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Foreword

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

Modal verbs terminology

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Introduction

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

The Release 1 edition of the DEN basic service has been published as ETSI EN 302 637-3 [i.13]. The present document is the first Release 2 version and provides the improved specification of the Release 1 version as a basis for future Release 2 versions of the DEN basic service: future versions of the present document will specify extensions to the DENM Release 1 format to support additional Day 2 and Day 3 use cases in a way allowing the facilities layer standard to be used with different security and lower layer technologies.

All future Release 2 versions will be based on this latest Release 1 version of the DEN basic service and will be backwards compatible with it in the sense that Release 1 implementations can receive and decode Release 2 DENM and utilize the Release 1 content without the need to understand the Release 2 content.

1 Scope

The present document provides the specification of the Release 2 DEN basic service.

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

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

2 References

2.1 Normative references

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

Referenced documents which are not found to be publicly available in the expected location might be found at https://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.

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

[1] ETSI TS 103 836-4-1: "Intelligent Transportation Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality; Release 2".

[2] ETSI TS 103 836-5-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol; Release 2".

[3] ETSI TS 102 965: "Intelligent Transport Systems (ITS); Application Object Identifier (ITS-AID); Registration; Release 2".

[4] ETSI TS 103 899: "Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition; Release 2".

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

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

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

[8] ETSI TS 103 097: "Intelligent Transport Systems (ITS); Security; Security header and certificate formats; Release 2".

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

2.2 Informative references

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

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

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

[i.1] ETSI TR 102 638 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions".

[i.2] Car2Car Communication Consortium: "Basic System Profile".

NOTE: Available at https://www.car-2-car.org/documents/basic-system-profile/.

[i.3] Car2Car Communication Consortium: Guidance for day 2 and beyond roadmap.

NOTE: Available at https://www.car-2-car.org/documents/general-documents/.

[i.4] C-Roads: "Harmonised C-ITS Specifications for Europe".

NOTE: Available at https://www.c-roads.eu/fileadmin/user_upload/media/Dokumente/Harmonised_specs_text.pdf.

[i.5] ETSI EN 302 895: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Local Dynamic Map (LDM)".

[i.6] ETSI TS 103 898: "Intelligent Transport Systems (ITS); Communications Architecture; Release 2".

[i.7] ETSI TS 103 836-3: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network Architecture; Release 2".

[i.8] ISO EN 17419: "Intelligent Transport Systems - Cooperative Systems - Classification and management of ITS applications in a global context".

[i.9] ETSI TS 102 723-5: "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 5: Interface between management entity and facilities layer".

[i.10] ETSI TS 102 723-8: "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 8: Interface between security entity and network and transport layer".

[i.11] ETSI TS 102 723-9: "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 9: Interface between security entity and facilities layer".

[i.12] ETSI TS 102 723-11: "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 11: Interface between networking and transport layer and facilities layer".

[i.13] ETSI EN 302 637-3 (V1.3.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

[i.14] ETSI TS 103 301: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services; Release 2".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 301 [i.14], ETSI TS 103 898 [i.6], ETSI TS 102 894-2 [5], ETSI EN 302 895 [i.5] and the following apply:

actionId: identifier of an detected event

À La Carte container: container of DENM that includes information of the detected event in addition to management container, situation container and location container

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

awareness area: geographic area in which information concerning the event is potentially applicable for use or for further distribution

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

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

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

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

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

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

destination area: geographical area for DENM dissemination

NOTE: The destination area is specified in ETSI TS 103 899 [4].

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

event: road hazard, driving environment, or traffic condition

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

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

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

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

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

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

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

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

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

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

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

3.2 Symbols

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

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

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

repetitionDuration	Duration of the DENM repetition
repetitionInterval	Time interval of the DENM repetition
stationId	Identifier of an ITS-S
T_F_Validity	Timer that indicates the end of the DENM processing of one specific actionId of the forwarding ITS-S
T_Forwarding	Timer for the scheduling of the DENM forwarding by the forwarding ITS-S
T_O_Validity	Timer that indicates the end of the DENM processing of one specific actionId of the originating ITS-S
T_R_Validity	Timer that indicates the end of the DENM processing of one specific actionId of the receiving ITS-S
T_Repetition	Timer for the scheduling of the DENM repetition by the originating ITS-S
T_RepetitionDuration	Timer that indicates the end of the DENM repetition
termination	Parameter that indicates the termination of an event
transmissionInterval	Time interval for DENM transmission
validityDuration	Duration of the DENM validity

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 898 [i.6] and the following apply:

ASN.1	Abstract Syntax Notation One
BSA	Basic Set of Applications
BTP	Basic Transport Protocol
C2C-CC	Car to Car Communication Consortium
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
EEBL	Electronic Emergency Break Light
FA-SAP	Facilities-Application Service Access Point
GN	GeoNetworking
HMI	Human Machine Interface
ISO	International Standardization Organization
ITS	Intelligent Transport System
ITS-AID	ITS-Application IDentifier
ITS-S	ITS Station
KAF	Keep Alive Forwarding
LDM	Local Dynamic Map
MF-SAP	Management Facilities Service Access Point

