



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

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Foreword

This draft European Standard (EN) has been produced by ETSI Technical Committee Intelligent Transport System (ITS), and is now submitted for the Public Enquiry phase of the ETSI standards EN Approval Procedure.

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

Part 1: "Functional Requirements";

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

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

The specification of the DEN basic service was initially developed by the European Car-to-Car Communication Consortium (C2C-CC) [i.2] and [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, SCOR@F, simTD, etc. These evaluation efforts have provided feedback to ETSI TC ITS.

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

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
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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) [i.1] that can be deployed within a three-year time frame after the completion of their standardization. In this BSA, the Road Hazard Warning (RHW) application is composed of multiple use cases. ETSI TC ITS defines the decentralized environmental notification (DEN) basic service that supports the various RHW use cases.

The 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 application. The 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 direct vehicle-to-vehicle or vehicle-to-infrastructure communications. At the receiver side, the DEN basic service of an receiving ITS-S processes the received DENM and provides the DENM content to an ITS application. This ITS application may request to present the information to the driver if the 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 the specification of the DEN basic service, which is in support of e.g. the BSA road safety application.

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

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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

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

2.1 Normative references

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

- [1] SAE J2735 (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 (V0.0.5): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary".
- [6] ITU-T Recommendation X.691/ISO/IEC 8825-2 (1997-12): "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)".

2.2 Informative references

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

- [i.1] 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: <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); V2V Application; Part 1: Road Hazard Signally (RHS) application requirements specification".
- [i.5] ETSI TS 101 539-2: "Intelligent Transport Systems (ITS); V2V Application; Part 2: Intersection Collision Risk Warning (ICRW) Application Specification".
- [i.6] ETSI TS 101 539-3: "Intelligent Transport Systems (ITS); V2V Application; Part 3: Longitudinal Collision Risk Warning (LCRW) Application Specification".
- [i.7] ETSI TR 102 863: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Local Dynamic Map (LDM); Rationale for and guidance on standardization".
- [i.8] ETSI EN 302 636-4-1: "Intelligent Transport System (ITS); Vehicular communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent 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 102 723-9: "Intelligent Transport Systems; OSI cross-layer topics; Part 9: Interface between security entity and facilities layer".
- [i.14] ETSI TS 102 723-11: "Intelligent Transport Systems; OSI cross-layer topics; Part 11: Interface between network and transport layers 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 2: Specification of Decentralized Environmental Notification Basic Service".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purpose of the present document, the terms and definitions given in SAE J2735 [1], EN 302 665 [2], TR 102 863 [i.7] and the following apply:

actionID: identifier of an detected event by an ITS station

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

NOTE: The BSA is defined in [i.1].

cancellation DENM: DEN message type sent by the ITS-S which originated the new DENM to indicate termination of the event

communication support: subset of facilities, providing support for communications

DEN basic service: facility at the facilities layer to support ITS applications, DENM management and DENM dissemination

DENM: ITS facilities layer PDU providing event information

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 specified in [4].

event: road hazard, driving environment, or traffic condition

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

negation DENM: DEN message type sent by any of the ITS-S not origin of the new DENM to indicate event termination

new DENM: DEN message type sent by any originator ITS-S that detects first occurrence of an event

originator ITS station: ITS station that generates the DENM and implements the DENM protocol of the ITS-S

forwarder ITS station: ITS station that forwards the DENM and implements the DENM protocol of the ITS-S

receiver ITS station: ITS station that receives the DENM from the ITS networking&transport layer and implements the DENM protocol of the ITS-S

reference position: geographical position that is represented with geographical coordinates

relevance area: area in which ITS stations are concerned by an event

update DENM: DEN message type sent by the ITS-S which originated the new DENM to indicate the evolution of the event

3.2 Symbols

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

actionID	Parameter that identifies an event 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 a DENM for an update of the event
appDENM_termination	Application request type to generate a DENM for a termination of the event
detectionTime	Timestamp at which an event or event update/termination is detected
referenceTime	Timestamp at which a DENM is generated by the DEN basic service
IF.DEN1	Interface between DEN basic service and ITS application for DENM transmission
IF.DEN2	Interface between DEN basic service and ITS application for DENM reception
IF.Mng	Interface between DEN basic service and ITS management entity
IF.N&T	Interface between DEN basic service and ITS networking & transport layer
IF.SEC	Interface between DEN basic service and ITS security entity
isNegation	Parameter that indicates the termination of an event
repetitionDuration	Duration of the DENM repetition
T_F_VValidity	Timer that indicates the end of the DENM processing of one specific <i>actionID</i> of the forwarder ITS-S
T_Forwarding	Timer for the scheduling of the DENM forwarding by the forwarder ITS-S
T_O_VValidity	Timer that indicates the end of the DENM processing of one specific <i>actionID</i> of the originator ITS-S
T_R_VValidity	Timer that indicates the end of the DENM processing of one specific <i>actionID</i> of the receiver ITS-S
T_Repetition	Timer for the scheduling of the DENM repetition by the originator ITS-S
ValidityDuration	Duration of the DENM validity

3.3 Abbreviations

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

ABS	Anti-lock braking system
AEB	Automatic Emergency Braking
API	Application Programming Interface
ASN	Abstract Syntax Notation
ASN.1	Abstract Syntax Notation One
BSA	Basic Set of Applications
BTP	Basic Transport Protocol
C2C-CC	Car to Car Communication Consortium
CAN	Controller Area Network
CR	Change Request
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
DSRC	Dedicated Short Range Communications
ESP	Electronic Stability Program
FA-SAP	Facilities-Application Service Access Point
HMI	Human Machine Interface
ISO	International Standardization Organization
ITS	Intelligent Transport System
ITS-S	ITS station
KAF	Keep alive forwarding
LDM	Local Dynamic Map
MF-SAP	Management Facilities Service Access Point
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
TEC	Traffic Event Compact
TPEG	Transport Protocol Experts Group
TS	Technical Specification
TTI	Traffic and Travel Information
UTC	Coordinated Universal Time
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 the ITS applications in order to alert road users of a detected event using the ITS communication technologies. A DENM contains information related to a variety of events that can be detected by ITS stations (ITS-S). A set of ITS applications are specified in [i.4], [i.5], [i.6], which includes multiple ITS use cases. It is expected that further use cases will be added in the future.

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 the event to other ITS-Ss located inside an area of relevance. The ITS-S that transmits DENM is denoted as originator ITS-S.
- The DENM transmission is initiated and terminated by the ITS application layer. Examples are provided in [i.4], [i.5] and [i.6].
- The transmission of a DENM may be repeated.
- The DENM transmission may persist as long as the event is present.
- An ITS-S may forward a DENM. This ITS-S is denoted as forwarder ITS-S.
- The termination of the DENM transmission is either automatically achieved once the event disappears after a predefined expiry time, or by an ITS-S that generates a special DENM to inform that the event has disappeared.
- An ITS-S, which receives a DENM, processes the information and may decide to present an appropriate warning or information to the user, as long as the information in the DENM is relevant to the ITS-S. This ITS-S is denoted as receiver ITS-S.

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

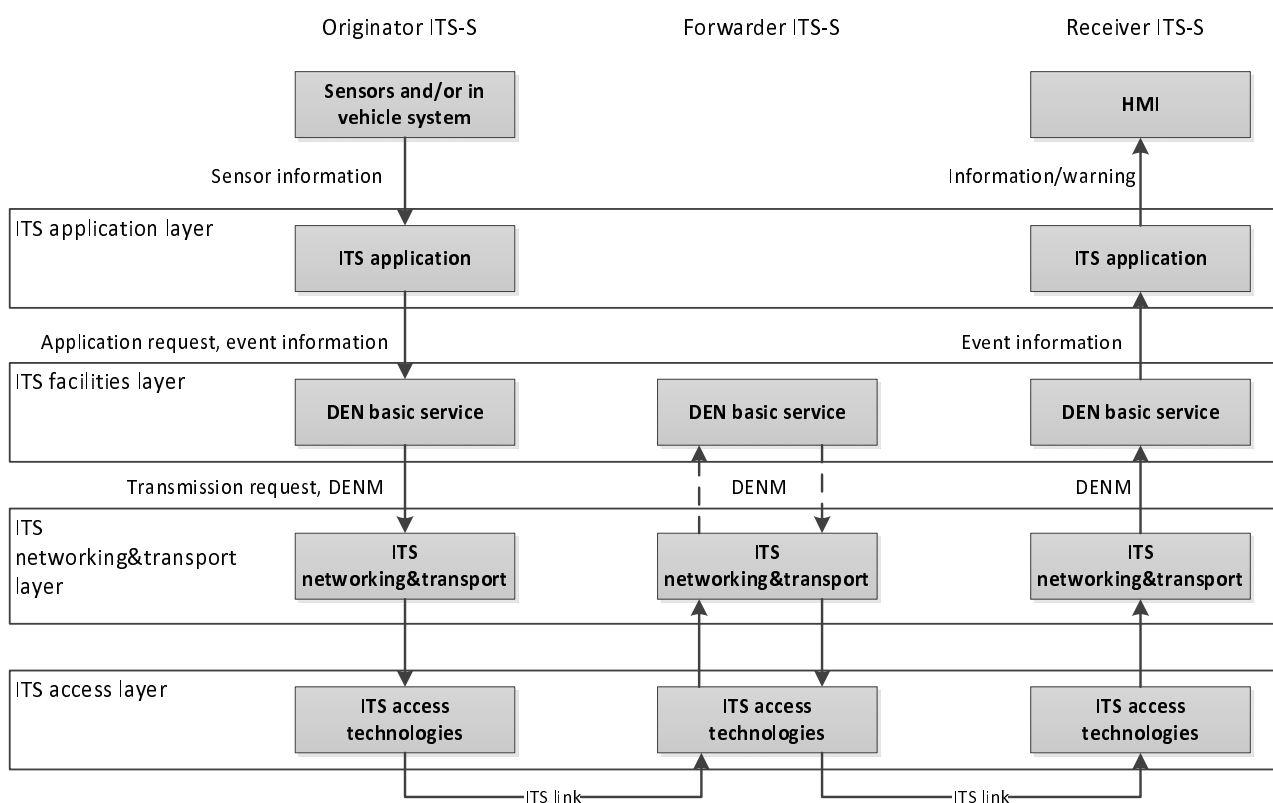


Figure 1: General data flow for ITS-S application supported by the DEN basic service

The solid lines illustrate the dataflow that is mandatory for all ITS applications supported by the DEN basic service. 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 the DENM from the originator ITS-S to the receiver ITS-S, if the receiver ITS-S is not located in the direct communication range of the originator 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 originator ITS-S has lost the capability to repeat the DENM. This optional facilities layer forwarding functionality is illustrated as a dotted line in Figure 1. Its protocol operation is specified in Clause 8.2.

4.2 Services provided by the DEN basic service

The Decentralized Environmental Notification (DEN) basic service is a facilities layer entity that operates the DENM protocol. It provides services to entities at the ITS applications layer. At the originator ITS-S, it triggers, updates and terminates the transmission of DENM. At the receiver ITS-S, the DEN basic service processes the received DENM and makes the information available for usage at ITS applications. Optionally, the DEN basic service may also provide forwarding functionalities.

The DEN basic service uses the services provided by the protocol entities of the ITS networking & transport layer to disseminate the DENM. Typically, for road safety ITS applications as specified in [i.4], [i.5], [i.6], the destination of a DENM transmission are ITS-Ss that are located in a pre-defined geographic area close to the detected event position. 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.

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 originator ITS-S transmits a DENM of an event caused by the ITS-S itself, such as electronic brake light event. The originator ITS-S manages the transmission and the termination of the DENM for this event. However, in some other situations, a DENM related to the same event may be transmitted by more than one originator ITS-Ss. An event may persist even after the originator ITS-S has passed by the event position. For example, multiple vehicle ITS-Ss may detect a black ice on the road surface and transmit DENM. 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 originator ITS-S. The DENM protocol is designed to manage such situations.

