM shall not be modified. The ITS PDU header shall be replaced by the ITS PDU header constructed by the forwarding ITS-S.

8.3.3 General protocol operation

Upon reception of a DENM with an *actionID* for which the KAF is activated, the DEN basic service shall execute the following operations:

- 1) Check if the *termination* exists in received DENM:
 - a. If yes, continue the operation.
 - b. Otherwise, omit execution of further steps.
- 2) Check if the *referenceTime* of the received DENM is equal or greater than the *referenceTime* value of the DENM entry in the forwarding ITS-S message table of the same *actionID*:
 - a. If the received *referenceTime* is equal to the entry *referenceTime*, start/restart *T_F_Forwarding* and omit execution of further steps.
 - b. If the received *referenceTime* is less than the entry *referenceTime*, discard the received DENM and omit execution of further steps.
 - c. Otherwise, continue the operation.
- 17) Calculate expiration time of timer *T_F_Validity* (clause 8.3.2.5):
 - a. If timer *T_F_Validity* is set to invalid value, omit execution of further steps.
 - b. Otherwise, continue operation.
- 18) Calculate timeout value for timer *T_Forwarding* (clause 8.3.2.5):
 - a. If timer *T_Forwarding* is set to invalid value, omit execution of further steps.
 - b. Otherwise, continue operation.
- 19) Start/restart timer *T_F_Validity* and *T_Forwarding*.
- 20) Reconstruct DENM by replacing the ITS PDU header.
- 21) Update DENM entry in forwarding ITS-S message table.
- 22) End.

When the timer *T_F_Validity* expires, the DEN basic service shall execute the following operations:

- 1) Stop *T_Forwarding* timer.
- 23) delete DENM entry from the forwarding message table.

When the timer *T_Forwarding* expires, the DEN basic service shall execute the following operations:

- 1) Check if the forwarding ITS-S is located in the relevance area or the destination area:
 - a. If not, omit execution of further steps.
 - b. Otherwise, continue operation.
- 2) Pass reconstructed DENM to ITS networking & transport layer.
- 3) Restart timer *T_Forwarding*.

The protocol operation is illustrated in Figure 11 and Figure 12.