MSB	Most Significant Bit
NF-SAP	Network Facilities Service Access Point
OSI	Open System Interconnection
PCI	Protocol Control Information
PDU	Protocol Data Unit
PER	Packed Encoding Rules
SF-SAP	Security Facilities Service Access Point
SSP	Service Specific Permissions
TS	Technical Specification

4 DEN basic service introduction

4.1 Background

The Decentralized Environmental Notification basic service (DEN) is an application support functionality operating at the facilities layer. The DEN basic service is responsible for the generation of DEN Messages (DENMs) based on received triggering information from applications. It is also responsible for the processing of received DENMs from other C-ITS stations. The DEN service is especially suited for the exchange of event based safety related information. The DENM information is mainly used by ITS applications in order to alert road users of a detected event using ITS communication technologies. DENM is used to describe a variety of events that can be detected by ITS stations (ITS-S). A set of ITS applications, ITS services and use cases for Day 1 are specified in the ETSI Basic Set of Applications [i.1], in the C2C-CC Basic System Profile [i.2] and the C-Roads Release [i.4]. Further Day 2 and Day 3 use cases are specified in the C2C-CC Roadmap [i.3].

The dissemination of DENM by a ITS-S 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 DENMs in order to disseminate the information about this event to other ITS-Ss located inside a destination area . The ITS-S that generates the DENM is denoted as originating ITS-S.
- DENM transmission is initiated and terminated by an ITS-S application at the ITS application layer.
- The transmission of a DENM may be repeated.
- DENM transmission may persist as long as the event is present.
- An ITS-S may forward a DENM. This ITS-S is denoted as forwarding ITS-S.
- The termination of DENM transmission is either automatically achieved by the facilities layer, i.e. the DEN basic service of the originating ITS-S when a predefined expiry time is reached, or by an ITS-S application that requests the generation of a DENM to inform that the event has terminated.
- An ITS-S, which receives a DENM, processes the information and may decide to present an appropriate warning or information to user, as long as the information in the received DENM is relevant to the ITS-S. This ITS-S is denoted as receiving ITS-S.

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

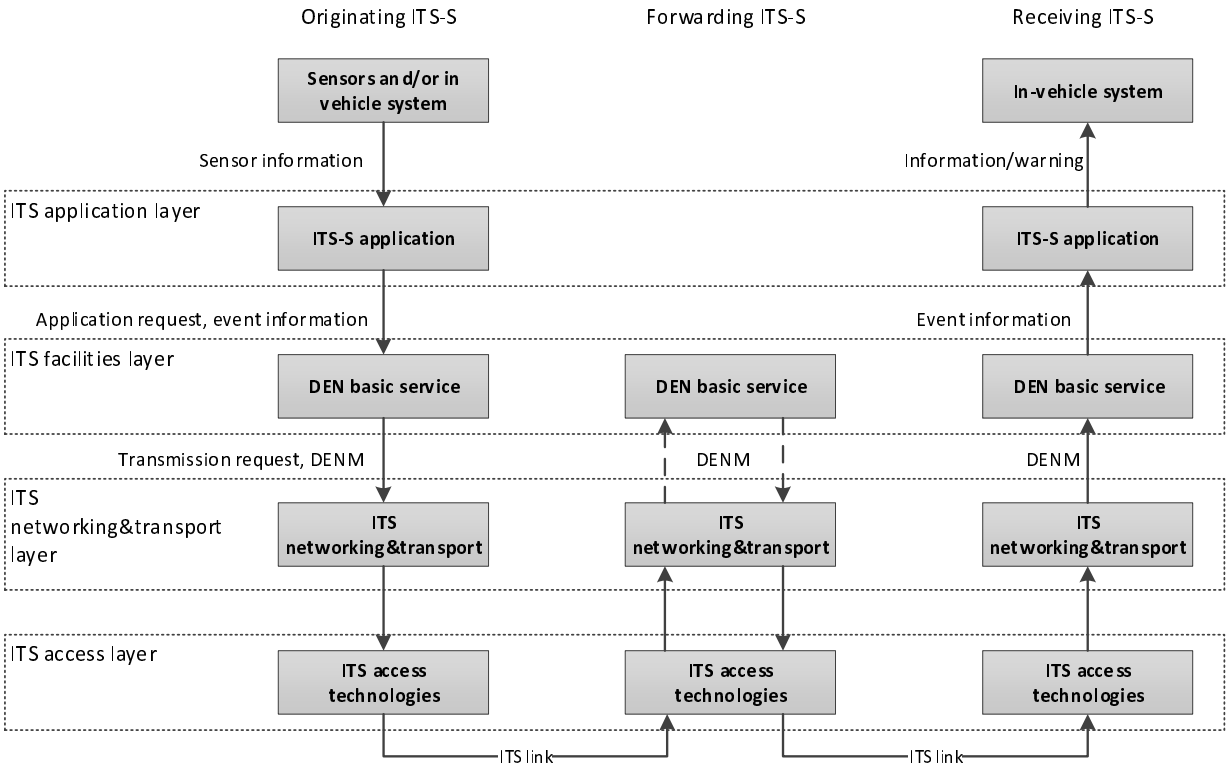

Figure 1: General data flow for ITS-S application supported by the DEN basic service

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

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

4.2 Services provided by the DEN basic service

The DEN basic service provides services to entities at the ITS application layer. At the originating ITS-S, an ITS-S application may trigger, update and terminate the transmission of DENMs. At the receiving ITS-S, the DEN basic service processes received DENMs and makes the information available for usage by ITS-S applications. Optionally, the DEN basic service may also provide forwarding functionality.