The following DENM types are defined:

- **New DENM:** A DENM generated by the DEN basic service when an event is detected by an originator ITS-S for the first time. This new DENM is assigned with a new identifier, denoted as *actionID*. A new DENM provides the event attributes, such as event position, event type, event detection time, etc.
- **Update DENM:** A DENM generated by the DEN basic service that includes the update information of a detected event. The update DENM is transmitted by the same originator ITS-S, which had generated the new DENM.
- **Cancellation DENM:** A DENM that informs the termination of an event. The cancellation DENM is transmitted by the same originator ITS-S which has generated the new DENM.
- **Negation DENM:** A DENM that informs the termination of the event which has been detected for the first time by another ITS-S than the originator ITS-S. The negation DENM is able to announce the termination of the event if the originator ITS-S which had generated the new DENM has lost the capacity to terminate the event by itself.

The DEN basic service of the originator ITS-S shall be able to construct the above DENMs types. ITS application of the originator ITS-S shall pass an application request to the DEN basic service in order to trigger the generation of all types of DENM. The type of the DENM to be constructed depends on the type of the application request sent from the ITS application to the DEN basic service.

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

5 DEN basic service functional description

5.1 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 applications in order to receive the application request for the DENM transmission and to provide the received DENM content to the ITS applications layer. Furthermore, the DEN basic service may interact with other facilities layer entities, in particular the Local Dynamic Map (LDM) as defined in [i.7], which is a facilities layer database for the management of higher layer data in the ITS-S. At the receiver ITS-S, the LDM may be updated with a received DENM and ITS 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 [2] as well as its logical interfaces with other entities and layers.

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

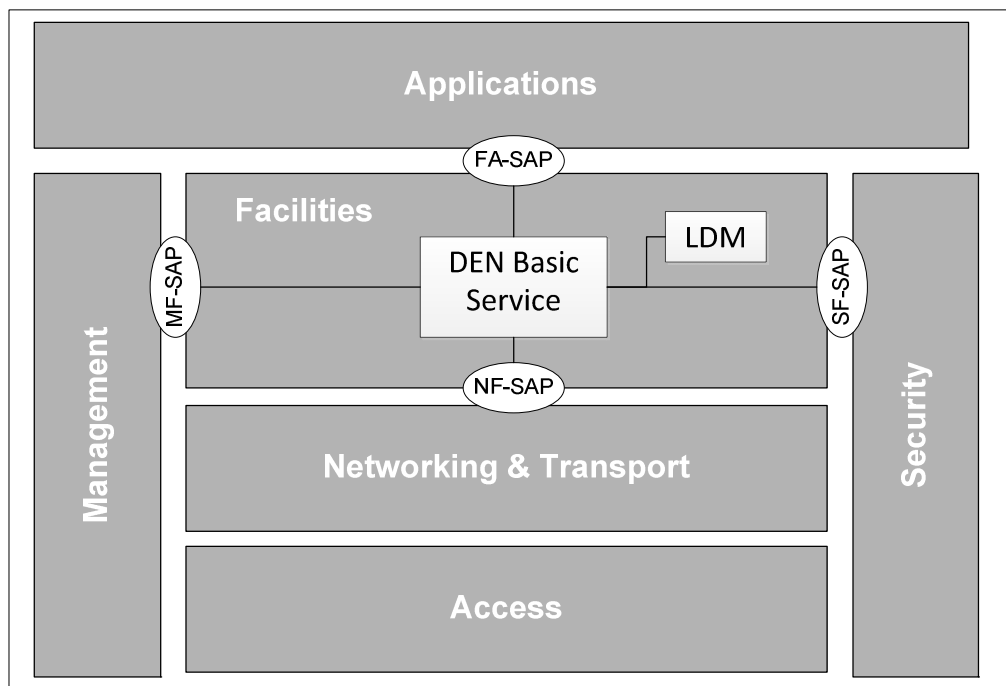


Figure 2: DEN basic service and logical interfaces

5.2 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 the received DENM.

- DENM transmission management:
 - This sub-function implements the DENM protocol operation of the originator ITS-S as specified in Clause 8.1, including in particular:
 - The generation of a new DENM as requested by the ITS applications at the originator ITS-S.
 - The generation of an update DENM as requested by the ITS applications at the originator ITS-S.
 - The termination of the DENM transmission as requested by the ITS applications at the originator ITS-S.
- NOTE: DENM termination refers to the generation of cancellation DENM or negation DENM as defined in Clause 4.2.
- The repetition of DENMs.
- DENM reception management:
 - This sub-function implements the DENM protocol operation of the receiver ITS-S as specified in Clause 8.3, including in particular:
 - The update of the receiver ITS-S message table.
 - The discarding of received invalid DENMs.
 - The provisioning of received DENM data to ITS applications and/or to other facilities layer entities of the receiver ITS-S.
 - DENM Keep Alive Forwarding (KAF):
 - This sub-function implements the DENM protocol operation of the forwarder ITS-S, as specified in Clause 8.2. It stores the received DENM during validity duration, and forwards it to the ITS-Ss located in the relevance area when applicable.
 - This sub-function is optional. The usage conditions of the KAF may either be defined by the ITS applications according to the application requirements or by a cross-layer functionality of the management entity. 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.

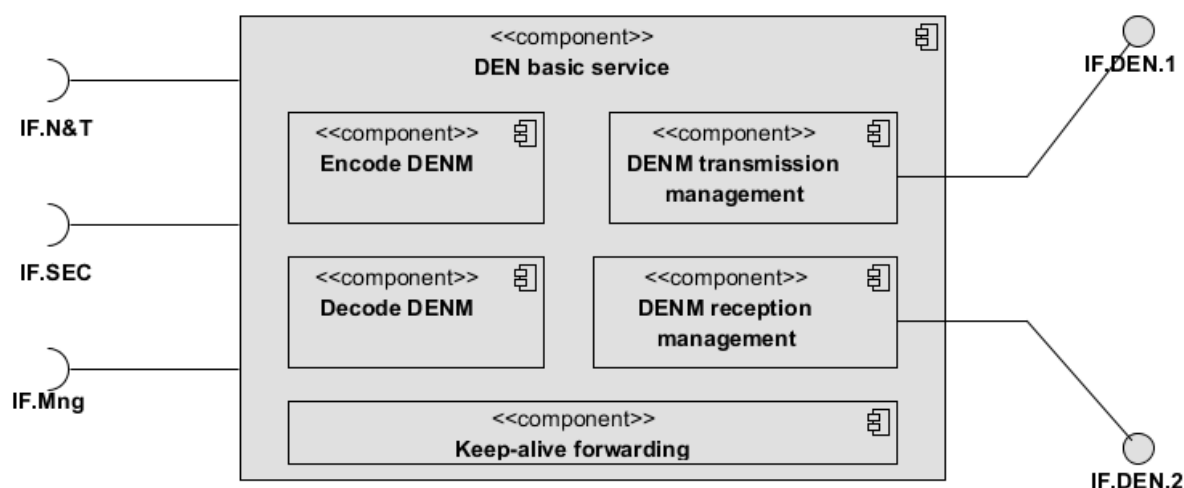


Figure 3: DEN basic service component diagram

5.3 Interfaces of the DEN basic service

5.3.1 Interfaces to the ITS applications

An ITS application is the ITS application layer entity that implements the application logic of one or more ITS use cases. It initiates the generation of all types of DENM as specified in Clause 4.2, according to pre-defined conditions as specified in [i.4], [i.5] and [i.6].

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

In another 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 originator ITS-S, the ITS application shall send a request to the DEN basic service to start the DENM transmission. Three types of application request are defined:

- *AppDENM_trigger*: The originator ITS-S detects a new event and triggers the transmission of a new DENM.
- *AppDENM_update*: The originator ITS-S detects the evolution of a detected event and requests the transmission of an update DENM to provide update information.
- *AppDENM_termination*: The originator ITS-S detects the termination of the 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 corresponding DENM of a specific type as defined in Clause 4.2 is generated and transmitted by the DEN basic service. A mapping between application request types and generated DENM types is illustrated in Table 1.

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 originator ITS-S has generated the new DENM or Negation DENM otherwise

The following clauses define the data being passed via the interfaces IF.DEN.1 and IF.DEN.2. Furthermore for the interface IF.DEN.1, the data being passed for each application request type is defined. For the sake of the presentation clearness, the data is categorized into the data passed from the ITS application to DEN basic service and the data returned from the DEN basic service to the ITS application.

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

For the application request type *AppDENM_trigger*, at least data specified in Table 2 shall be exchanged via the interface IF.DEN.1.

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

Category	Data	Data requirement	Mandatory/Optional
Data passed from application to DEN basic service	Event detection time	{ <i>DENM.denm.management.detectionTime</i> } as specified in Annex A.	Mandatory
	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, denoted as <i>RepetitionDuration</i> . It shall not be superior to the <i>validityDuration</i> .	Optional (see note 2)
	All information included in the situation container	{ <i>DENM.denm.situation</i> } as specified in Annex A.	Optional (see note 3)
	All information contained in the DENM location container	{ <i>DENM.denm.location</i> } as specified in Annex A.	Optional (see note 3)
	All information contained in the DENM alacarte container	{ <i>DENM.denm.alacarte</i> } as specified in Annex A.	Optional (see note 4)
	Relevance area of the event	{ <i>DENM.denm.management.relevanceDistance</i> } and { <i>DENM.denm.management.relevanceTrafficDirection</i> } as specified in Annex A.	Mandatory
	Traffic class of the DENM	GN traffic class as defined in [i.8], if GeoNetworking/BTP is used. (see note 5)	Mandatory
	Transmission interval for DENM repetition	In units of milliseconds.	Optional (see note 6)
	KAF request	Application request to DEN basic service to realize the Keep-Alive Forwarding for DENM.	Optional (see note 7)
Data returned from DEN basic service to the requesting application	actionID or other applicable identifier	{ <i>DENM.denm.management.actionID</i> } as specified in Annex A. The DEN basic service shall return the actionID or other applicable identifier created by the DEN basic service to the requesting ITS application. (see note 8)	Mandatory (see note 9)
	Failure notification	The DEN basic service shall return a failure notification to the requesting application under the condition as specified in Clause 8.	Optional (see note 10)
<p>NOTE 1: Applicable if the ITS application detects the event expiry time.</p> <p>NOTE 2: Applicable if the ITS application request the DENM repetition.</p> <p>NOTE 3: Application may request DEN basic service to collect data from other facilities.</p> <p>NOTE 4: Applicable if the ITS application request the transmission of alacarte container.</p> <p>NOTE 5: General definition of traffic class and mapping to specific protocol stack will be provided by the ETSI TC ITS.</p> <p>NOTE 6: Applicable if the ITS application requests the repetition of the DENM.</p> <p>NOTE 7: Applicable if the ITS application requests the FAF of the DENM.</p> <p>NOTE 8: 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 application and DEN basic service.</p> <p>NOTE 9: This data is passed from the DEN basic service to the ITS application.</p> <p>NOTE 10: Applicable as specified in Clause 8.</p>			

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

For the application request type *AppDENM_update*, at least data as specified in Table 3 shall be exchanged via the interface IF.DEN.1.