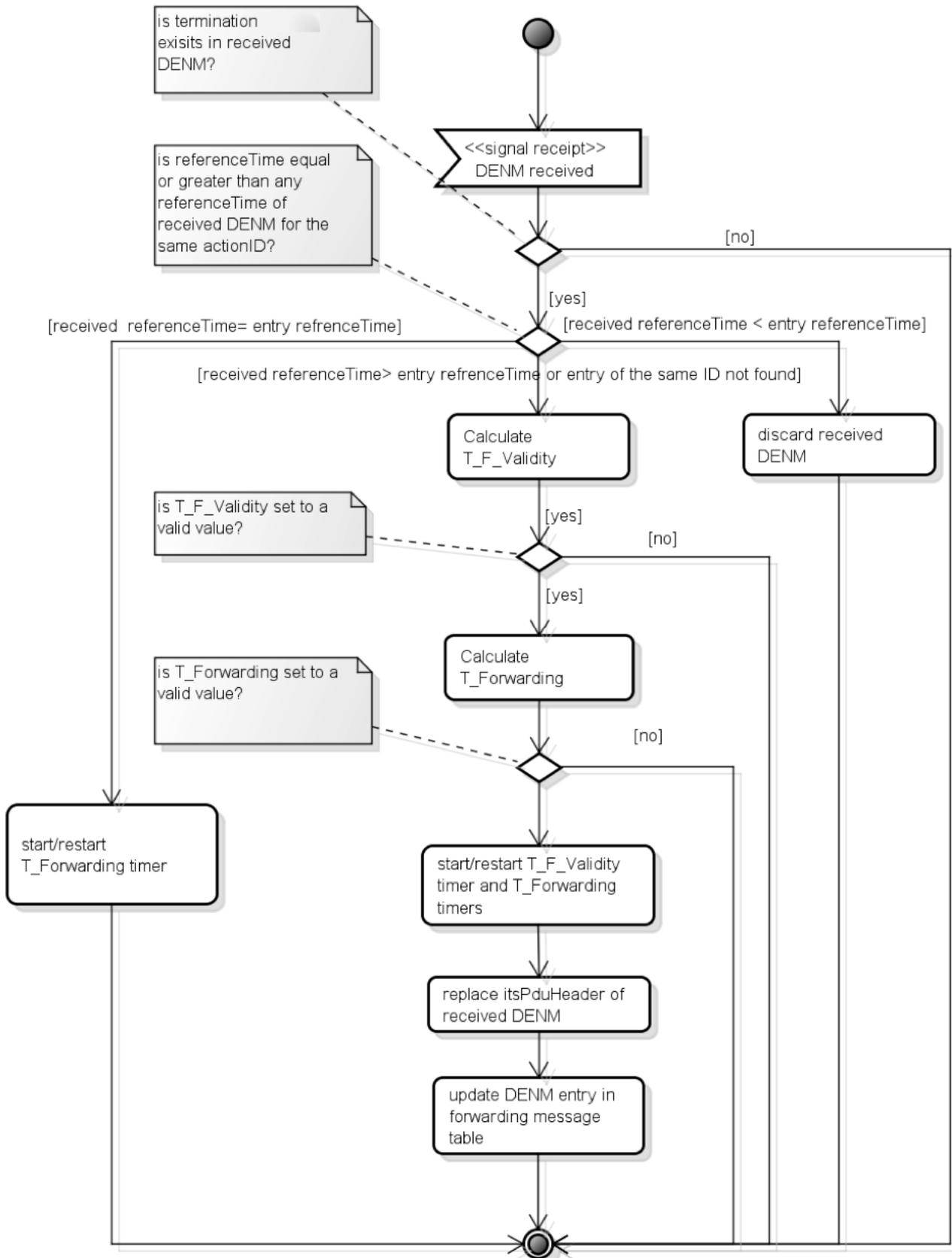


Figure 11: Forwarding ITS-S activity diagram

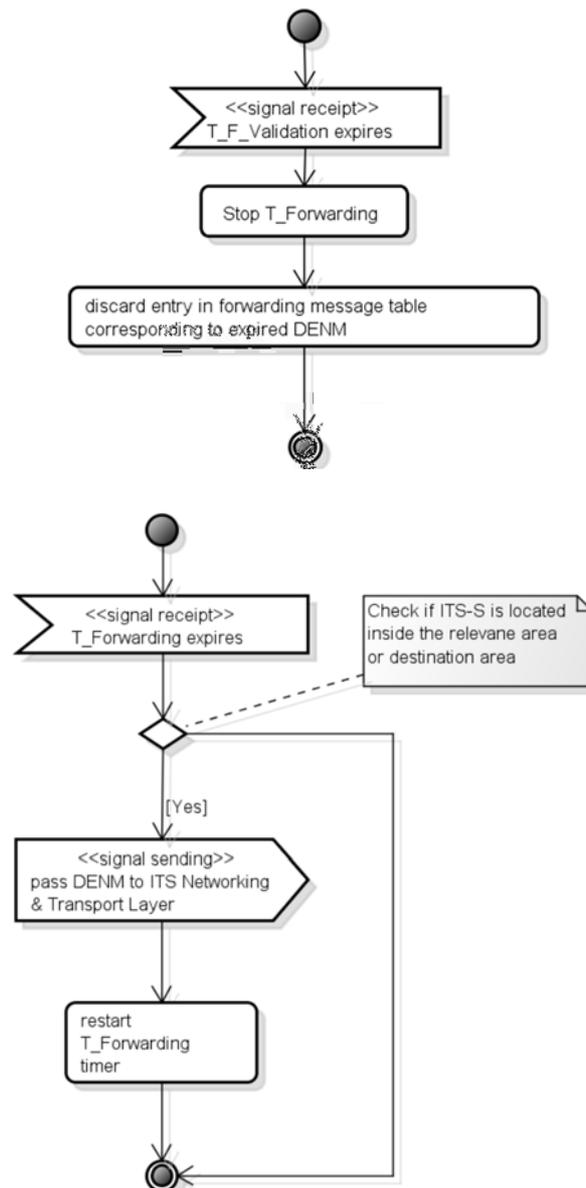


Figure 12: Forwarding ITS-S activity diagram: timeout management

8.3.4 Exception handling

8.3.4.1 General requirements

The forwarding ITS-S shall apply the exception handling rule specified in this clause.

8.3.4.2 DENM construction exception

If the DEN basic service cannot construct a DENM successfully, the DEN basic service shall stop executing further operations of the forwarding.

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

8.4 Receiving ITS-S operation

8.4.1 Protocol data setting rules

8.4.1.1 General requirements

The data setting for the receiving ITS-S operation shall be as specified in Annex B and may follow the rules defined in this clause.

8.4.1.2 *actionID*

The receiving ITS-S shall not set the *actionID*.

8.4.1.3 *referenceTime*

The receiving ITS-S shall not set the *referenceTime*.

8.4.1.4 *termination*

The receiving ITS-S shall not set the *termination*.

8.4.1.5 *T_R_Validity*

T_R_Validity is the time that indicates the end of DENM validity. It is used in the receiving ITS-S message table for keeping up-to-date DENM information. Its expiration time may be set to:

- the offset of the *validityDuration* starting from the *detectionTime*, if the *validityDuration* is present in the received DENM;
- the default offset of the *validityDuration* of 600 s starting from the *detectionTime*, if the *validityDuration* is not present in the received DENM.

8.4.1.6 Receiving ITS-S message table

The DEN basic service may maintain an ITS-S message table with at least the following data for the receiving protocol operation:

- *actionID*: *actionID* value of the received DENMs until the *T_R_Validity* is expired.
- *referenceTime*: The value of the *referenceTime* refers to the most recent value of received DENMs of the same *actionID*.
- *termination*: The value of the *termination* refers to the most recent value of received DENMs of the same *actionID*.
- *detectionTime*: The value of the *detectionTime* refers to the most recent value of received DENMs of the same *actionID*.

NOTE: DENMs stored in the receiving ITS-S message table are indexed with *actionID*.

A DENM with a specific *actionID* may be stored in the receiving ITS-S message table as long as the timer *T_R_Validity* is not expired. When the timer *T_R_Validity* expires, all data related to the corresponding *actionID* (including the *actionID* entry) may be deleted from the receiving ITS-S message table.

At a point in time, any stored DENM in the receiving ITS-S message table may be associated with one of three states:

- ACTIVE state: Receiving ITS-S has not received the *termination* data from all received DENMs of the *actionID*.
- CANCELLED state: The *termination* value of DENM stored in the receiving ITS-S message table is 0.

- NEGATED state: The *termination* value of DENM stored in the receiving ITS-S message table is 1.

The state of a DENM indicates the most updated status of received DENMs of the same *actionID*.

The receiving ITS-S message table may be updated upon the reception of a DENM, under the following conditions:

- the *referenceTime* of a received DENM is greater than the latest value stored in the receiving message table; or
- the state of the DENM is changed due to a received DENM when the *referenceTime* or *detectionTime* of a received DENM is equal or greater than the latest values stored in the receiving message table; or
- the DENM entry with the *actionID* is deleted when the timer *T_R_Validity* expires.

If a received DENM does not satisfy any of the above conditions, the received DENM is considered to be outdated and may be discarded by the receiving ITS-S. The receiving ITS-S message table is not updated with this received DENM.