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

NOTE 1: Typically, for road safety ITS applications, the destination of a DENM transmission are ITS-Ss that are located in a pre-defined geographic area in which the event information may be relevant for traffic participants, e.g. close to the detected event position.

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

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

In some situations, the originating ITS-S transmits a DENM of an event originated by the vehicle itself, such as an electronic brake light event. The originating ITS-S manages the transmission and the termination of the DENM for this event. However, in some other situations, DENMs related to the same event may be transmitted by more than one originating ITS-Ss that detect the same event, such as several vehicle ITS-Ss travelling through the same location. In yet some other situations, the event might instead or additionally be detected by roadside sensors connected to a traffic management centre and the event information relayed to selected roadside ITS-S(s) to generate and transmit DENMs within or near to the destination area. In addition, in case the originating ITS-S is mobile (e.g. vehicle ITS-S or personal ITS-S), an event may persist even after the originating ITS-S has moved to a position far from the event position. For example, multiple vehicle ITS-Ss may detect black ice on the road surface and transmit DENMs. These DENMs can optionally be maintained by and relayed to other ITS-Ss, even after the detecting vehicle ITS-Ss have left the black ice location.

The DENM protocol is designed to manage these situations. The following DENM types are defined:

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

NOTE 3: Whether a negation DENM is transmitted may depend on the application requirements and the deployment requirements defined for example in the C2C-CC Basic System Profile [i.2] and the C-Roads Release [i.4]. Therefore, definition of conditions under which the generation and transmission of negation DENM is allowed is out of scope of the present document.

The DEN basic service of the originating ITS-S shall be able to generate at least DENMs of type New and Update. The generation of Cancellation and Negation DENMs is optional. The ITS-S application of the originating ITS-S sends an application request to the DEN basic service in order to trigger the generation of DENMs. The type of the DENM to be generated depends on the type of the application request.

Due to the different detection capabilities of ITS-Ss, the quality of the provided information in a DENM may vary. However, predefined conditions are to be satisfied by an ITS-S in order to initiate and terminate the transmission of DENMs for a specific event. These conditions are specified as ITS application requirements in the C2C-CC Basic System Profile [i.2] and the C-Roads Release [i.4].

5 DEN basic service functional specification

5.1 Introduction

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

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

5.2 DEN basic service in the ITS architecture

The DEN basic service is a facilities layer entity that implements the DENM protocol. It interfaces with ITS-S applications in order to receive the application request for DENM transmission and to provide the received DENM content to the ITS-S applications. Furthermore, the DEN basic service may interact with other facilities layer entities, in particular the Local Dynamic Map (LDM) as defined in ETSI EN 302 895 [i.5], which is a facilities layer database. At the receiving ITS-S, the LDM may be updated with a received DENM and ITS-S applications may retrieve event related information from the LDM database for further processing.

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

Figure 2 presents the DEN basic service in the ITS-S architecture as defined in ETSI TS 103 898 [i.6] as well as its logical interfaces with other entities and layers.