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

Category	Data	Data requirement	Mandatory/Optional
Data passed from application to DEN basic service	<i>actionID</i> or other applicable identifier for which the update is detected	{ <i>DENM.denm.management.actionID</i> } as specified in Annex A.	Mandatory
	Event update detection time	{ <i>DENM.denm.management.detectionTime</i> } as specified in Annex A.	Mandatory
	Event validity duration	{ <i>DENM.denm.management.validityDuration</i> } as specified in Annex A.	Optional (see note 1)
	Any information included in the situation container	{ <i>DENM.denm.situation</i> } as specified in Annex A.	Optional (see note 1)
	Any information contained in the DENM location container	{ <i>DENM.denm.location</i> } as specified in Annex A.	Optional (see note 1)
	Any information contained in the DENM alacarte container	{ <i>DENM.denm.alacarte</i> } as specified in Annex A.	Optional (see note 1)
	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 1)
	Traffic class of the DENM	GN traffic class as defined in [i.8], if GeoNetworking/BTP is used. (see note 2)	Optional (see note 1)
	Transmission interval for the DENM repetition	In units of milliseconds.	Optional (see note 1)
Data returned from DEN basic service to the requesting application	KAF request	Application request to DEN basic service to realize the Keep-Alive Forwarding for DENM.	Optional (see note 3)
	Failure notification	The DEN basic service shall return a failure notification to the requesting application under the condition as specified in Clause 8.	Optional (see note 4)

NOTE 1: Applicable if an update of the data is detected.
NOTE 2: General definition of traffic class and mapping to specific protocol stack will be provided by the ETSI TC ITS.
NOTE 3: Applicable if the ITS application requests the FAF of the DENM.
NOTE 4: Applicable as specified in Clause 8.

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

For the application request type *AppDENM_termination*, at least data as specified in Table 4 shall be exchanged via the interface IF.DEN.1.

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

Category	Data	Data requirement	Mandatory/Optional
Data passed from application to DEN basic service:	actionID or other applicable identifier for which the termination is detected	{ <i>DENM.denm.management.actionID</i> } as specified in Annex A.	Mandatory
	Event termination detection time	{ <i>DENM.denm.management.detectionTime</i> } as specified in the Annex A.	Mandatory
	DENM repetition duration	{ <i>DENM.denm.management.validityDuration</i> } as specified in Annex A.	Optional (see note 1)
	Traffic class of the DENM	GN traffic class as defined in [i.8], if GeoNetworking/BTP is used. (see note 2)	Mandatory
	Transmission interval for the DENM repetition	In units of milliseconds.	Optional (see note 1)
	KAF request	Application request to DEN basic service to realize the Keep-Alive Forwarding for DENM.	Optional (see note 3)
Data returned from DEN basic service to the requesting application	Failure notification	The DEN basic service shall return a failure notification to the requesting application under the condition as specified in Clause 8.	Optional (see note 4)
NOTE 1: Applicable if the application requests the DENM repetition.			
NOTE 2: General definition of traffic class and mapping to specific protocol stack will be provided by the ETSI TC ITS.			
NOTE 3: Applicable if the ITS application requests the FAF of the DENM.			
NOTE 4: Applicable as specified in Clause 8.			

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

At the receiver ITS-S, the DEN basic service may provide the received DENM content in whole or in part to the ITS application or to the LDM facility 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 application at the receiving ITS-S may not need the interface IF.DEN.2 to receive DENM information, but via the LDM data base as described in Clause 5.1.

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

Category	Data	Data requirement	Mandatory/Optional
Data passed from the DEN basic service to the ITS application	DENM	{ <i>denm</i> } in whole or in part as specified in Annex A.	Optional (see note)
NOTE: Applicable if an ITS application of the receiving ITS-S requires the content of received DENM.			

5.3.1.5 Methods for data exchanges between DEN basic service and ITS application

In one possible implementation of the IF.DEN.2, DENM content is provided directly by the DEN basic service to the ITS application when a new DENM is received (push mode), or on demand when an ITS application requests specific DENM content to the DEN basic service (pull mode). DEN basic service realizes the data filtering and provides the requested data to the ITS application of the receiving ITS-S. 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 applications sends the request to the DEN basic service, the data is pushed from the application to the DEN basic service. And DEN basic service returns data as specified in Clauses 5.3.1, 5.3.2 and 5.3.3 based on the application request.

NOTE: It is not the purpose of the present document to specify the data exchange method of the interfaces between the DEN basic service and ITS application.

5.3.2 Interface to the ITS networking & transport layer

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 [i.14].

For ITS applications specified in [i.4], [i.5] and [i.6], point-to-multipoint communication [3] shall be used for the dissemination of DENM.

At the originator ITS-S, the DEN basic service delivers the 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 the receiving ITS-S, if the receiving ITS-S is considered as the destination of the DENM dissemination, the ITS networking & transport layer shall pass the received DENM to the DEN basic service.

Minimum data being passed between DEN basic service and ITS networking & transport layer for the originator and receiver ITS-S is as specified in Table 6.

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

Category	Data	Data requirement	Mandatory/Optional
Data passed from the DEN basic service to the ITS networking & transport layer	DENM	{denm} as specified in Annex A.	Mandatory
	DENM destination area	The definition of the DENM destination area shall be as specified in [4].	Mandatory
	Transmission interval for the DENM repetition	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 application requests the DENM repetition.			
NOTE 2: Applicable if the receiving ITS-S is considered by the ITS networking & transport layer as the destination of DENM dissemination.			

At the receiver ITS-S, if the receiver ITS-S is located in the destination area, the ITS networking & transport layer delivers the DENM to the DEN basic service.

5.3.2.1 Interface to the GeoNetworking/BTP stack

A DENM may rely on the services provided by the GeoNetworking/BTP stack to disseminate the DENM to a geographic destination area.

Data being passed between 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 originator ITS-S

Category	Data	Data requirement	Mandatory/Optional
Data passed from the DEN basic service to GeoNetworking/BTP	Message type	{denm.header.messageID} as specified in Annex A.	Mandatory
	BTP type	BTP header type B ([i.9], Clause 7.2.2).	Optional (see note 1)
	Destination port	As specified in [i.9] (see note 2)	Optional (see note 1)
	Destination port info	Reserved for future use.	Optional (see note 1)
	GN Packet transport type	GeoBroadcast protocol shall be used for DENM dissemination.	Optional (see note 1)
	Traffic class of the DENM	As defined in [i.8].	Mandatory
	GN Maximum packet lifetime		Optional (see note 1)
	GN Hoplimit		Optional (see note 1)
	Length,	Length of the DENM	Mandatory
NOTE 1: Applicable if the value is not set in the configuration Management Information Base (MIB) of GN or if the value is different from the value as set in MIB.			
NOTE 2: When a global registration authority for ITS application [i.11] is operational, the BTP destination port registered with this authority should be used.			

5.3.2.2 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 for DENM dissemination [3].

NOTE: The transmission of DENM over the IPv6 stack is out of scope of the present specification.

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.

5.3.3 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 [i.12].

5.3.4 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). The interface IF.SEC may be realized as the NF-SAP [i.13].

6 DENM dissemination

6.1 DENM dissemination concepts

6.1.1 Event identification

The event identification is enabled by the parameter named *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 the ITS-S ID of the originator ITS-S and a sequence number. The sequence number is assigned for each detected event.

Each time the originator ITS-S detects an event for the first time, the sequence number shall be incremented. When the sequence number reaches the range limit as specified in Annex A, it shall restart from 0.

NOTE: The *actionID* is linked to one originator ITS-S. In case multiple originator ITS-Ss detect the same event for the first time, the assigned *actionID* will be different in each originator ITS-S.

The *actionID* is used in originator, forwarder and received ITS-S for the DENM protocol operation. The *actionID* shall enable an ITS-S to distinguish DENMs transmitted from different originator ITS-Ss and DENMs transmitted by the same originator ITS-S for different events.

6.1.2 Trigger, update, repetition and termination of DENM

6.1.2.1 DENM trigger

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

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

6.1.2.2 DENM update

The originator ITS-S may detect the evolution of the event some time after the DENM trigger. The ITS 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 referred to as DENM update.

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

The *actionID* shall remain unchanged for DENM update.

6.1.2.3 DENM repetition

In between two consequent DENM updates, a DENM may be repeated by the DEN basic service of the originator ITS-S at a pre-defined transmission interval, in order that the 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 application. If the ITS application requires the repetition of DENM, the ITS application at the originator ITS-S shall provide the following data in the application request as specified in Clause 5.3.1:

- transmission interval;
- event *detectionTime*; and
- *repetitionDuration*.

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. If any of the three above data are not provided by the ITS application, the DEN basic service shall not execute the DENM repetition.

The DENM repetition shall apply to the most updated DENM.

6.1.2.4 DENM termination

The DENM termination indicates the end of the detected event. The termination can be indicated either by the originator ITS-S that originally requested the DENM trigger or by other originator ITS-Ss.

- DENM termination by the originator ITS-S that requested the DENM trigger:
 - For originator 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 application of the originator ITS-S.

- Moreover, before the expiration of the *validityDuration*, the originator 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 *isCancellation* is used for the cancellation DENM. For the generation of the cancellation DENM, the *isCancellation* shall be set to TRUE.
- For the generation of a cancellation DENM, the *actionID* value shall be identical to the *actionID* as set for the application request *appDENM_trigger*.

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

- DENM termination by an originator ITS-S that has not requested the DENM trigger:
 - If an ITS-S has received a DENM from other ITS-S regarding an event, it passes the indicated event location when the received DENM is still valid (i.e. *validityDuration* is not expired) and detects that the event has terminated. The ITS application at this ITS-S may send a *AppDENM_termination* request to the DEN basic service, the DEN basic service shall generate a negation DENM as defined in Clause 4.2.
 - The parameter *isNegation* is used for the negation DENM. When an ITS-S negates a DENM, *isNegation* shall be updated and its value shall be set to TRUE.
 - For the generation of a negation DENM, the *actionID* shall remain unchanged.. The *referenceTime* shall be set to the value of the latest received DENM of the same *actionID* from the originator 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* of the originator ITS-S that constructs the negation DENM.

NOTE 3: The ITS-S that initiates the negation DENM should satisfy some predefined conditions as defined by ITS applications in [i.4], [i.5] and [i.6].

For the cancellation and negation DENM, the *dectionTime* shall be set as the time at which the event termination is detected by the originator ITS-S. Once the cancellation or negation DENM is transmitted, the value of *actionID* may be deleted and freed to be used for other events later on

Once cancellation or negation DENM are verified to be trustworthy by the receiver ITS-S, all information related to the previously received DENMs concerning the same *actionID* shall be deleted by the DEN basic service.

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

6.1.3 Relevance area

6.1.3.1 DENM relevance area

A DENM shall 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 originator ITS-S when the DENM was transmitted.

The relevance area is set by the ITS application of the originator ITS-S and shall be included in the DENM. A receiver 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 standard, following information shall be provided as the relevance area information:

- *relevanceDistance*: The distance within which the event is considered relevant to the receiver ITS-S.
- *relevanceTrafficDirection*: The traffic direction along which the receiver 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 relevance traffic direction of the DENM related to the event is the upstream direction of the traffic jam. While for the accident occurred in rural road, the *relevanceDirection* may be both traffic conditions.

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 the location referencing information of the event position. In the present document, the location referencing used by DENM is the *traces* information.

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

NOTE: Details of waypoints setting and usage are beyond the scope of the present document.

A DENM shall include at least one trace. Multiple traces may be included, if receiver ITS-Ss can approach the detected event from different road sections or from different traffic directions (e.g. in an intersection situation).

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

A receiver 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 [4], three geometric shapes are currently 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 originator 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. However, the destination area shall cover the relevance area. The DEN basic service shall convert the relevance area to the destination area in the format compliant to the one as specified in [4].

6.1.4 DENM forwarding

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

6.1.4.1 Packet centric forwarding

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

NOTE: The specification of this function is out of the scope of the presentation standard. When GeoNetworking/BTP stack is used, this functionality is specified in [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 the DEN basic service in Figure 2. The main objective of the KAF is to store a received DENM in the DEN basic service and to forward the DENM to other ITS-Ss when necessary.

The KAF may be triggered by the DEN basic service or by the ITS application. Once the functionality is triggered, the KAF shall store the received DENM 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 relevance area of the event;
- the event is not cancelled by the originator ITS-S;
- the event is not negated by any originator ITS-S.