8.4.2 General protocol operation

Upon reception of a DENM, the DEN basic service may execute the following operations:

- 1) Decode DENM; Calculate expiration time for timer *T_R_Validity* (clause 8.4.1.5):
 - a. If expiration time is in the past, discard the received DENM and omit execution of further steps.
 - b. Otherwise, continue the operation.
- 2) Lookup entries in the receiving ITS-S message table with the received *actionID*:
 - a. If entry does not exist in the receiving ITS-S message table, check if *termination* data exists in the received DENM:
 - i. If yes, discard the received DENM and omit execution of further steps.
 - ii. Otherwise, check SSP and CauseCode if available:
 1. If SSP value is not consistent with *causeCode* in *eventType*, discard the received DENM and omit execution of further steps.
 2. Otherwise, create an entry in the receiving ITS-S message table with the received DENM and set the state to ACTIVE.
 - b. If entry does exist in the receiving ITS-S message table, check if the received *referenceTime* is less than the entry *referenceTime*, or the received *detectionTime* is less than the entry *detectionTime*:
 - i. If yes, discard the received DENM and omit execution of further steps.
 - ii. Otherwise, check if the received DENM is a repeated DENM of the entry, i.e. the received *referenceTime* equals to the entry *referenceTime*, the received *detectionTime* equals to the entry *detectionTime*, and the received *termination* value equals to the entry state:
 1. If yes, discard received DENM and omit execution of further steps.
 2. Otherwise, check SSP and CauseCode if available:
 - a. If SSP value is not consistent with *causeCode* in *eventType*, discard the received DENM and omit execution of further steps.
 - b. Otherwise, update the entry in receiving ITS-S message table, set entry state according to the *termination* value of the received DENM.
- 3) Start/restart *T_R_Validity* timer.
- 4) Inform ITS-S applications of the DENM entry and state if applicable.
- 5) End.

When the timer $T_{R_Validity}$ expires, the DEN basic service may execute the following operations:

- 1) Delete DENM entry from the receiving ITS-S message table.
- 2) Notify application if necessary (clause 5.4.1).

The protocol operation is illustrated in Figure 13 and Figure 14.

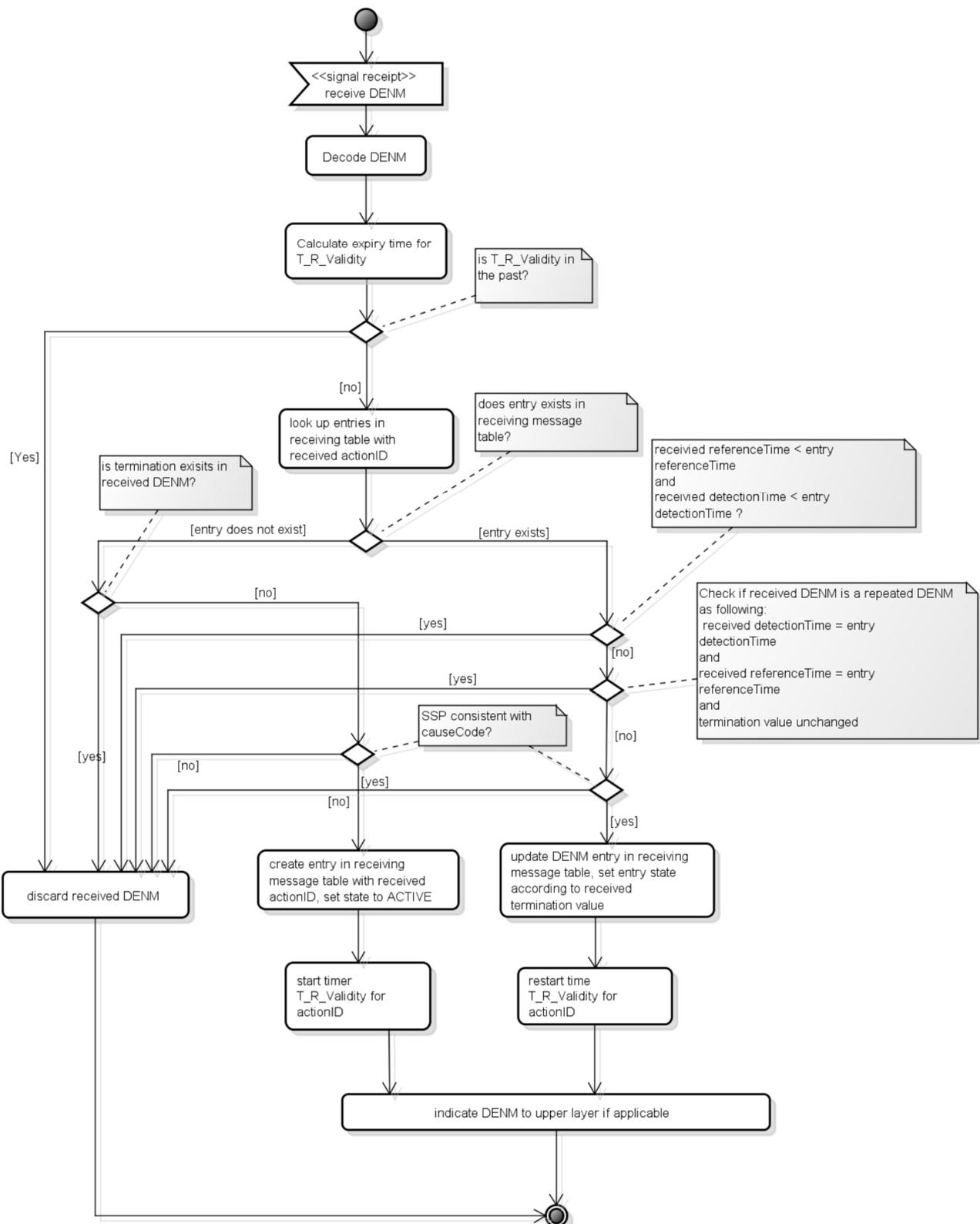


Figure 13: Receiving ITS-S activity diagram

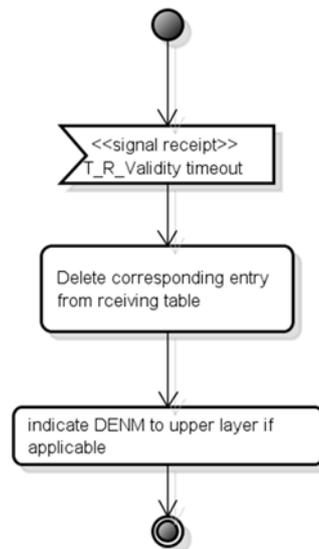


Figure 14: Receiving ITS-S activity diagram: timeout management

8.4.3 Exception handling

8.4.3.1 General requirements

The receiving ITS-S may apply the exception handling rules specified in this clause.