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

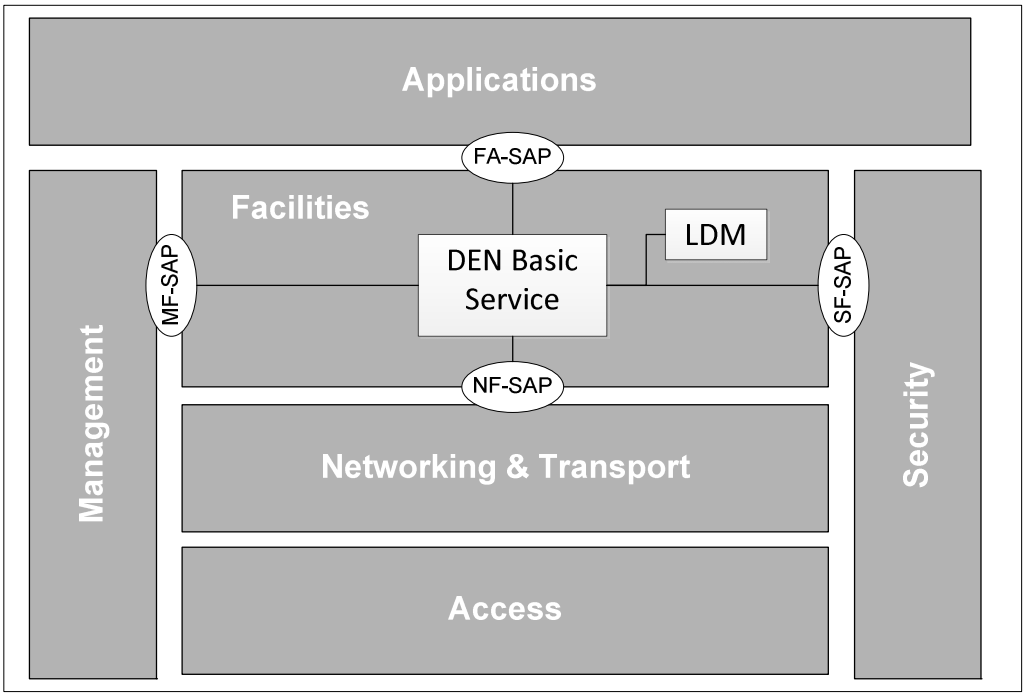

Figure 2: DEN basic service and logical interfaces

The operation of the DEN basic service on ITS infrastructure devices is specified in ETSI TS 103 301 [i.14].

5.3 DEN basic service functional architecture

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

- Generate DENM:
  - This sub-function defines the actual content of the DENM based on input from the ITS-S applications and encodes a DENM according to the format specified in Annex A of the present document.
- Decode DENM:
  - This sub-function decodes a received DENM.
- DENM transmission management:
  - This sub-function implements the DENM protocol operation of the originating ITS-S as specified in clause 8.2, including in particular:
    - The generation of a new DENM as requested by the ITS-S applications at the originating ITS-S.
    - The generation of an update DENM as requested by the ITS-S applications at the originating ITS-S.
    - The termination of the DENM transmission as requested by the ITS-S applications at the originating ITS-S.

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

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

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

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

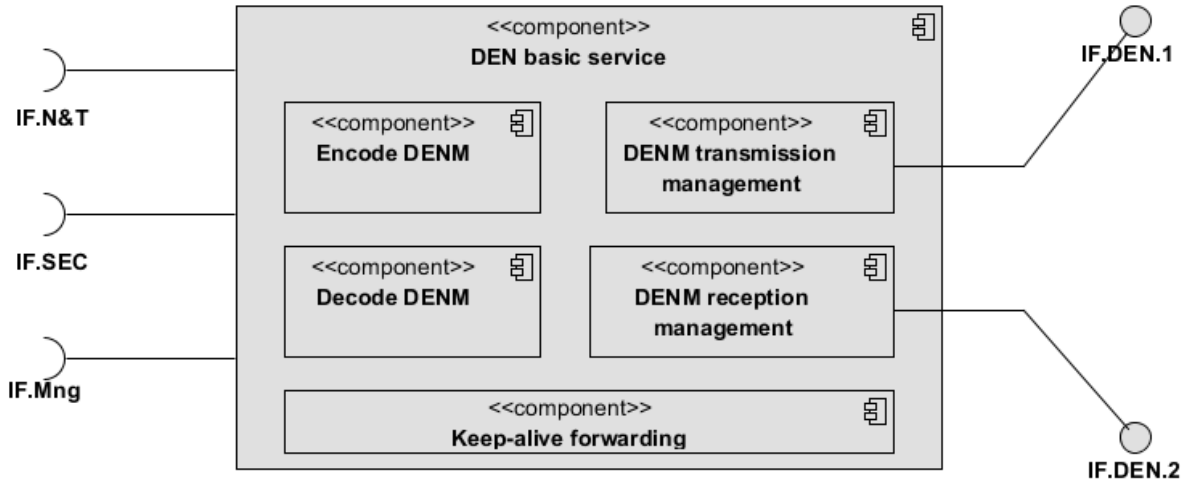

Figure 3: DEN basic service component diagram

5.4 Interfaces of the DEN basic service

5.4.1 Interfaces to the ITS application layer

5.4.1.1 Introduction

An ITS-S application can request the generation of different types of DENM as specified in clause 4.2, according to pre-defined conditions, for example as specified in the C2C-CC Basic System Profile [i.2] and the C-Roads Release [i.4].