The KAF may redeliver one DENM being stored in the DEN basic service to the ITS networking & transport layer for dissemination if necessary. In one possible protocol, the KAF may forward DENM if the DEN basic service has not received a DENM forwarded by any other ITS-S neither a DENM transmitted from the originator ITS-S within a certain period of time. Only the DENMs with the most recent *referenceTime* will be forwarded by the KAF.

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

Detailed protocol operation of the KAF is specified in Clause 8.2.

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 [5].

NOTE: According to the requirements of specific ITS application. The data contained in DENM may be obtained from different source, 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 [i.4] [i.5] and [i.6]. Further confidence constraints of a DENM data element may be specified by the ITS applications. In this case, such constraints are specified in the present standards.

6.2.2 General security constraints

Security header is not included in DENM.

NOTE: The detailed specifications of DENM security mechanism is out of the scope of the present document.

6.2.3 General priority constraints

The DENM priority is defined by the related use case as specified in [i.4], [i.5] and [i.6].

Priority information is provided in the PCI across the OSI layers and/or transmitted by lower layers as specified as *trafficClass* in [i.8]. Therefore it is not included in the DENM.

7 DENM format specification

7.1 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 originator ITS-S.

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

- The management container contains information related to the DENM management and the DENM protocol, including *actionID*, *referenceTime*, *isCancellation* and *isNegation*.
- 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 alacarte 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 alacarte container are optional containers. For a cancelation or a negation DENM, the situation container and the location container shall not be present. If the situation container is present, the location container shall be present as well. The alacarte container is present only when applicable as specified in application specification standards, such as [i.4], [i.5] and [i.6].

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

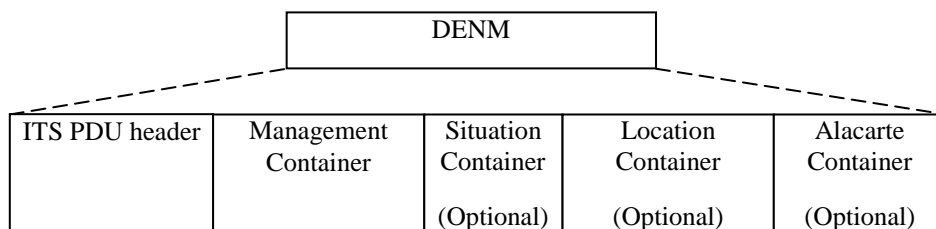


Figure 4: General structure of a DENM

7.1.1 ITS PDU header

The ITS PDU header shall be as specified in [5]. Detailed data presentation rules of the ITS PDU header in the context of DENM shall be as specified in Annex B.

7.1.2 DENM management container

The management container shall include the following information:

- *referenceTime*: shall be as defined in Clause B.39.
- *actionID*: shall be as defined in Clauses 6.1.2 and B.7.
- *detectionTime*: shall be as defined in Clause B.10.

- *validityDuration*: shall be as defined in Clause B.55. If this information is not provided by the application layer, the *validityDuration* shall not be present in the DENM management container. The *validityDuration* value may be updated or extended by the ITS application of the originator 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.
- *isNegation*: shall be as defined in Clauses 6.1.2 and B.24.
- *isCancellation*: shall be as defined in Clauses 6.1.2 and B.25.
- *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.
- *eventPosition*: The event position is use case specific and provided by the ITS application to the DEN basic service, it shall be as defined in Clause B.13.
- *relevanceDistance*: As specified in Clauses 6.1.3.1 and B.40.
- *relevanceTrafficDirection*: As specified in Clauses 6.1.3.1 and B.41.

7.1.3 DENM situation container

The situation container shall include the following information that describes the detected event:

- *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 originator ITS-S. The value 0 shall be set when the information is unavailable.
- *eventType*: This DE provides a description of the event type being detected. It shall be as defined in Clause B.16. For each specific event type, a unique code shall be used. The value of the cause code is based on the TPEG TEC specification as defined in [i.10]. The *eventType* is composed of two DEs, namely the direct cause code and sub cause code:
 - *CauseCode*: the direct cause code provides a high level description of the detected event type.
 - *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 [i.10].

The *subCauseCode* shall be set to "0" if the no specific information of the *subCauseCode* is available.

- *linkedCause*: This DE indicates an event which may be linked with the *eventType*. It shall be as defined in Clause B.28. 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.

Table 8 lists the *directCauseCode* and *subCauseCode* values for all ITS use cases as defined in [i.4], [i.5] and [i.6] that make use of the DEN basic service.

NOTE 2: ETSI TC ITS harmonizes *causeCode* and *subCauseCode* values with the TPEG TEC standard ISO TS 18234-9 [i.10].

For the event types that have been assigned the *causeCode* and *subCauseCode* values in ISO TS 18234-9 [i.10], the same values are used in the DENM situation container. For events types, for which the *causeCode* and *subCauseCode* values are not assigned in [i.10], a value is assigned by ETSI TC ITS.

In Table 8, references to ISO TS 18234-9 [i.10] cause codes and related sub cause codes are indicated when applicable.

NOTE 3: Future values are expected to be added for other event types.

Table 8: 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 [i.10]	0	Unavailable
			1	As specified in <i>tec101</i> of Clause 9.11 in [i.10]
			2	Traffic jam slowly increasing, as specified in Clause 5.3.8 in [i.4], not specified in [i.10]
			3	Traffic jam increasing, as specified in Clause 5.3.8 in [i.4], not specified in [i.10]
			4	Traffic jam strongly increasing, as specified in Clause 5.3.8 in [i.4], not specified in [i.10]
			5	Traffic stationary, as specified in Clause 5.3.8 in [i.4], not specified in [i.10]
			6	Traffic jam slightly decreasing, as specified in Clause 5.3.8 in [i.4], not specified in [i.10]
			7	Traffic jam decreasing, as specified in Clause 5.3.8 in [i.4], not specified in [i.10]
			8	Traffic jam strongly decreasing, as specified in Clause 5.3.8 in [i.4], not specified in [i.10]
Accident	2	Specified as accidents in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 7	As specified in <i>tec102</i> of Clause 9.12 in [i.10]
			8	Assistance requested (e-call)
Roadworks	3	Specified as road works in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 3	As specified in <i>tec103</i> of Clause 9.13 in [i.10]
			4	Winter service
			5	Street cleaning
Adverse weather condition - adhesion	6	Specified as slippery road in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 10	As specified in <i>tec106</i> of Clause 9.16 in [i.10]
Hazardous location - Surface condition	9	Specified as hazardous driving conditions in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 9	As specified in <i>tec109</i> of Clause 9.18 in [i.10]
Hazardous location - Obstacle on the road	10	Specified as objects on the road in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 7	As specified in <i>tec110</i> of Clause 9.19 in [i.10]
Hazardous location - Animal on the road	11	Specified as animals on the road in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 4	As specified in <i>tec111</i> of Clause 9.20 in [i.10]
Human presence on the road	12	Specified as people on roadway in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 3	As specified in <i>tec112</i> of Clause 9.21 in [i.10]
Wrong way driving	14	Specified as vehicle on wrong carriageway in <i>tec002</i> of Clause 9.2 in [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 [i.10]	0	Unavailable
			1 to 5	As specified in <i>tec115</i> of Clause 9.23 in [i.10]
Adverse weather condition - extreme weather condition	17	Specified as extreme weather condition in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 6	As specified in <i>tec117</i> of Clause 9.25 in [i.10]
Adverse weather condition - visibility	18	Specified as visibility reduced in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 8	As specified in <i>tec118</i> of Clause 9.26 in [i.10]

Cause code description	Direct cause code	Mapping with TPEG-TEC	Sub cause code	Sub cause description
Adverse weather condition -Precipitation	19	Precipitation as defined in [i.10], Clause 8.3.2	0	Unavailable
			1 to 3	As defined in <i>tec119</i> of Clause 9.27 in [i.10]
Slow vehicle	26	Specified as slow moving vehicles in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 8	As defined in <i>tec126</i> of Clause 9.32 in [i.10]
Dangerous end of queue	27	Specified as dangerous end of Queue in <i>tec002</i> of Clause 9.2 in [i.10]	0	Unavailable
			1 to 4	As defined in <i>tec127</i> of Clause 9.33 in [i.10]
Vehicle breakdown	91	Values are assigned referring to [i.4], Clause 5.3.3	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 [i.4], Clause 5.3.3	8	Tyre puncture
			0	Unavailable
			1	Accident without e-Call triggered
			2	Accident with e-Call manually triggered
			3	Accident with e-Call automatically triggered
Human problem	93	Values are assigned referring to [i.4], Clause 5.3.3	4	Accident with e-Call triggered without a possible access to a cell network.
			0	Unavailable
			1	Glycaemia problem
Stationary vehicle	94	Not specified in [i.10] Values are assigned referring to [i.4], Clause 5.3.3	2	Heart problem
			0	Unavailable
			1	Human Problem
			2	Vehicle breakdown
			3	Post crash
			4	Public transport stop
Emergency vehicle approaching	95	Not specified in [i.10] Values are assigned referring to [i.4], Clause 5.3.1	5	Carrying dangerous goods
			0	Unavailable
			1	Emergency vehicle approaching
Hazardous location indication - Dangerous Curve	96	Not specified in [i.10]. Values are assigned referring to [i.4], Clause 5.3.7	2	Prioritized vehicle approaching
			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

Cause code description	Direct cause code	Mapping with TPEG-TEC	Sub cause code	Sub cause description
Collision risk	97	Intersection collision Not specified in [i.10] Values are assigned referring to [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 [i.10] Values are assigned referring to [i.4], Clause 5.3.4	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

7.1.4 DENM location container

The location container shall include the following information:

- *eventPositionHeading*: Shall be as defined in Clause B.12. 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.
- *eventSpeed*: Shall be defined in Clause B.13. 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.
- *traces*: Shall be as specified in Clauses 6.1.3.2 and B.49.
- *roadClass*: 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.

7.1.5 DENM alacarte container

The alacarte container contains additional information that is not provided by other containers. This container provides the possibility for ITS application to include application specific data.

All information included in the alacarte container is optional. They shall be present when the data is provided by the ITS application.

The present document includes the alacarte container specification for use cases as specified in [i.4], [i.5], and [i.6]. It includes the following use case specific container:

- *laneNumber*: 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.19.
- *externalTemperature*: This information may be added for the adverse weather condition use case as specified in [i.4]. It indicates the ambient temperature at the event position when an abnormal weather condition is detected. It shall be as defined in Clause B.15.

- *roadWorks*: This container may be added for the roadwork use case as specified in [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 [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.31.
- *carryingDangerousGoods*: This container may be added for the stationary vehicle use case as specified in [i.4]. It provides information of the dangerous goods carried by the stationary vehicle. It shall be as defined in Clause B.8.
- *stationaryVehicle*: This container may be added for the stationary vehicle use case as specified in [i.4]. It shall be as defined in Clause B.47.

It is expected that other use case specific alacarte container to be added in the future.

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 [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 [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 ISO/IEC 8825-2 [6] shall be used for DENM encoding and decoding.

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

8 Protocol operation of the DEN basic service

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

- Originator ITS-S operation (Clause 8.1);
- Forwarder ITS-S operation (Clause 8.2); and
- Receiver ITS-S operation (Clause 8.3).

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

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

An ITS-S 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.

8.1 Originator ITS-S operation

8.1.1 Protocol data setting rules

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

8.1.1.1 *actionID*

At start up, the *sequenceNumber* in the *actionID* shall be set to the value that refers to the last used value.

NOTE: In order to refer to the value of the *actionID* of the last detected event, the *actionID* need to be saved even if the operation of the DEN basic service or the operation of the ITS-S is interrupted.