8.4.3.2 DENM decoding exception

If the received DENM cannot be decoded by the DEN basic service, the operation may stop, and the received DENMs may be discarded.

Annex A (normative): ASN.1 specification of DENM

```

DENM-PDU-Descriptions {itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wgl (1) en
(302637) denm (1) version (2)
}

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
ItsPduHeader, CauseCode, Speed, InformationQuality, ReferencePosition, ClosedLanes,
DangerousGoodsExtended, Heading, LanePosition, LightBarSirenInUse, RoadType, HeightLonCarr,
PosLonCarr, PosCentMass, PositioningSolutionType, RequestResponseIndication, StationType,
SpeedLimit, StationarySince, TimestampIts, WheelBaseVehicle, TurningRadius, PosFrontAx,
PositionOfOccupants, Temperature, VehicleMass, VehicleIdentification, EnergyStorageType, ActionID,
ItineraryPath, NumberOfOccupants, PositionOfPillars, RelevanceTrafficDirection, RestrictedTypes,
Traces, TransmissionInterval, ValidityDuration, RelevanceDistance, EventHistory, TrafficRule,
DeltaReferencePosition FROM ITS-Container {
itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wgl (1) ts (102894) cdd (2) version (2)
};

DENM ::= SEQUENCE {
    header ItsPduHeader,
    denm DecentralizedEnvironmentalNotificationMessage
}

DecentralizedEnvironmentalNotificationMessage ::= SEQUENCE {
    management ManagementContainer,
    situation SituationContainer OPTIONAL,
    location LocationContainer OPTIONAL,
    alacarte AlacarteContainer OPTIONAL
}

ManagementContainer ::= SEQUENCE {
    actionID ActionID,
    detectionTime TimestampIts,
    referenceTime TimestampIts,
    termination Termination OPTIONAL,
    eventPosition ReferencePosition,
    relevanceDistance RelevanceDistance OPTIONAL,
    relevanceTrafficDirection RelevanceTrafficDirection OPTIONAL,
    validityDuration ValidityDuration DEFAULT defaultValidity,
    transmissionInterval TransmissionInterval OPTIONAL,
    stationType StationType,
    ...
}

SituationContainer ::= SEQUENCE {
    informationQuality InformationQuality,
    eventType CauseCode,
    linkedCause CauseCode OPTIONAL,
    eventHistory EventHistory OPTIONAL,
    ...
}

LocationContainer ::= SEQUENCE {
    eventSpeed Speed OPTIONAL,
    eventPositionHeading Heading OPTIONAL,
    traces Traces,
    roadType RoadType OPTIONAL,
    ...
}

ImpactReductionContainer ::= SEQUENCE {
    heightLonCarrLeft HeightLonCarr,
    heightLonCarrRight HeightLonCarr,
    posLonCarrLeft PosLonCarr,
    posLonCarrRight PosLonCarr,
    positionOfPillars PositionOfPillars,
    posCentMass PosCentMass,
    wheelBaseVehicle WheelBaseVehicle,
    turningRadius TurningRadius,
}

```

```
    posFrontAx PosFrontAx,
    positionOfOccupants PositionOfOccupants,
    vehicleMass VehicleMass,
    requestResponseIndication RequestResponseIndication
}

RoadWorksContainerExtended ::= SEQUENCE {
    lightBarSirenInUse LightBarSirenInUse OPTIONAL,
    closedLanes ClosedLanes OPTIONAL,
    restriction RestrictedTypes OPTIONAL,
    speedLimit SpeedLimit OPTIONAL,
    incidentIndication CauseCode OPTIONAL,
    recommendedPath ItineraryPath OPTIONAL,
    startingPointSpeedLimit DeltaReferencePosition OPTIONAL,
    trafficFlowRule TrafficRule OPTIONAL,
    referenceDenms ReferenceDenms OPTIONAL
}

StationaryVehicleContainer ::= SEQUENCE {
    stationarySince StationarySince OPTIONAL,
    stationaryCause CauseCode OPTIONAL,
    carryingDangerousGoods DangerousGoodsExtended OPTIONAL,
    numberOfOccupants NumberOfOccupants OPTIONAL,
    vehicleIdentification VehicleIdentification OPTIONAL,
    energyStorageType EnergyStorageType OPTIONAL
}

AlacarteContainer ::= SEQUENCE {
    lanePosition LanePosition OPTIONAL,
    impactReduction ImpactReductionContainer OPTIONAL,
    externalTemperature Temperature OPTIONAL,
    roadWorks RoadWorksContainerExtended OPTIONAL,
    positioningSolution PositioningSolutionType OPTIONAL,
    stationaryVehicle StationaryVehicleContainer OPTIONAL,
    ...
}

defaultValidity INTEGER ::= 600

Termination ::= ENUMERATED {isCancellation(0), isNegation(1)}

ReferenceDenms ::= SEQUENCE (SIZE(1..8, ...)) OF ActionID

END
```

Annex B (normative): Description for data elements and data frames

B.1 header

Description	<p>The ITS PDU header of a DENM. This DF includes the protocol version of the DENM <i>protocolVersion</i>, DENM message type identifier <i>messageID</i> and station identifier <i>stationID</i> of the originating ITS-S or ITS-S that optionally forwards the DENM.</p> <p>The DE <i>protocolVersion</i> is used to select the appropriate protocol decoder at the receiving ITS-S.</p>
Data setting and presentation requirements	<p>For the present standard, the value of the DE <i>protocolVersion</i> shall be set to 2, the DE <i>messageID</i> shall be set to 1.</p> <p>For the originating ITS-S, the <i>stationID</i> shall be set to the station ID of the originating ITS-S.</p> <p>For the forwarding ITS-S, the <i>stationID</i> shall be set to the station ID of the forwarding ITS-S, if the DENM is forwarded.</p> <p>This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>ItsPduHeader</i>.</p>

B.2 denm

Description	DENM payload. It includes the mandatory container <i>management</i> container and optional containers <i>situation</i> container, <i>location</i> container and <i>alacarte</i> container.
Data setting and presentation requirements	This DF shall be presented as specified in Annex A.