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

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

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

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

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

Table 1: Mapping between application request types and DENM types

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

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

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

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

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

Category	Data	Definition (see note 9)	Remarks
Data passed from ITS-S application to DEN basic service	Event detection time	*{DENM.denm.management.detectionTime*} as specified in Annex A.	
	Event position	*{DENM.denm.management.eventPosition*} as specified in Annex A.	
	Awareness area of the event	*Additionally to the event position: {DENM.denm.management.awarenessDistance}* and *{DENM.denm.management.awarenessTrafficDirection}* as specified in Annex A.	Optional (see note 6)
	Event validity duration	*{DENM.denm.management.validityDuration}* as specified in Annex A.	Optional (see note 1)
	Repetition duration	Duration of the DENM repetition in units of milliseconds, denoted as *repetitionDuration*.	Optional (see note 2)
	Transmission interval	*{DENM.denm.management.transmissionInterval}* as specified in Annex A.	Optional (see note 3)
	Repetition interval	Interval of DENM repetition in units of milliseconds, denoted as *repetitionInterval.*	Optional (see note 2)
	Information contained in the situation container	*{DENM.denm.situation}* as specified in Annex A. This also contains the relevance zone information.	Optional (see note 4 and note 6)
	Information contained in the location container	*{DENM.denm.location}* as specified in Annex A.	Optional (see note 4)
	Information contained in the À La Carte container	*{DENM.denm.alacarte}* as specified in Annex A.	Optional (see note 5)
	Destination area	Destination area for DENM dissemination as specified in ETSI TS 103 899 [4].	
	Traffic class	GN traffic class of the DENM as defined in ETSI TS 103 836-4-1 [1], if GeoNetworking/BTP is used.	
Data returned from DEN basic service to the requesting ITS-S application	actionId or other applicable identifier (see note 7)	*{DENM.denm.management.actionId*} as specified in Annex A. The DEN basic service returns the *actionId* or other applicable identifier created by the DEN basic service to the requesting ITS-S application, in case the request was successfully handled.	
	Failure notification	The DEN basic service returns a failure notification to the requesting application under the condition as specified in clause 8.	Optional (see note 8)

Category	Data	Definition (see note 9)	Remarks
NOTE 1: Applicable if the ITS-S application detects or estimates the event expiration time. NOTE 2: Applicable if the ITS-S application requests the DENM repetition. NOTE 3: Applicable if the ITS-S application requests the KAF for the DENM. NOTE 4: As alternative of providing data via IF.DEN.1, the requesting ITS-S application may request DEN basic service to collect data from other facilities of the facilities layer. NOTE 5: Applicable if the ITS-S application requests the transmission of an À La Carte container. NOTE 6: Alternatively applicable if the ITS-S application has the knowledge of the awareness area or relevance zone (see clauses 6.1.3.1 and 6.1.3.2). NOTE 7: An applicable identifier is associated to the *actionId* as created by the DEN basic service, it may be used for the interaction between the ITS-S application and the DEN basic service. NOTE 8: Applicable as specified in clause 8. NOTE 9: Data format is up to implementation.			

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

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

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

Category	Data	Definition (see note 7)	Remarks
Data passed from application to DEN basic service	*actionId* or other applicable identifier	*ActionID* or other applicable identifier for which the update is detected (see note 1). *{DENM.denm.management.actionId*} as specified in Annex A.	
	Event update detection time	*{DENM.denm.management.detectionTime*} as specified in Annex A.	
	Event position	*{DENM.denm.management.eventPosition*} as specified in Annex A.	
	Awareness area of the event	*Additionally to the event position: {DENM.denm.management. awarenessDistance}* and {*DENM.denm.management. awarenessTrafficDirection}* as specified in Annex A.	Optional (see note 2 and note 5)
	Event validity duration	*{DENM.denm.management.validityDuration}* as specified in Annex A.	Optional (see note 2)
	Repetition duration	Duration of the DENM repetition in units of milliseconds, denoted as *repetitionDuration*.	Optional (see note 2 and note 3)
	Transmission interval	*{DENM.denm.management.transmissionInterval}* as specified in Annex A.	Optional (see note 2 and note 4)
	Repetition interval	Interval of DENM repetition in units of milliseconds, denoted as *repetitionInterval.*	Optional (see note 2 and note 3)
	Information contained in the situation container	*{DENM.denm.situation}* as specified in Annex A. This also contains the relevance zone information.	Optional (see note 2 and note 5)
	Information contained in the location container	*{DENM.denm.location}* as specified in Annex A.	Optional (see note 2)
	Information contained in the À La Carte container	*{DENM.denm.alacarte}* as specified in Annex A.	Optional (see note 2)
	Destination area	Destination area for DENM dissemination as specified in ETSI TS 103 899 [4].	
	Traffic class	GN traffic class of the DENM as defined in ETSI TS 103 836-4-1 [1], if GeoNetworking/BTP is used.	Optional (see note 2)

Category	Data	Definition (see note 7)	Remarks
Data returned from DEN basic service to the requesting application	*actionId* or other applicable identifier (see note 1)	*{DENM.denm.management.actionId}* as specified in Annex A. The DEN basic service returns the *actionId* or other applicable identifier created by the DEN basic service to the requesting ITS-S application.	
	Failure notification	The DEN basic service returns a failure notification to the requesting application under the condition as specified in clause 8.	Optional (see note 6)
NOTE 1: An applicable identifier is associated to the *actionId* as created by the DEN basic service, it may be used for the interaction between the ITS-S application and DEN basic service. NOTE 2: Applicable if an update of the data is detected. NOTE 3: Applicable if the ITS-S application requests the DENM repetition. NOTE 4: Applicable if the ITS-S application requests the KAF for the DENM. NOTE 5: Applicable if the ITS-S application has the knowledge of the awareness area or the relevance zone (see clause 6.1.3.1 and 6.1.3.2). NOTE 6: Applicable as specified in clause 8. NOTE 7: Data format is up to implementation.			