For the application request type *AppDENM_trigger*, a new *actionID* shall be assigned to an unused value. The *sequenceNumber* in the *actionID* shall be incremented each time a new event is detected by the originator ITS-S. When the *sequenceNumber* reaches the range limit as specified in Annex A, it shall restart from 0 and set to the next unused value.

For the application request type *AppDENM_update*, the application shall pass information as defined in Clause 5.3.1 to the DEN basic service. During the generation of an update DENM, the *actionID* shall remain unchanged.

For the application request type *AppDENM_termination*, the application shall pass information as defined in Clause 5.3.1 to the DEN basic service. During the generation of negation DENM, the *actionID* shall remain unchanged.

8.1.1.2 *referenceTime*

For the application request type *AppDENM_trigger*, the *referenceTime* shall be set to the time at which DENM is generated by the DEN basic service. In case application request DENM repetition, the *referenceTime* shall remain unchanged during the repetition.

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*, the DEN based service shall first verify whether the value of the *stationID* in the *actionID* as provided by the application request is identical to the originator ITS-S *stationID*. In case the two *stationIDs* are identical, a cancellation DENM shall be generated and the *isCancellation* shall be set to TRUE. If the two *stationIDs* are different, a negation DENM shall be generated. For the negation DENM, the *referenceTime* shall be set to the value of the latest received DENMs of the same *actionID*.

8.1.1.3 *isNegation* and *isCancellation*

For the application request type *AppDENM_trigger* and *AppDENM_update*, the *isNegation* and *isCancellation* shall be set to FALSE.

For the application request type *AppDENM_termination*, the *isNegation* flag shall be set to TRUE if a negation DENM is to be generated. The *isCancellation* shall be set to TRUE if a cancellation DENM is to be generated.

8.1.1.4 *T_O_V*alidity, *T_R*epetitionDuration and *T_R*epetition

The timer *T_O_V*alidity is the time that indicates the end of the DENM validity for the originator 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 originator ITS-S. Its expiration time shall be set to:

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

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

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

- the transmission interval, if the parameter is provided by the ITS application;
- an invalid value, if the transmission interval is not provided by the ITS application.

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

For all application request types, the *T_Repetition* and *T_repetitionDuration* shall not be superior to the *validityDuration*.

8.1.1.5 Originator ITS-S message table

The DEN basic service shall maintain at least all data as defined in the present clause.

NOTE: For application that requests DENM repetition, the DENM payload needs to be stored in the originator ITS-S message table.

8.1.2 General protocol operation

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

- 1) Process application request:
 - a) If request type of application is *appDENM_trigger*:
 - i. Assign *actionID* values (Clause 8.1.1.1).
 - b) If request type is *appDENM_update*:
 - i. If *actionID* provided by the ITS application does not exist in the originator ITS-S message table, send a failure notification to the ITS application and omit the execution of further steps.
 - ii. Otherwise, continue the operation.
 - c) If request type is *appDENM_termination*:
 - i. If *actionID* provided by the ITS application does not exist in the originator ITS-S message table, neither in the receiver ITS-S message table as defined in Clause 8.3.1, send a failure notification to the ITS application and omit the execution of further steps.
 - ii. Otherwise, continue the operation.
- 2) Assign *isCancellation* and *isNegation* values.
- 3) Collect other data (Clause 7.1).
- 4) Construct DENM (ASN.1 specification in Annex A) and set *referenceTime*.
- 5) Set expiration time for timer *T_O_VValidity* (Clause 8.1.1.4):
 - a) If expiration time of timer *T_O_VValidity* is in the past, send a failure notification to the ITS application and omit the execution of further steps.
 - b) Otherwise, continue the operation.

- 6) Start/restart timer *T_O_VValidity*.
- 7) Pass DENM to the ITS networking&transport layer.
- 8) Repetition scheduling:
 - a) If repetition is requested by ITS application:
 - i. Set timeout value for timer *T_ Repetition* and *T_ RepetitionDuration* start/restart timers.
 - b) If repetition is not requested by the ITS application:
 - i. Set the timeout values to invalid and stop timer *T_ Repetition* and *T_ RepetitionDuration*.
- 9) Save DENM in originator ITS-S message table, wait for the next application request.

If the timer *T_O_VValidity* expires, the DEN basic service shall execute the following operations:

- i. Stop timer *T_ Repetition*.
- ii. Stop timer *T_ RepetitionDuration*.
- iii. Discard DENM from originator ITS-S message table.

If the timer *T_ Repetition* expires, the DEN basic service shall execute the following operations:

- iv. check if *T_ repetitionDuration* expires;
 - iv.1. if no, pass DENM to ITS networking&transport layer and restart timer *T_ Repetition*;
 - iv.2. if yes, stop timer *T_ Repetition* and *T_ RepetitionDuration*.

The protocol operation is illustrated in Figure 5.

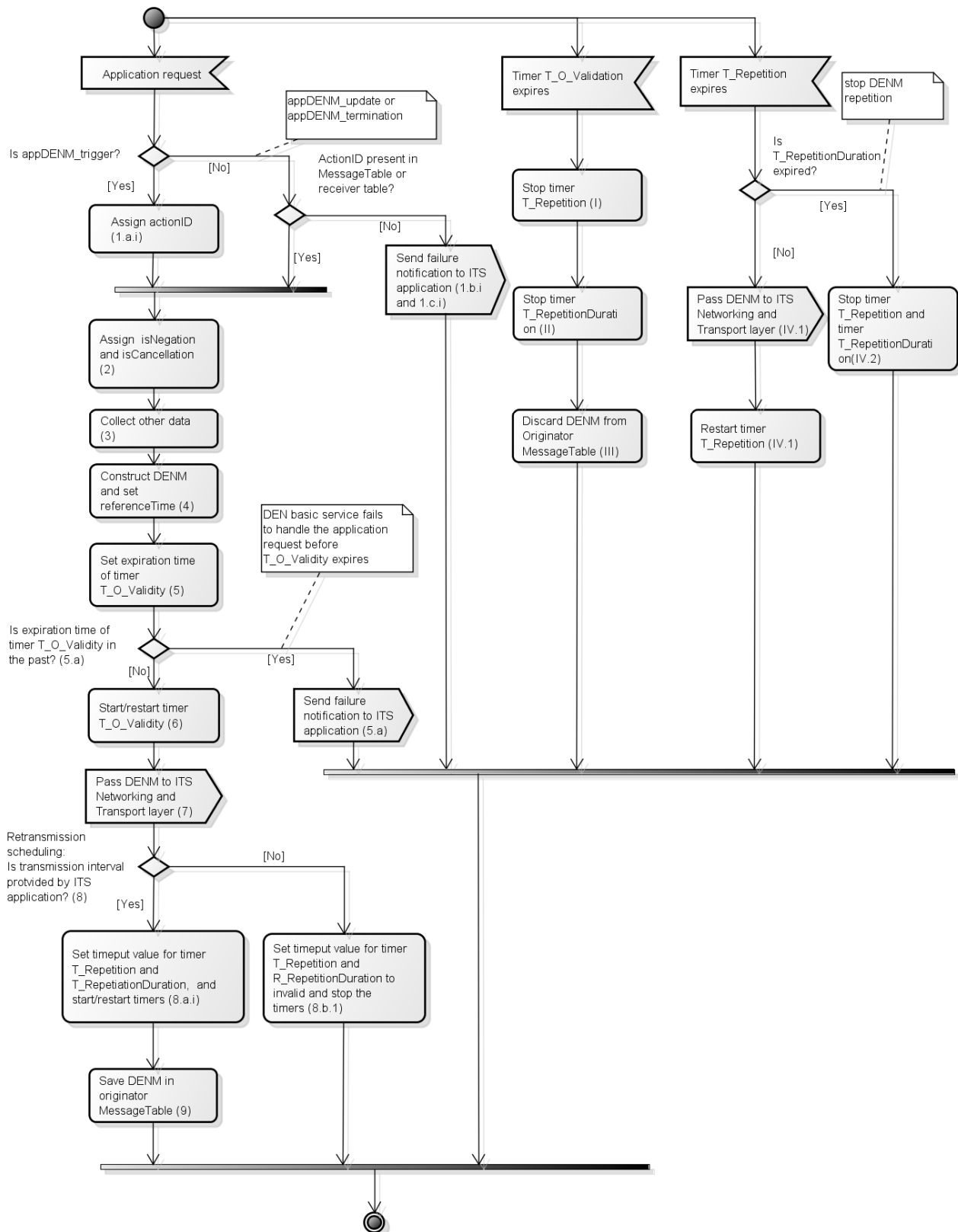


Figure 5: Originator ITS-S activity diagram

8.1.3 Exception handling

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

8.1.3.1 DENM construction exception.

If the DEN basic service could not construct a DENM successfully, the DEN basic service shall send a failure notification to the ITS 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).

8.1.3.2 *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 originator ITS-S message table, the DEN basic service shall send a failure notification to the ITS application.

For the application request type *AppDENM_termination*, if the corresponding *actionID* does not exist in the receiver ITS-S message table as defined in Clause 8.3.1, the DEN basic service shall send a failure notification to the ITS application.

8.1.3.3 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 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.

8.2 Forwarder ITS-S operation

The forwarder ITS-S operation is related to the Keep-alive Forwarding (KAF) functionality 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 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.

8.2.1 Protocol data setting rules

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

8.2.1.1 *actionID*

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

8.2.1.2 *referenceTime*

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

8.2.1.3 isNegation and isCancellation

The forwarder ITS-S shall not set the *isNegation* and *isCancellation*.

8.2.1.4 T_F_Validity and T_Fowarding

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_Fowarding* schedules the DENM forwarding from the DEN basic service to the ITS networking&transport layer. Its timeout value shall be set to:

- 2 times of the transmission interval plus a random delay in the range of [0 ms to 150 ms], if *transmissionInterval* and *validityDuration* are present in the received DENM and the resulting timeout value is not superior to 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 2 times of the transmission interval plus a random delay (0 ms to 150 ms) is superior to 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_Fowarding*.

NOTE 4: If the *transmissionInterval* is not present in the DENM, the application of the originator ITS-S does not require the repetition of the DENM. In this case, it is assumed that the originator ITS-S does not require the DENM to be kept alive and to be forwarded by an intermediate ITS-S.

8.2.1.5 Forwarder ITS-S message table

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

The update of the forwarder ITS-S message table shall follow the rules as defined in the receiver ITS-S operation specified in Clause 8.3.

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

8.2.1.6 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 alacarte container of the DENM shall not be modified. The ITS PDU header shall be replaced by the ITS PDU header constructed by the forwarder ITS-S.

8.2.2 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) Set expiration time of timer *T_F_VValidity* (Clause 8.2.1.4):
 - a) if timer *T_F_VValidity* is set to invalid value, stop timer and omit execution of further steps;
 - b) Otherwise, continue operation.
- 2) Start/restart timer *T_F_VValidity*.
- 3) Forwarding scheduling:
 - a) if transmission interval is present in received DENM:
 - i. set timeout value for timer *T_Forwarding* (Clause 8.2.1.4) and start/restart timer;
 - b) if transmission interval is not present in received DENM:
 - i. Set timeout value of timer *T_Forwarding* to invalid (Clause 8.2.1.4) and stop timer.
- 4) Update forwarder ITS-S message table (Clause 8.2.1.5), wait for next DENM reception.

If the timer *T_F_VValidity* expires, the DEN basic service shall execute the following operations:

- I. stop timer *T_Forwarding*;
- II. delete DENM from forwarder message table.