B.3 management

Description	Management container of a DENM as described in clause 7.1.3. It contains information required for the DENM protocol processing.
Data setting and presentation requirements	This DF shall be presented as specified in Annex A.

B.4 situation

Description	Situation container of a DENM as described in clause 7.1.4. It contains information of the event type and event detection quality.
Data setting and presentation requirements	<p>This DF is optional. It shall not be present in cancellation DENM and negation DENM.</p> <p>This DF shall be presented as specified in Annex A.</p>

B.5 location

Description	Location container of a DENM as described in clause 7.1.5. It contains information of the location referencing.
Data setting and presentation requirements	This DF is optional. It shall not be present in cancellation DENM and negation DENM. This DF shall be presented as specified in Annex A.

B.6 alacarte

Description	A la carte container of a DENM as described in clause 7.1.6. It contains use case specific information that has not been provided in other DENM containers.
Data setting and presentation requirements	This DF is optional. It shall not be present in cancellation DENM and negation DENM. It shall be present in a new DENM or update DENM, if the information is required by the ITS application. This DF shall be presented as specified in Annex A.

B.7 actionID

Description	Identifier generated by the DEN basic service for new DENM. The <i>actionID</i> differs from the <i>actionIDs</i> generated by other ITS-Ss and from the <i>actionIDs</i> generated by the same ITS-S for other detected events. It is used by a receiving ITS-S to process information for DENMs that are multiply received. The <i>actionID</i> is maintained by the originating ITS-S.
Data setting and presentation requirements	The data setting rules of <i>actionID</i> are as specified in clause 8.2.1.2. This DF is composed of an ITS-S identifier and a sequence number. The ITS-S ID describes the station ID of the originating ITS-S that generates a new DENM. The sequence number is set each time a new DENM is created. It is used to differentiate from events detected by the same ITS-S. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>ActionID</i> .

B.8 carryingDangerousGoods

Description	DF included in the <i>stationaryVehicle</i> DF in the <i>alacarte</i> container if a vehicle carrying dangerous goods is involved in a stationary vehicle event. It provides information on the type of dangerous goods, the required emergency action and other information. This DF is included in <i>stationaryVehicle</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when the information is required by the ITS application. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>DangerousGoodsExtended</i> .

B.9 closedLanes

Description	This DF indicates whether the roadwork has caused the closure of one or several driving lanes. Optionally, the DF may indicate whether a hard shoulder lane is closed to traffic or may be used for specific usage (e.g. for stopping). This DF is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when the information is required by the ITS application. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>ClosedLanes</i> .

B.10 defaultValidity

Description	Default value for DENM validity duration used for DENM protocol operation, as specified in clause 8.2.1.5.
Data setting and presentation requirements	This DE shall be presented as specified in Annex A.

B.11 detectionTime

Description	Time at which the event is detected by the originating ITS-S. For the DENM repetition, this DE shall remain unchanged. For the DENM update, this DE shall be the time at which the event update is detected. For the DENM termination, this DE shall be the time at which the termination of the event is detected.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>Timestamppls</i> .

B.12 energyStorageType

Description	This DE provides the vehicle energy storage type information of the stationary vehicle as specified in ETSI TS 101 539-1 [i.4], such as electric, diesel, etc. This DE is included in <i>stationaryVehicle</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DE is OPTIONAL. It shall be present when the information is required by the ITS application. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>EnergyStorageType</i> .

B.13 eventHistory

Description	<p>The DF consists of a list of event points which represents the dimension of a plain event in a predefined order. In case that the plain event is detected by a vehicle ITS-S, the DF consists of a list of event detection points along the path that the detecting ITS-S has travelled over some past time and/or distance. Each event point corresponds to a point at which the same event was detected along the path.</p> <p>In the present document up to 40 <i>EventPoint</i> may be added in this DF. The generation of each <i>EventPoint</i> is specified in the related ITS application requirements.</p>
Data setting and presentation requirements	<p>The <i>EventPoint</i> closest to the current detected event point with respect to the <i>detectionTime</i> or <i>eventPosition</i> shall be put as the first point. It represents an offset delta position and optionally an offset delta detection time with regards to the current detected event point. The delta detection time may not be present, in case the detecting plain event is pre-defined by the detecting ITS-S, e.g. a roadwork zone covering a certain distance along the road.</p> <p>Other event points shall be structured in ascending order according to the <i>detectionTime</i> or <i>eventPosition</i>. Each event point represents an offset delta position with respect to the previous <i>EventPoint</i>.</p> <p>This DF is OPTIONAL, it shall be present if required by the ITS application.</p> <p>This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>EventHistory</i>.</p>

B.14 eventPosition

Description	<p>Geographical position of the detected event.</p> <p>The position of an event is determined by the originating ITS-S.</p>
Data setting and presentation requirements	<p>When the event position corresponds to the position of a vehicle ITS-S, the <i>eventPosition</i> shall be set to the position of the vehicle ITS-S at <i>detectionTime</i>.</p> <p>This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>ReferencePosition</i>.</p>

B.15 eventPositionHeading

Description	<p>The heading direction of the event and the confidence of the heading information, if applicable.</p> <p>If not specified elsewhere, 95 % confidence interval shall apply to this DF. An ITS application may require specific confidence interval.</p>
Data setting and presentation requirements	<p>This DF is OPTIONAL. It shall be present when this information is required by the ITS application.</p> <p>This DF shall be as presented as specified in ETSI TS 102 894-2 [5] <i>Heading</i>.</p>

B.16 eventSpeed

Description	Moving speed of a detected event and the confidence of the moving speed information. If not specified elsewhere, 95 % confidence interval shall apply to this DF. An ITS application may require specific confidence interval.
Data setting and presentation requirements	When the <i>eventPosition</i> corresponds to the position of a vehicle ITS-S, the <i>eventSpeed</i> shall be set to the vehicle speed at <i>detectionTime</i> . This DF is OPTIONAL. It shall be present if this information is required by the ITS application. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>Speed</i> .