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

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

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

Category	Data	Definition (see note 7)	Remarks
Data passed from application to DEN basic service:	*actionId* or other applicable identifier	*actionId* or other applicable identifier for which the termination is detected (see note 1). *{DENM.denm.management.actionId}* as specified in Annex A.	
	Event termination detection time	*{DENM.denm.management.detectionTime}* as specified in the Annex A.	
	Event position	Position at which the event termination is detected. *{DENM.denm.management.eventPosition}* as specified in Annex A.	
	Awareness area of the event	*Additionally to the event position: {DENM.denm.management. awarenessDistance}* and *{DENM.denm.management. awarenessTrafficDirection}* as specified in Annex A.	Optional (see note 2 and note 5)
	Event validity duration	Validity of the event termination information. *{DENM.denm.management.validityDuration}* as specified in Annex A.	Optional (see note 2)
	Repetition duration	Duration of the DENM repetition in units of milliseconds, denoted as *repetitionDuration*.	Optional (see note 3)
	Transmission interval	*{DENM.denm.management.transmissionInterval}* as specified in Annex A.	Optional (see note 4)
	Repetition interval	Interval of DENM repetition in units of milliseconds, denoted as *repetitionInterval*.	Optional (see note 3)
	Destination area	Destination area for DENM dissemination as specified in ETSI TS 103 899 [4]	
	Traffic class	GN traffic class of the DENM as defined in ETSI TS 103 836-4-1 [1], if GeoNetworking/BTP is used.	

Category	Data	Definition (see note 7)	Remarks
Data returned from DEN basic service to the requesting application	*actionId* or other applicable identifier (see note 1)	*{DENM.denm.management.actionId}* as specified in Annex A. The DEN basic service returns the *actionId* or other applicable identifier created by the DEN basic service to the requesting ITS-S application.	
	Failure notification	The DEN basic service returns a failure notification to the requesting application under the condition as specified in clause 8.	Optional (see note 6)
NOTE 1: An applicable identifier is associated to the *actionId* as created by the DEN basic service, it may be used for the interaction between the ITS-S application and DEN basic service. NOTE 2: Applicable if the application detects the event termination information expiry time. NOTE 3: Applicable if the application requests the DENM repetition. NOTE 4: Applicable if the ITS-S application requests the KAF for the DENM. NOTE 5: Applicable if the ITS-S application has the knowledge of the awareness area (see clause 6.1.3.1 and 6.1.3.2). NOTE 6: Applicable as specified in clause 8. NOTE 7: Data format is up to implementation.			

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

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

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

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

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

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

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

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

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

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

5.4.2 Interface to the ITS networking & transport layer

5.4.2.1 General requirements

The DEN basic service exchanges information with the ITS networking & transport layer via the interface IF.N&T (Figure 3).

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

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

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

Category	Data	Definition (see note 3)	Remarks
Data passed from DEN basic service to the ITS networking & transport layer	DENM	*{denm}* as specified in Annex A.	
	Destination area	Destination area for DENM dissemination. The definition of DENM destination area shall be as specified in ETSI TS 103 899 [4].	
	Repetition interval	In units of milliseconds.	Optional (see note 1)
	its_aid	See SN-SIGN in ETSI TS 102 723-8 [i.10] and ETSI TS 102 965 [3] for the ITS-AID value.	Optional (see note 4)
	permissions	See SN-SIGN in ETSI TS 102 723-8 [i.10] and clause 6.2.2.2 for the permissions.	Optional (see note 4)
Data passed from the ITS networking & transport layer	Received DENM	*{denm}* as specified in Annex A.	Optional (see note 2)
	report	See SN-VERIFY in ETSI TS 102 723-8 [i.10]	Optional (see note 4)
	Certificate_id	See SN-VERIFY in ETSI TS 102 723-8 [i.10]	Optional (see note 4)
	its_aid	See SN-VERIFY in ETSI TS 102 723-8 [i.10]	Optional (see note 4)
	permissions	See SN-VERIFY in ETSI TS 102 723-8 [i.10]	Optional (see note 4)
NOTE 1: Applicable if the ITS-S application requests the DENM repetition by the ITS networking & transport layer. The repetition may also be performed by the DEN basic service at the facility layer as described in clause 5.4.1. NOTE 2: Applicable of the receiving ITS-S is considered by the ITS networking & transport layer as inside the destination area. NOTE 3: Data format is up to implementation. NOTE 4: Present only if ETSI ITS security [8] and [9] at the network layer security is used.			

5.4.2.2 Interface to the GeoNetworking/BTP stack

The DEN basic service may use the GeoNetworking/BTP protocol stack to disseminate a DENM to a destination area.

If the GeoNetworking/BTP protocol stack is used, BTP header type B as specified in ETSI TS 103 836-5-1 [2] and GeoBroadcast protocol as specified in ETSI TS 103 836-4-1 [1] shall be used for the DENM dissemination.

Data being passed between the DEN basic service and the GeoNetworking/BTP stack is specified in Table 6 and in Table 7 and goes through the NF-SAP ETSI TS 102 723-11 [i.12].

In case network layer security is used, GN security profile shall be set to SECURED.