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

- III. Check if forwarder ITS-S is located in relevance area:
 - i. if not, delete DENM from forwarder ITS-S message table and omit execution of further steps;
 - ii. otherwise, continue operation.
- IV. Check other DENMs received during *T_Forwarding*:
 - i. If no DENM of the same *actionID* is received:
 - 1) reconstruct DENM by replacing ITS PDU header of latest DENM stored in the forwarder ITS-S message table;
 - 2) pass reconstructed DENM to ITS networking & transport layer; then go to step VII.
 - ii. otherwise, continue operation.
- V. Check *referenceTime* of received other DENMs with the same *actionID*:
 - i. If *referenceTime* of all received DENMs are inferior to the latest value stored in the forwarder ITS-S message table:
 - 1) discard received other DENMs;
 - 2) reconstruct DENM by replacing PDU header of latest DENM stored in forwarder ITS-S message table;
 - 3) pass reconstructed DENM to ITS networking & transport layer; then go to step VII;
 - ii. otherwise, continue operation.

VI. Check if state of DENM in the forwarder ITS-S message table is to be modified due to the received other DENMs according to Clause 8.3:

- i. if yes, update the forwarder ITS-S message table according to Clause 8.3, wait for next DENM reception;
- ii. if no, discard the received other DENMs.

VII. Restart timer $T_Forwarding$.

The protocol operation is illustrated in Figure 6.

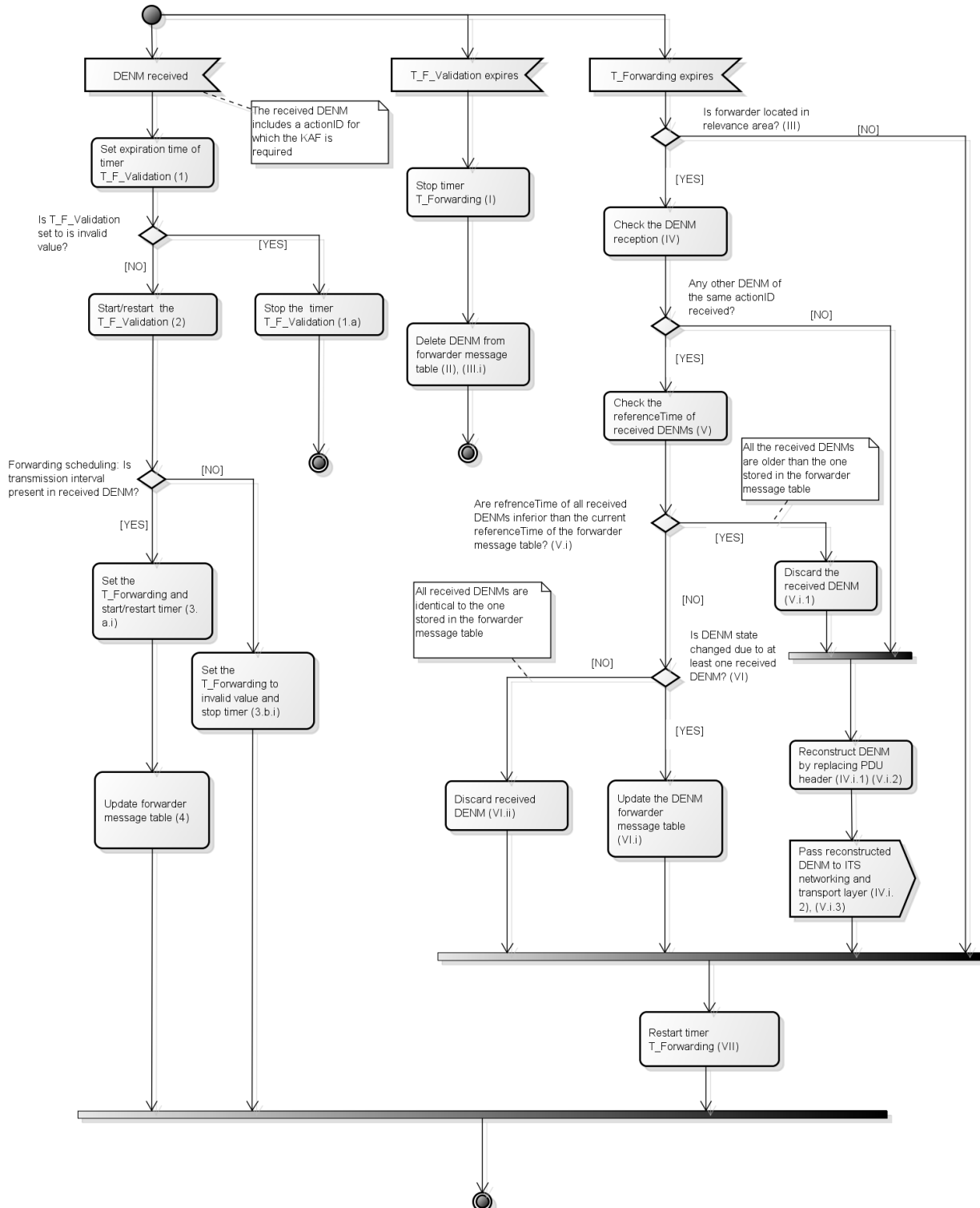


Figure 6: Forwarder ITS-S activity diagram

8.2.3 Exception handling

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

8.2.3.1 DENM reconstruction exception

If the DEN basic service could not reconstruct 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).

8.3 Receiver ITS-S operation

8.3.1 Protocol data setting rules

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

8.3.1.1 *actionID*

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

8.3.1.2 *referenceTime*

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

8.3.1.3 *isNegation* and *isCancellation*

The receiver ITS-S shall not set the *isNegation* and *isCancellation*.

8.3.1.4 *T_R_Validity*

The *T_R_Validity* is the time that indicates the end of the DENM validity for the receiver protocol operations. Its expiration time shall 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.

8.3.1.5 Receiver ITS-S message table

The DEN basic service shall maintain At least the following data for the receiver protocol operation:

- *actionID*: *actionID* value of all 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*.
- *isNegation*: The value of the *isNegation* refers to the most recent value of received DENMs of the same *actionID*.
- *isCancellation*: The value of the *isCancellation* 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 receiver ITS-S message table are indexed with *actionID*.

A DENM with a specific *actionID* shall be stored in the receiver ITS-S message table as long as the timer *T_R_VValidity* is not expired. When the timer *T_R_VValidity* expires, all data related to the corresponding *actionID* may be deleted from the receiver ITS-S message table.

Any stored DENM in the receiver ITS-S message table may be associated with three states:

- Active state: Both the *isCancellation* and *isNegation* values stored in the receiver ITS-S message table are set to FALSE.
- Cancelled state: The *isCancellation* value of DENM stored in the receiver ITS-S message table is TRUE.
- Negated state: The *isNegation* value of DENM stored in the receiver ITS-S message table is TRUE.

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

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

- the *referenceTime* of a received DENM is superior than the latest value stored in the receiver message table; or
- the state of the DENM is changed due to a received DENM; or
- the record of the DENM with the *actionID* is deleted when the timer *T_R_VValidity* expires.

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

8.3.2 General protocol operation

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

- 1) Decode DENM;
- 2) Set expiration time for timer *T_R_VValidity* (Clause 8.3.1.4):
 - a) if timeout of timer *T_R_VValidity* is in the past, check if *actionID* exists in the receiver ITS-S message data:
 - i. If yes, delete DENM record from the receiver ITS-S message table, stop timer and omit execution of further steps.
 - ii. If no, discard received DENM and go to step 4).
 - b) Otherwise, start/restart timer *T_R_VValidity*.
- 3) Receiver ITS-S message update:
 - a) If *actionID* of received DENM does NOT exist in receiver ITS-S message table, check if received DENM is cancellation DENM or negation DENM (*isCancellation*=TRUE or *isNegation* = TRUE):
 - i. If yes, discard received DENM and go to step 4).
 - ii. Otherwise, insert received DENM into receiver message table.
 - b) If *actionID* of received DENM exists in receiver ITS-S message table, check *referenceTime* of received DENM:
 - i. If received *referenceTime* is more recent (superior) than latest value of the receiver ITS-S message table, update receiver message table with received DENM (update *state*, *referenceTime*, *isNegation*, *isCancellation* and *detectionTime*).

- ii. If received *referenceTime* is older (inferior) than latest value of the receiver message table, discard received DENM and go to step 4).
- iii. If received *referenceTime* is equal to latest value of receiver ITS-S message table, check *detectionTime* of the received DENM:
 - 1) If *detectionTime* is more recent than latest value of receiver message table, update receiver message table with received DENM (update *state*, *referenceTime*, *isNegation*, *isCancellation* and *detectionTime*).
 - 2) Otherwise, discard received DENM and go to step 4).
- 4) Pass the received DENM information to the application if necessary (Clause 5.3.1), wait for the next DENM reception or timer event.

If the timer *T_R_VValidity* expires, the DEN basic service shall execute the following operations:

- I. Delete DENM record from the receiver ITS-S message table.
- II. Notify application if necessary (Clause 5.3.1).

The protocol operation is illustrated in Figure 7.

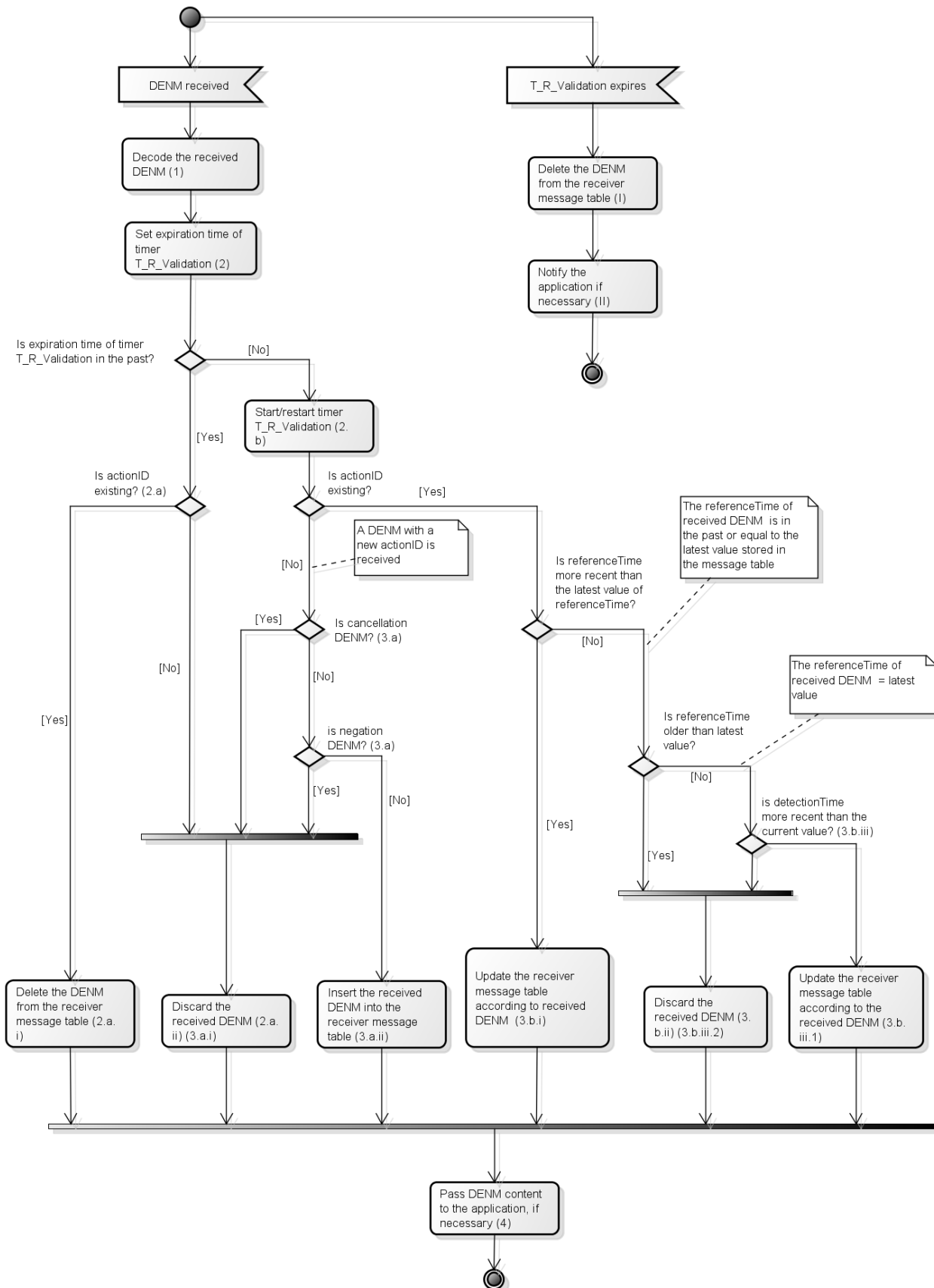


Figure 7: Receiver ITS-S activity diagram

8.3.3 Exception handling

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

8.3.3.1 DENM decoding exception

If the received DENM cannot be decoded by the DEN basic service, the operation shall stop, discard the DENM and wait for the next DENM reception or timer event.