B.17 eventType

Description	Description for the event type, including direct cause and sub cause. The assignment of the event cause codes is based on TISA TAWG11071 [i.10] and the specification in Table 10 in clause 7.1.4 of the present document.
Data setting and presentation requirements	This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>CauseCode</i> .

B.18 externalTemperature

Description	Information included in the <i>alacarte</i> container for the adverse weather condition use case as specified in ETSI TS 101 539-1 [i.4]. It indicates the ambient temperature at the event position.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>Temperature</i> .

B.19 heightLonCarrLeft

Description	Height of left longitudinal carrier of the vehicle from base to top. The left carrier refers to the left side seen from vehicle rear to vehicle front. This DE is included in the <i>impactReduction</i> DF.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>HeightLonCarr</i> .

B.20 heightLonCarrRight

Description	Height of right longitudinal carrier of the vehicle from base to top. The right carrier refers to the right side seen from vehicle rear to vehicle front. This DE is included in the <i>impactReduction</i> DF.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>HeightLonCarr</i> .

B.21 impactReduction

Description	DF included in the <i>alacarte</i> container of DENM to support the pre-crash use case. It contains the vehicle detailed information required for mitigating the consequences of a collision.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when this information is required by the ITS application. This DF shall be presented as specified in Annex A.

B.22 incidentIndication

Description	This DF indicates the incident related to the roadworks to provide additional information of the roadworks zone. This DF is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when the information is required by the ITS application. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>CauseCode</i> .

B.23 informationQuality

Description	Quality level of the information provided by the ITS-S application of the originating ITS-S. It indicates the probability of the detected event being truly existent at the event position.
Data setting and presentation requirements	This DE is set according to the ITS application requirements. If the information is unknown, the DE shall be set to 0. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>InformationQuality</i> .

B.24 lanePosition

Description	The lane position of the event position in the road counted from the outside boarder of the road. This DE is included in the <i>alacarte</i> container. If this data is provided, the originating ITS-S is required to determine the lane position with a predefined confidence level as defined by the ITS applications (e.g. 95 %).
Data setting and presentation requirements	This DE is OPTIONAL. It shall be present when this information is required by the ITS application. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>LanePosition</i> .

B.25 lightBarSirenInUse

Description	<p>This DE indicates whether a roadwork vehicle has switched on the light bar or siren.</p> <p>This DE is included in <i>roadWorks</i> DF in the <i>alacarte</i> container. It is used when the roadwork involves a specific roadwork vehicle.</p>
Data setting and presentation requirements	<p>This DE is OPTIONAL. It shall be present when this information is required by the ITS application.</p> <p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>LightBarSirenInUse</i>.</p>

B.26 linkedCause

Description	<p>Description for a linked event of the provided <i>eventType</i>, including direct cause and sub cause of the linked event.</p> <p>The assignment of the <i>linkedCause</i> is based on TISA TAWG11071 [i.10] and the specification in Table 10 in clause 7.1.4 of the present document.</p>
Data setting and presentation requirements	<p>This DF is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S.</p> <p>This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>CauseCode</i>.</p>

B.27 numberOfOccupants

Description	<p>This DE provides the estimated number of occupants involved in the stationary vehicle event as specified in ETSI TS 101 539-1 [i.4].</p> <p>This DE is included in <i>stationaryVehicle</i> DF in the <i>alacarte</i> container.</p>
Data setting and presentation requirements	<p>This DE is OPTIONAL, it shall be present when the information is required by the ITS application.</p> <p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>NumberOfOccupants</i>.</p>

B.28 posCentMass

Description	<p>Perpendicular distance from centre of mass of an empty charged vehicle to vehicle front bumper.</p> <p>This DE is included in the <i>impactReduction</i> DF.</p>
Data setting and presentation requirements	<p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>PosCentMass</i>.</p>

B.29 posFrontAx

Description	Perpendicular distance between the front wheel axle and front bumper. This DE is included in the <i>impactReduction</i> DF.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>PosFrontAx</i> .

B.30 positioningSolution

Description	This DE indicates technical solution being used by the originating ITS-S to estimate the event position. Typically, this DE may be included for events that are caused by vehicle ITS-S. This DE is included in the <i>alacarte</i> container.
Data setting and presentation requirements	This DE is OPTIONAL, it shall be present when the information is required by the ITS application. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>PositioningSolutionType</i> .

B.31 positionOfOccupants

Description	This DF indicates whether a in vehicle seat is occupied at the moment when the <i>impactReduction</i> is generated. The in vehicle seats layout is defined in rows from the front to the rear of the vehicle. The left seat of a row refers to the left side with regards to the vehicle heading direction. This DE is included in the <i>impactReduction</i> container.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>PositionOfOccupants</i> .

B.32 positionOfPillars

Description	The <i>positionOfPillars</i> contains a list of distance, which refers to the perpendicular distance between centre of vehicle front bumper to vehicle A pillar, between neighbour vehicle pillars until the last pillar of the vehicle. This DF is included in the <i>impactReduction</i> DF. This DF is defined for passenger vehicles only.
Data setting and presentation requirements	This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>PositionOfPillars</i> . Each pilliar distance shall be presented as specified in ETSI TS 102 894-2 [5] <i>PosPillar</i> .