In case facility layer security is used, GN security profile shall be set to UNSECURED.

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

Category	Data	Requirement (see note 3)	Remarks
Data passed from the DEN basic service to GeoNetworking/BTP	BTP type	BTP header type B (ETSI TS 103 836-5-1 [2], clause 7.2.2).	Optional (see note 1)
	Destination port	As specified in ETSI TS 103 836-5-1 [2]. (see note 2).	Optional (see note 1)
	Destination port info	As specified in ETSI TS 103 836-5-1 [2].	Optional (see note 1)
	GN Packet transport type	GeoNetworking GeoBroadcast protocol.	Optional (see note 1)
	GN Destination address	Specified as Destination area in Table 6.	
	GN communication profile	Unspecified, ITS G5 or LTE-V2X.	Optional (see note 1)
	GN security profile	SECURED or UNSECURED.	Optional (see note 1)
	Traffic class	As defined in ETSI TS 103 836-4-1 [1].	
	GN Maximum packet lifetime	Shall not exceed *validityDuration.*	Optional (see note 1)
	GN Hoplimit		Optional (see note 1)
	Length	Length of the DENM.	
NOTE 1: Applicable if the value is not provided or different from the ITS-S configuration. NOTE 2: When a global registration authority for ITS application ISO EN 17419 [i.8] is operational, the BTP destination port registered with this authority should be used. NOTE 3: Data format is up to implementation.			

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

The DEN basic service may use the IPv6 protocol stack or the combined IPv6/GeoNetworking protocol stack as defined in ETSI TS 103 836-3 [i.7] for DENM dissemination.

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

NOTE 2: In case IP based transport is used to transfer the facility layer DENM between interconnected actors, security constraints as outlined in clause 6.1.1.2 and clause 6.2.2 may not be applicable. This is because trust among the participating actors, e.g. using mutual authentication, and authenticity of information can be based on other standard IT security methods, such as IPSec, DTLS, TLS or other VPN solutions that provide an end to end secure communication path between known actors.

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

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

5.4.3 Interface to the ITS management entity

The DEN basic service may exchange information with the ITS management entity via the interface IF.Mng (Figure 3). The interface IF.Mng may be realized as the MF-SAP ETSI TS 102 723-5 [i.9].

5.4.4 Interface to the ITS security entity

In case facility layer security is used, the DEN basic service exchanges information directly with the ITS security entity via the interface IF.SEC (Figure 3).

NOTE 1: The interface IF.SEC goes through the SF-SAP ETSI TS 102 723-9 [i.11].

NOTE 2: in case ETSI ITS network layer security is used, the networking & transport layer interfaces with the ITS security entity through SN-SAP ETSI TS 102 723-8 [i.10].

6 DENM dissemination requirements

6.1 DENM dissemination concepts

6.1.1 Event identification

6.1.1.1 actionId

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

The *actionId* shall be the combination of an ITS-S ID and a sequence number. The ITS-S ID corresponds to *stationId* of the originating ITS-S that detects an event for the first time or to the virtual *stationId* of a central entity that provides the information to the ITS-S, e.g. a traffic management centre that provides data to a roadside ITS-S to be sent as DENM. The sequence number is assigned to the *actionId* for each new DENM.

For each new DENM, a value shall be assigned to a sequence number that has not been assigned together with the *stationId* value in a period of configurable length in the past.

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

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

6.1.1.2 *stationId* update and *actionId* management

ITS stations that are part of an ecosystem which use the trust model according to ETSI TS 102 940 [9] and ITS certificates according to ETSI TS 103 097 [8] and that are of type [Itss_WithPrivacy] as defined in ETSI TS 102 940 [9] shall implement functionalities that assigns temporal *stationIds* (pseudonyms) to be used at the facilities layer and to be included in a generated *actionId*. This *stationId* shall change over time as required in ETSI TS 102 940 [9] for [Itss_WithPrivacy].

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

NOTE: ITS stations of type [Itss_NoPrivacy] as defined in ETSI TS 102 940 [9] may not implement functionalities that assigns temporal stationIds (pseudonyms). ITS stations that are not part of an ecosystem, which uses the trust model according to ETSI TS 102 940 [9] and ITS certificates according to ETSI TS 103 097 [8] may not need to implement functionalities that assigns temporal stationIds (pseudonyms) either.

6.1.2 Trigger, update, repetition and termination of DENM

6.1.2.1 DENM trigger

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

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

6.1.2.2 DENM update

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

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

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

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

6.1.2.3 DENM repetition

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

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

- *repetitionInterval*.
- *repetitionDuration*.

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

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

6.1.2.4 DENM termination

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

- DENM termination by the originating ITS-S that requested the DENM trigger:
  - For originating ITS-S that requested the DENM trigger, the DEN basic service shall stop the DENM repetition automatically at the end of the *repetitionDuration.* The *repetitionDuration* may be updated by the ITS-S application of the originating ITS-S.
  - Moreover, before the expiration of the *validityDuration*, the originating ITS-S may detect the termination of the event. In this case, the DEN basic service shall generate a cancellation DENM as defined in clause 4.2. The parameter *termination* is used for the cancellation DENM. For the generation of a cancellation DENM, *termination* shall be set to *isCancellation*.
  - For the generation of a cancellation DENM, the *actionId* value shall be identical to the *actionId* as set for the application request *appDENM_trigger*, as long as the *stationId* remains unchanged.