Annex A (normative):

ASN.1 specification of DENM

```

DENM-PDU-Descriptions {
  itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) en (302637) denm (1) version
  (1)
}

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
  ItsPduHeader, CauseCode, Percentage, StationID, Movement, InformationQuality, ReferencePosition,
  DangerousGoodsExtended, Direction, LaneNumber, LightBarSirenInUse, PathHistory, RoadClass,
  HeightLonCarr, PosLonCarr, PosPillar, PosCentMass, PositioningSolutionType,
  RequestResponseIndication, StationType, SpeedLimit, StationarySince, TimestampIts, WheelBaseVehicle,
  TurningRadius, PosFrontAx, PositionOfOccupants, Temperature, VehicleMass, VehicleIdentification,
  EnergyStorageType FROM ITS-Container {
  itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) en (302637) cc (0) version (1)
};

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,
  isNegation    BOOLEAN,
  isCancellation BOOLEAN,
  eventPosition ReferencePosition,
  relevanceDistance RelevanceDistance,
  relevanceTrafficDirection RelevanceTrafficDirection,
  validityDuration ValidityDuration DEFAULT defaultValidity,
  transmissionInterval TransmissionInterval OPTIONAL
}

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

LocationContainer ::= SEQUENCE {
  eventSpeed Movement OPTIONAL,
  eventPositionHeading Direction OPTIONAL,
  traces Traces,
  roadClass RoadClass 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
}

PositionOfPillars ::= SEQUENCE (SIZE(1..3, ...)) OF PosPillar

RoadWorksContainerExtended ::= SEQUENCE {
    lightBarSirenInUse LightBarSirenInUse OPTIONAL,
    closedLanes ClosedLanes OPTIONAL,
    restriction RestrictedTypes OPTIONAL,
    speedLimit SpeedLimit OPTIONAL,
    incidentIndication CauseCode OPTIONAL,
    recommendedPath ItineraryPath OPTIONAL    --Traces without timestamps
}

ClosedLanes ::= SEQUENCE {
    hardShoulderStatus HardShoulderStatus OPTIONAL,
    drivingLaneStatus DrivingLaneStatus,
    ...
}

HardShoulderStatus ::= ENUMERATED { availableForStopping(0), closed(1), availableForDriving(2) }

DrivingLaneStatus ::= BIT STRING { outermostLaneClosed(0), secondLaneFromOutsideClosed(1) } (SIZE
(1..14))

RestrictedTypes ::= SEQUENCE OF StationType

StationaryVehicleContainer ::= SEQUENCE {
    stationType StationType,
    stationarySince StationarySince OPTIONAL,
    stationaryCause CauseCode OPTIONAL,
    carryingDangerousGoods DangerousGoodsExtended OPTIONAL,
    numberOfOccupants INTEGER(0..127) OPTIONAL,
    vehicleIdentification VehicleIdentification OPTIONAL,
    energyStorageType EnergyStorageType OPTIONAL
}

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

ActionID ::= SEQUENCE {
    originatorStationID StationID,
    sequenceNumber SequenceNumber
}

SequenceNumber ::= INTEGER (0..65535)

defaultValidity INTEGER ::= 600

ValidityDuration ::= INTEGER { timeOfDetection(0), oneSecondAfterDetection(1) } (0..86400)

Traces ::= SEQUENCE SIZE(0..7) OF PathHistory

ItineraryPath ::= SEQUENCE SIZE(0..40) OF ReferencePosition

TransmissionInterval ::= INTEGER { oneMilliSecond(1), tenSeconds(10000) } (1..10000)

RelevanceDistance ::= ENUMERATED { lessThan50m(0)
, lessThan100m(1), lessThan200m(2), lessThan500m(3), lessThan1000m(4), lessThan5km(5),
lessThan10km(6), over10km(7) }

RelevanceTrafficDirection ::= ENUMERATED { unavailable(0), upstreamTraffic(1),
downstreamTraffic(2), allTrafficDirection(3) }

END

```

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

This annex provides the following information:

- Detailed description of data elements and data frames in the DENM as well as specified in Annex A.
- Data setting rules of data elements and data frames in the DENM as well as specified in Annex A.

B.1 header

Description	The ITS PDU header of DENM. This DF includes the protocol version of DENM <i>protocolVersion</i> , DENM message type identifier <i>messageID</i> and station identifier <i>stationID</i> of the originator ITS-S or ITS-S that optionally forwards the DENM. The DE <i>protocolVersion</i> is used to select the appropriate protocol decoder at the receiver ITS-S. This DE <i>messageID</i> should be harmonized with other V2X message identifier definition. For the originator ITS-S, the <i>stationID</i> presents the station ID of the originator ITS-S. For the forwarder ITS-S, the <i>stationID</i> presents the station ID of the forwarder ITS-S, if the DENM is forwarded.
Data setting and presentation requirements	For the present standard, the value of the DE <i>protocolVersion</i> shall be set to 1. For DENM, the DE <i>messageID</i> shall be set to 1. This DF shall be presented as specified in [5] <i>ItsPduHeader</i> .

B.2 denm

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

B.3 management

Description	Management container of DENM as described in Clause 7.1.2. 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 DENM as described in Clause 7.1.3. It contains information of the event type and event detection quality.
Data setting and presentation requirements	This DF is optional; it shall not be present for the cancelation DENM and negation DENM. This DF shall be presented as specified in Annex A.

B.5 location

Description	Location container of DENM as described in Clause 7.1.4. It contains information of the location referencing.
Data setting and presentation requirements	This DF is optional; it shall not be present for the cancelation DENM and negation DENM. This DF shall be presented as specified in Annex A.

B.6 alacarte

Description	Alacarte container of DENM as described in Clause 7.1.5. 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 for the cancelation DENM and negation DENM and shall not be present if the information is not required by the ITS application of the originator ITS-S. This DF shall be presented as specified in Annex A.

B.7 actionID

Description	Identifier generated by the DEN basic service at the request of ITS application each time an ITS-S detects an event at a specific position for the first time. The <i>actionID</i> differs from all <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 to allow receiver ITS-S to process information for DENMs that are multiply received.
Data setting and presentation requirements	The <i>actionID</i> shall be maintained by the originator ITS-S, the data setting rules are as specified in Clause 8.1.1. The <i>actionID</i> DE is composed of an ITS-S identifier and a sequence number. This DF shall be presented as specified in Annex A.

B.8 carryingDangerousGoods

Description	Information container included in the stationaryVehicle alacarte 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.
Data setting and presentation requirements	This DF is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DF shall be presented as specified in [5] <i>DangerousGoodsExtended</i> .

B.9 closedLanes

Description	This DF indicates whether the roadwork has caused the closure of one or several lanes. This DE is included in <i>roadWorks</i> alacarte container.
Data setting and presentation requirements	This DF is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DF shall be presented as specified in Annex A.

B.10 detectionTime

Description	Time at which the event is detected by the originator ITS-S. It is provided by the ITS application of the originator ITS-S. For the DENM repetition, this DE shall remain unchanged. For update DENM, 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 [5] <i>Timestampts</i> .

B.11 drivingLaneStatus

Description	This DE indicates the current opening status of a driving lane. When a lane is closed, the corresponding bit shall be set to 1. The lane number is counted from the outside border of the road. This DE is included in the <i>roadworks</i> alacarte container.
Data setting and presentation requirements	This DE is OPTIONAL. It shall be present if the information is required by the ITS application. This DE shall be presented as specified in Annex A.

B.12 energyStorageType

Description	This DE provides the vehicle energy storage type information of the stationary vehicle as specified in [i.4], such as electric, diesel etc... This DE is included in <i>stationaryVehicle</i> alacarte container.
Data setting and presentation requirements	This DE is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DE shall be presented as specified in [5] <i>EnergyStorageType</i> .

B.13 eventPosition

Description	Geographical position of the detected event. The position of the event is determined by the originator ITS-S.
Data setting and presentation requirements	This DF shall be presented as specified in [5] <i>ReferencePosition</i> .

B.14 eventPositionHeading

Description	The heading direction of the event and the confidence of the heading information, if applicable. 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	This DF is OPTIONAL, it shall be present when this information is required by the ITS application of the originator ITS-S. This DF shall be as presented as specified in [5] <i>Direction</i> .

B.15 eventSpeed

Description	Moving speed of the detected event and the confidence of the moving speed information. If the detected event is related to a vehicle ITS-S, the eventSpeed corresponds to the vehicle speed. 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	This DF is OPTIONAL, it shall be present if this information is required by the ITS application of the originator ITS-S. The <i>eventPosition</i> shall be presented as specified in [5] <i>Movement</i> .

B.16 eventType

Description	Description for the event type, including direct cause and sub cause. The assignment of the event cause codes is based on [i.10] and the specification in Table 8 in Clause 7.1.3 of the present document.
Data setting and presentation requirements	This DF shall be presented as specified in [5] <i>CauseCode</i> .

B.17 externalTemperature

Description	Information included in the alacarte container for the adverse weather condition use case as specified in [i.4]. It indicates the ambient temperature at the event position when an abnormal weather condition is detected by the originator ITS-S.
Data setting and presentation requirements	This DE is represented in unit of Celsius degree. This DE shall be presented as specified in [5] <i>Temperature</i> .

B.18 hardShoulderStatus

Description	This DE indicates the current status of hardshoulder lane whether it is available for special usage (emergency vehicle, breakdown vehicle etc.) or closed to all vehicles. This DE is included in the <i>roadworks</i> alacarte container as Optional data. It shall be present if the information is required by the ITS application.
Data setting and presentation requirements	This DE shall be presented as specified in Annex A.

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> container.
Data setting and presentation requirements	This DE is represented in unit of centimetre. Values equal or higher than 99 shall be set to 99. Value 100 shall be set if the data is unavailable. This DE shall be presented as specified in [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> container
Data setting and presentation requirements	This DE is represented in unit of centimetre. Values equal or higher than 99 shall be set to 99. Value 100 shall be set if the data is unavailable. This DE shall be presented as specified in [5] <i>HeightLonCarr</i> .

B.21 impactReduction

Description	Data container included in the alacarte 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 of the originator ITS-S. 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 DE is included in <i>roadWorks</i> alacarte container.
Data setting and presentation requirements	This DE is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DF shall be presented as specified in [5] <i>CauseCode</i> .

B.23 informationQuality

Description	Quality level of the information provided by the ITS application of the originator ITS-S. It indicates the probability of the detected event being truly existent at the event position.
Data setting and presentation requirements	This DE shall be provided by the ITS application of the originator ITS-S. If the application is not able to determine the value, it shall provide the value set to 0. This DE shall be presented as specified in Annex A.

B.24 isNegation

Description	This DE indicates that the event described by a previously received DENM does not exist anymore.
Data setting and presentation requirements	The <i>isNegation</i> shall be maintained by the originator ITS-S. The data setting rules of this DE is as specified in Clause 8.1.1. This DE shall be presented as specified in Annex A.