B.33 posLonCarrLeft

Description	Distance from the centre of vehicle front bumper to the front of the left longitudinal carrier of vehicle. The left carrier refers to the left seen from vehicle rear to vehicle front. This DE is included in the <i>impactReduction</i> DF.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>PosLonCarr</i> .

B.34 posLonCarrRight

Description	Longitudinal distance from the centre of vehicle front bumper to the front of right longitudinal carrier of vehicle. The right carrier refers to the right side seen from vehicle rear to vehicle front. This DE is included in the <i>impactReduction</i> DF.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>PosLonCarr</i> .

B.35 recommendedPath

Description	This DF indicates the recommended itinerary in order to contour the roadworks zone. A recommended path is presented with a list of path points in the order from the starting point closest to the roadworks zone to the end point of the recommended path. This DF is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when the information is required by the ITS application. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>ItineraryPath</i> .

B.36 referenceDenms

Description	The DF indicates is a sequence of <i>actionIDs</i> for different DENMs that describe the same event. If it is available it is part of all DENMs describing this event. This DF is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present if required by the ITS application. This DF consists of list of other DENMs describing the same road work event. Each DENM shall be presented as specified in ETSI TS 102 894-2 [5] <i>ActionID</i> .

B.37 referenceTime

Description	This DE refers to the time at which a new DENM, an update DENM or a cancellation DENM is generated. This DE is maintained by the DEN basic service of the originating ITS-S.
Data setting and presentation requirements	The <i>referenceTime</i> is maintained by the originating ITS-S, the data setting rules are as specified in clause 8.2.1.3. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>TimestampPlts</i> .

B.38 relevanceDistance

Description	The distance in which event information is relevant for the receiving ITS-S, starting from the event position as defined in clause 6.1.3.1.
Data setting and presentation requirements	This DE is OPTIONAL. It shall be present when the information is required by the ITS application. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>RelevanceDistance</i> .

B.39 relevanceTrafficDirection

Description	The traffic direction along which the event information is relevant for the receiving ITS-S, as defined in clause 6.1.3.1.
Data setting and presentation requirements	This DE is OPTIONAL. It shall be present when the information is required by the ITS application. This DE shall be as presented as specified in ETSI TS 102 894-2 [5] <i>RelevanceTrafficDirection</i> .

B.40 requestResponseIndication

Description	This DE is included in <i>impactReduction</i> DF in the <i>alacarte</i> container. It indicates whether the originating ITS-S transmitting the <i>impactReduction</i> DF is requesting the receiving ITS-S to provide also its <i>impactReduction</i> DF. On reception of a DENM with this DE set to 0, the receiving ITS-S may in turn transmit a DENM with its <i>impactReduction</i> DF as response to the request.
Data setting and presentation requirements	In request case, this DE shall be set to 0. In response case, this DE shall be set to 1. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>RequestResponseIndication</i> .

B.41 restriction

Description	This DF indicates the types of vehicles that are restricted to access the road work zone. More than one vehicle types may be provided by this DF if the restriction apply to multiple vehicle types. This DF is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when the information is required by the ITS application. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>RestrictedTypes</i> .

B.42 roadType

Description	The road type information at the event position.
Data setting and presentation requirements	This DE is OPTIONAL. It shall be present when this information is required by the ITS application. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>RoadType</i> .

B.43 roadWorks

Description	DF included in the <i>alacarte</i> container for the road work use case as specified in ETSI TS 101 539-1 [i.4]. It includes information of the road work zone and specific access conditions.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when this information is required by the ITS application. This DF shall be presented as specified in Annex A.

B.44 speedLimit

Description	This DE indicates the speed limitation applied to the roadwork zone. This DE is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DE is OPTIONAL. It shall be present when the information is required by the ITS application. This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>SpeedLimit</i> .

B.45 startingPointSpeedLimit

Description	<p>The DF indicates the effective starting position of a speed limit being applied to the roadwork zone. Generally speaking, the speed limit applies a certain distance prior to the roadwork zone starting position. It is described as a delta position with regards to the <i>eventPosition</i> for a DENM.</p> <p>This DF is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.</p>
Data setting and presentation requirements	<p>This DF is OPTIONAL. It shall be present if required by the ITS application.</p> <p>This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>DeltaReferencePosition</i>.</p>

B.46 stationaryCause

Description	<p>This DE provides additional information to describe causes of the stationary vehicle event such as human problem as defined in ETSI TS 101 539-1 [i.4].</p> <p>This DE is included in <i>stationaryVehicle</i> DF in the <i>alacarte</i> container.</p>
Data setting and presentation requirements	<p>This DE is OPTIONAL. It shall be present when the information is required by the ITS application.</p> <p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>CauseCode</i>.</p>

B.47 stationarySince

Description	<p>This DE provides the time duration of the stationary vehicle being stationary.</p> <p>This DE is included in <i>stationaryVehicle</i> DF in the <i>alacarte</i> container.</p>
Data setting and presentation requirements	<p>This DE is OPTIONAL. It shall be present when the information is required by the ITS application.</p> <p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>StationarySince</i>.</p>

B.48 stationaryVehicle

Description	<p>DF included in the <i>alacarte</i> container for the stationary vehicle use case as specified in ETSI TS 101 539-1 [i.4]. It provides information of the stationary vehicle.</p>
Data setting and presentation requirements	<p>This DF is OPTIONAL. It shall be present when the information is required by the ITS application.</p> <p>This DF shall be presented as specified in Annex A.</p>

B.49 stationType

Description	<p>This DE provides the station type information of the originating ITS-S.</p>
Data setting and presentation requirements	<p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>StationType</i>.</p>

B.50 termination

Description	<p>This DE indicates if the type of generated DENM is a cancellation DENM or a negation DENM.</p> <p>The <i>termination</i> is maintained by the originating ITS-S.</p>
Data setting and presentation requirements	<p>This DE is OPTIONAL. It shall be present if the generated DENM is a cancellation DENM or negation DENM.</p> <p>The data setting rules of this DE is as specified in clause 8.2.1.4.</p> <p>This DE shall be presented as specified in Annex A.</p>

B.51 traces

Description	<p>This DF is the location referencing information of <i>eventPosition</i>. It includes a group of traces as defined in clause 6.1.3.2.</p> <p>Each trace describes a set of consecutive <i>PathPoint</i> positions leading to the event position.</p> <p>ITS-Ss located near to or inside this trace path may be concerned by the event. Multiple traces may be defined in case multiple road sections or traffic flows are leading to the event position. In the present standards, up to seven traces may be added in a DENM.</p> <p>For each trace, multiple <i>PathPoint</i> positions are provided to describe the trace path.</p>
Data setting and presentation requirements	<p>Within one trace, the <i>PathPoint</i> closest to the event position shall be put as the first waypoint, it presents an offset delta position with regards to the <i>eventPosition</i>. Other <i>PathPoints</i> shall be structured in ascending order according to the distance to the <i>eventPosition</i> along the trace path. Each <i>PathPoint</i> presents an offset delta position and optionally an offset travel time with regards to the previous <i>PathPoint</i>.</p> <p>The DE <i>PathDeltaTime</i> as defined in <i>PathPoint</i> in ETSI TS 102 894-2 [5] is OPTIONAL, it shall be present if the information is required by the ITS application.</p> <p>When the event position corresponds to the position of a vehicle ITS-S, the first trace in the DF shall be the <i>PathHistory</i> of the vehicle as defined in the CA basic service ETSI EN 302 637-2 [7].</p> <p>The <i>traces</i> shall be presented as specified as in ETSI TS 102 894-2 [5] <i>Traces</i>.</p> <p>Each trace shall be presented as specified in ETSI TS 102 894-2 [5] <i>PathHistory</i>.</p>

B.52 trafficFlowRule

Description	<p>The DE indicates the side of the road to which the traffic should flow around a roadwork. The traffic could flow to the left or to the right of the roadwork.</p> <p>This DE is included in <i>roadWorks</i> DF in the <i>alacarte</i> container.</p>
Data setting and presentation requirements	<p>This DE is OPTIONAL. It shall be present if required by the ITS application.</p> <p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>TrafficRule</i>.</p>

B.53 transmissionInterval

Description	<p>Time interval for DENM transmission as defined by the originating ITS-S.</p> <p>This DE informs the receiving ITS-Ss about the intended transmission interval of two consecutive DENM transmissions. It is used for the forwarding ITS-S operation.</p>
Data setting and presentation requirements	<p>This DE is optional. If the ITS-S application of the originating ITS-S does not provide this information to the DEN basic service, the DE shall not be included in DENM. In this case, the DENM shall not be forwarded by the forwarding ITS-S.</p> <p>This DE shall be presented as specified ETSI TS 102 894-2 [5] <i>TransmissionInterval</i>.</p>

B.54 turningRadius

Description	<p>The turning radius of a vehicle is the size of the smallest circular turn (i.e. U-turn) that the vehicle is capable of making.</p> <p>This DE is included in the <i>impactReduction</i> DF in the <i>alacarte</i> container.</p> <p>When a trailer is present, this DE shall provide the turning radius of the vehicle.</p>
Data setting and presentation requirements	<p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>TurningRadius</i>.</p>

B.55 validityDuration

Description	<p>Validity duration of a DENM.</p> <p>The <i>validityDuration</i> is set by the originating ITS-S. Therefore it represents an estimation of how long the event may persist. It implies the duration over which the DENM should be kept at the DEN basic service of the receiving ITS-S and the DENM dissemination be maintained in the relevance area or destination area, until the expiration of <i>validityDuration</i>.</p> <p>In case the expiry time of the event cannot be estimated at the originating ITS-S, a default value is used for the DENM protocol operation.</p> <p>This DE may be renewed by the originating ITS-S, if the pre-set expiry time has reached to its limit and the originating ITS-S detects that the event persists.</p>
Data setting and presentation requirements	<p>The DE is represented as a time offset in the unit of second since <i>detectionTime</i>.</p> <p>This DE is optional. It shall be present if the information is required by the ITS application. If the DE is not present in DENM, a default value <i>defaultValidity</i> is assumed.</p> <p>This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>ValidityDuration</i>.</p>

B.56 vehicleIdentification

Description	This DF provides the vehicle identification of the stationary vehicle as specified in ETSI TS 101 539-1 [i.4], including the World Manufacturer Identifier (WMI) code and the Vehicle Descriptor Section (VDS) as defined in ISO 3779 [i.15]. This DF is included in <i>stationaryVehicle</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DF is OPTIONAL. It shall be present when the information is required by the ITS application. This DF shall be presented as specified in ETSI TS 102 894-2 [5] <i>VehicleIdentification</i> .

B.57 vehicleMass

Description	This DE indicates the mass of an empty load vehicle. This DE is included in the <i>impactReduction</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>VehicleMass</i> .

B.58 wheelBaseVehicle

Description	Perpendicular distance between front and rear axle of the wheel base of a passenger vehicle. This DE is included in the <i>impactReduction</i> DF in the <i>alacarte</i> container.
Data setting and presentation requirements	This DE shall be presented as specified in ETSI TS 102 894-2 [5] <i>WheelBaseVehicle</i> .

Annex C (informative): Bibliography

- ISO 17572-3 (2008): "Intelligent transport systems (ITS) -- Location referencing for geographic databases".
- SAE J2266: "Location Referencing Message Specification (LRMS)".
- European FP7 project PRE-DRIVE C2X: "Detailed description of selected applications and corresponding technical requirements", Deliverable D 4.1.
- ETSI TS 102 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".
- ISO/DTS 18234-6: "Intelligent transport systems -- Traffic and Travel Information (TTI) -- TTI via Transport Protocol Expert Group (TPEG) data-streams -- Part 6: Location referencing applications".

History

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