B.25 isCancellation

Description	This DE indicates that the event termination has been detected by the originator ITS-S that has generated the corresponding new DENM.
Data setting and presentation requirements	The <i>isCancellation</i> shall be maintained by the originator ITS-S. The data setting rules of this DE is as specified in Clause 8.1.1. This DE shall be presented as specified in Annex A.

B.26 laneNumber

Description	The lane position of the event position in the road counted from the outside boarder of the road. If this data is provided, the originator 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 DF is OPTIONAL, it shall be present when this information is required by the ITS application of the originator ITS-S. This DF shall be presented as specified in [5] <i>LaneNumber</i> .

B.27 lightBarSirenInUse

Description	This DE indicates whether a roadwork vehicle has switched on the light bar or siren. This DE is included in <i>roadWorks</i> alacarte container.
Data setting and presentation requirements	This DE is OPTIONAL, it is used when the roadwork involves a specific roadwork vehicle This DE shall be presented as specified in [5] <i>LightBarSirenInUse</i> .

B.28 linkedCause

Description	Description for the linked cause of the provided event type, including direct cause and sub cause. The assignment of the <i>linkedCause</i> is based on [i.10] and the specification in Table 8 in Clause 7.1.3 of the present document.
Data setting and presentation requirements	This DF is optional and shall be present if the information is provided by the ITS application of the originator ITS-S. This DF shall be presented as specified in [5] <i>CauseCode</i> .

B.29 numberOfOccupants

Description	This DE provides the estimated number of occupants involved in the stationary vehicle event as specified in [i.4]. This DE is included in <i>stationaryVehicle</i> alacarte container.
Data setting and presentation requirements	This DE is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DE shall be presented as specified in Annex A.

B.30 originatorStationID

Description	This DE provides the station ID of the originator ITS-S. It is included in the <i>actionID</i> DF.
Data setting and presentation requirements	This DE shall be presented as specified in [5] <i>StationID</i> .

B.31 posCentMass

Description	Perpendicular distance from centre of mass of an empty charged vehicle to vehicle front bumper. This DE is included in the <i>impactReduction</i> container.
Data setting and presentation requirements	This DE is represented in unit of 10 centimetres. Values equal or higher than 62, shall be set to 62. Value 63 shall be set if the data is unavailable. This DE shall be presented as specified in [5] <i>PosCentMass</i> .

B.32 posFrontAx

Description	Perpendicular distance between the front wheel axle and front bumper. This DE is included in the <i>impactReduction</i> container.
Data setting and presentation requirements	This DE is represented in unit of 10 centimetres. Values equal or higher than 19 shall be set to 19. Value 20 shall be set if the data is unavailable. This DE shall be presented as specified in [5] <i>PosFrontAx</i>

B.33 positioningSolution

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

B.34 positionOfOccupants

Description	This DF indicates whether a in vehicle seat is occupied at the moment when the <i>impactReduction</i> is transmitted. 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 <i>PositionOfOccupants</i> .

B.35 positionOfPillars

Description	<p>Vehicle pillars refer to the vertical or near vertical support of vehicle, designated respectively as the A, B, C or D and other pillars moving in profile view from the front to rear.</p> <p>The <i>positionOfPillars</i> contains a list of distance, that 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.</p> <p>This DE is included in the <i>impactReduction</i> container.</p> <p>This DE is defined for passenger vehicles only.</p>
Data setting and presentation requirements	<p>The first value of the <i>positionOfPillars</i> refers to the perpendicular distance from the centre of vehicle front bumper to vehicle A pillar. The second value refers to the perpendicular distance from the centre position of A pillar to the B pillar of vehicle and so on until the last pillar.</p> <p>The distance is represented in unit of 10 centimetres. Values equal or higher than 29 shall be set to 29. Value 30 shall be set if the data is unavailable.</p> <p>This DF shall be presented as specified in Annex A.</p> <p>Each distance of the DF shall be presented as specified in [5] <i>PosPillar</i>.</p>

B.36 posLonCarrLeft

Description	<p>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.</p> <p>This DE is included in the <i>impactReduction</i> container.</p>
Data setting and presentation requirements	<p>This DE is represented in unit of centimetre. Values equal or higher than 126 shall be set to 126. Value 127 shall be set if the data is unavailable.</p> <p>This DE shall be presented as specified in [5] <i>PosLonCarr</i>.</p>

B.37 posLonCarrRight

Description	<p>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.</p> <p>This DE is included in the <i>impactReduction</i> container.</p>
Data setting and presentation requirements	<p>This DE is represented in unit of centimetre. Values equal or higher than 126 shall be set to 126. Value 127 shall be set if the data is unavailable.</p> <p>This DE shall be presented as specified in [5] <i>PosLonCarr</i>.</p>

B.38 recommendedPath

Description	<p>This DF indicates the recommended itinerary in order to contour the roadworks zone.</p> <p>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.</p> <p>This DF is included in <i>roadWorks</i> alacarte container.</p>
Data setting and presentation requirements	<p>This DF is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S.</p> <p>This DF shall be presented as specified in Annex A.</p>

B.39 referenceTime

Description	<p>For the generation of new DENM, this DE shall be set as the time at which DENM is generated.</p> <p>For generation of update DENM, the DE shall be set as the time at which update DENM is generated. Therefore, the DE shall be updated for each DENM update.</p> <p>For the generation of cancellation DENM, the DE shall be set as the time at which cancellation DENM is generated.</p> <p>For the generation of negation DENM, the DE shall be set as the latest value as stored in the receiver message table of the originator ITS-S. It enables the receiver of the negation DENM to check for which DENM the negation is targeted.</p> <p>For DENM repetition, the DE shall not be updated.</p> <p>This DE is maintained by the DEN basic service of the originator ITS-S.</p>
Data setting and presentation requirements	This DE shall be presented as specified in [5] <i>TimestampPlts</i> .

B.40 relevanceDistance

Description	The distance in which the event information is relevant for the receiver ITS-S, starting from the event position.
Data setting and presentation requirements	This DE shall be presented as specified in Annex A.

B.41 relevanceTrafficDirection

Description	The traffic direction along which the event information is relevant for the receiver ITS-S.
Data setting and presentation requirements	This DE shall be as presented as specified in Annex A.

B.42 requestResponseIndication

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

B.43 restriction

Description	<p>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.</p> <p>This DF is included in <i>roadWorks</i> alacarte container.</p>
Data setting and presentation requirements	<p>This DF is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S.</p> <p>This DF shall be presented as specified in Annex A.</p>

B.44 roadClass

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 of the originator ITS-S. This DE shall be presented as specified in [5] <i>RoadClass</i> .

B.45 roadWorks

Description	Information container included in the alacarte container for the road work use case as specified in [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 of the originator ITS-S. This DF shall be presented as specified in Annex A.

B.46 sequenceNumber

Description	This DE is a sequence number set each time a new DENM is created. It is used to differentiate different events detected by the same ITS-S. It is included in the <i>actionID</i> DF.
Data setting and presentation requirements	This DE shall be presented as specified in Annex A.

B.47 speedLimit

Description	This DE indicates the speed limitation applied to the roadwork zone. This DE is included in <i>roadWorks</i> alacarte container.
Data setting and presentation requirements	This DE is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DE is represented in unit of kilometre per hour. Values equal or higher than 150 shall be set to 150. This DE shall be presented as specified in [5] <i>SpeedLimit</i> .

B.48 stationaryCause

Description	This DE provides additional information to describe causes of the stationary vehicle event such as Human problem as defined in [i.4]. This DE is included in <i>stationaryVehicle</i> container.
Data setting and presentation requirements	This DE is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DE shall be presented as specified in [5] <i>CauseCode</i> .

B.49 stationarySince

Description	This DE provides the time duration of the stationary vehicle being stationary. This DE is included in <i>stationaryVehicle</i> container. The duration is presented in unit of minutes. For stationary vehicle being stationary for more than 15 minutes, the DE shall be set to 3.
Data setting and presentation requirements	This DE is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DE shall be presented as specified in [5] <i>StationarySince</i> .

B.50 stationaryVehicle

Description	Information container included in the alacarte container for the stationary vehicle use case as specified in [i.4]. It provides information of the stationary vehicle.
Data setting and presentation requirements	This DF is OPTIONAL, it shall be present when the information is required by the ITS application of the originator ITS-S. This DF shall be presented as specified in Annex A.

B.51 stationType

Description	This DE provides the station type information of the stationary vehicle. This DE is included in <i>stationaryVehicle</i> alacarte container.
Data setting and presentation requirements	This DE shall be presented as specified in [5] <i>StationType</i> .

B.52 traces

Description	This DF is the location referencing information of <i>eventPosition</i> . It includes a group of traces as specified in [5] type <i>PathHistory</i> . Each trace describes a set of consecutive <i>PathPoint</i> positions leading to the event position. 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 8 traces may be added in a DENM. For each trace, multiple <i>PathPoint</i> positions are provided to describe the trace. In the present standards, up to 40 <i>PathPoints</i> may be added in one trace.
Data setting and presentation requirements	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 event along the trace path. Each <i>PathPoint</i> presents an offset delta position with regards to the previous <i>PathPoint</i> . The DE <i>PathDeltaTime</i> as defined in <i>PathPoint</i> in [5] is Optional, it shall be present if the information is required by the ITS application of the originator ITS-S. The <i>traces</i> shall be presented as specified as in Annex A. Each trace shall be presented as specified in [5] <i>PathHistory</i> .

B.53 transmissionInterval

Description	Time interval for DENM repetition as defined by the originator ITS-S. This DE informs the receiver ITS-Ss about the intended transmission interval of two consecutive DENM transmissions. It may be used for the forwarder ITS-S operation.
Data setting and presentation requirements	This DE is optional. If the ITS application of the originator 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 repeated or forwarded by the originator ITS-S and the forwarder ITS-S. This DE shall be presented as specified in Annex A.

B.54 turningRadius

Description	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. This DE is included in the impactReduction container. When a trailer is present, this DE shall provide the turning radius of the vehicle.
Data setting and presentation requirements	This DE is represented in unit of 1/4 meters. Values equal or higher than 254 shall be set to 254. Value 255 shall be set if the data is unavailable. This DE shall be presented as specified in [5] TurningRadius.

B.55 validityDuration

Description	Time at which the DENM should be deleted from the DEN basic service. The <i>validityDuration</i> is set by the originator ITS-S. Therefore it is only an estimation of how long the event may persist. It implies the duration over which the DENM should be kept at the DEN basic service of the receiver ITS-S and the DENM dissemination be maintained in the relevance area, until the expiration of <i>validityDuration</i> or until a cancellation DENM or a negation DENM is received. In case the expiry time of the event cannot be estimated at the originator ITS-S, a default value is used for DENM protocol. This DE may be renewed by the originator ITS-S, if the pre-set expiry time has reached to its limit and the originator ITS-S detects that the event persists. The <i>actionID</i> shall be remained unchanged when the <i>validityDuration</i> is renewed.
Data setting and presentation requirements	The DE is represented as a time offset in the unit of second since <i>detectionTime</i> . This DE is optional. It shall be present if the information is provided by the ITS application of the originator ITS-S. This DE shall be presented as specified in Annex A.

B.56 vehicleIdentification

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

B.57 vehicleMass

Description	This DE indicates the mass of a vehicle. This DE is included in the <i>impactReduction</i> container.
Data setting and presentation requirements	This DE is represented in unit of 100 kilograms. Values equal or higher than 1 023 shall be set to 1 023. Value 1 024 shall be set if the data is unavailable. This DE shall be presented as specified in [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> container.
Data setting and presentation requirements	This DE is represented in unit of 10 centimetres. Values equal or higher than 126 shall be set to 126. Value 127 shall be set if the data is unavailable. This DE shall be presented as specified in [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

Document history		
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