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

- DENM termination by an originating ITS-S that has not requested the DENM trigger, i.e. that has not created *actionId* of the event for which the DENM termination is intended:
  - If an ITS-S has received a DENM from other ITS-S regarding an event, passes the indicated event position when the received DENM is still valid (i.e. *validityDuration* is not expired), and detects that the event has terminated, then the ITS-S application at this ITS-S may send a *AppDENM_termination* request to the DEN basic service, upon which the DEN basic service shall generate a negation DENM as defined in clause 4.2.

- The parameter *termination* is used for the negation DENM. For the generation of a negation DENM, *termination* shall be set to *isNegation*.

- For the generation of a negation DENM, the *actionId* shall be set to the *actionId* of the event for which the DENM negation refers to. The *referenceTime* shall be set to the value of the latest received DENM of the same *actionId* from the originating ITS, in order that the receiving ITS-S is able to match to which DENM the negation is reported by the negation DENM.

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

NOTE 3: The ITS-S that initiates the negation DENM satisfies some predefined conditions as defined by ITS applications.

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

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

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

6.1.3 Geographic location information

6.1.3.1 Awareness area

Depending on the use case as identified by the event type, the awareness area is defined by the ITS-S application of the originating ITS-S. The provided information shall be included in the DENM as made available to the DEN basic service. A receiving ITS-S may make use of the awareness area information in order to prepare for possible actions, such as giving input to the vehicle´s Human Machine Interface.

According to the event type and the event location, the size and the shape of the awareness area varies. The awareness area may be defined as:

- Single circular awareness area: this option can be used for use cases where the event is located somewhere inside a (static or dynamic) circular area, such as:

  - The Hazardous Location Notification - Weather Condition Warning, Temporarily Slippery Road, or Animal or Person on the Road use cases defined in [i.4].

  - The Dangerous situation, Special Vehicle Warning, Stationary Vehicle Warning, Traffic Jam use cases defined in [i.2].

- Single linear awareness area: this option can be used for use cases where the event is located somewhere along a stretch of road such as the Hazardous Location Notification - Wrong Way Driver, Weather Condition Warning (first option) or Temporarily Slippery Road use cases defined in [i.4].

- Multiple circular awareness areas: this option can be used for use cases where the event is located somewhere inside multiple circular areas, such as the Weather Condition Warning (second option) use case defined in [i.2].

One or more of the following information shall be used as awareness area information as defined in Table 8:

- *eventPosition*: the centre position of the single circular awareness area.

- *awarenessDistance*: the radius of the circular awareness area in which the receiving ITS-S may encounter the event.

- *awarenessTrafficDirection*: the traffic direction along which the receiving ITS-S may encounter the event.

- *eventZone:*
  - option with eventDeltaTime ABSENT: a list of waypoints that together represent a linear awareness area.
  - option with eventDeltaTime PRESENT: a list of waypoints that each represents the centre position of a circular awareness area.

Table 8: awareness area information

awareness area type	*eventPosition*	*awarenessDistance*	*awarenessTrafficDirection*	*eventZone*
Single circular awareness area	Present	Present	Optional	Absent
Single linear awareness area	Present	Absent	Optional	Present, with eventDeltaTime ABSENT
Multiple circular awareness areas (see note)	Present	Present	Optional	Present, with eventDeltaTime PRESENT

The eventPosition, awarenessDistance, awarenessTrafficDirection and eventZone shall be as specified in Annex A.

NOTE: If a DENM contains an eventZone and a awarenessDistance component, multiple awareness areas exist. One area is located at the eventPosition component and each point in the eventZone component creates an additional, individual awareness area, each with the awarenessDistance as radius. In case of a Single linear awareness area, the lateral extension of the area is not provided. Any awareness or relevance analysis is up to the receiver in that case.

6.1.3.2 Relevance zone

Alternatively to the awareness area, and depending on the use case as identified by the event type, the relevance zone is defined by the ITS-S application of the originating ITS-S. The provided information shall be included in the DENM as made available to the DEN basic service. The eventType component implicitly indicates if an awareness area or a relevance zone is included in the DENM. A receiving ITS-S may make use of the relevance zone information in order to perform actions such as giving input to the vehicle´s Human Machine Interface or driving automation functions.

According to the event type and the event location, the size and the shape of the relevance zone varies. The relevance zone may be defined as:

- A point based relevance zone, i.e. a degenerate circle with radius zero located at the event position. This option can be used for use cases where the event is with high certainty located in a certain position, such as the Hazardous Location Notification – Accident Zone, Stationary Vehicle or Traffic Jam (dangerous end of queue) use cases or the Road Works Warning - Lane Closure and Road Closure use cases, e.g. providing the start of the closure of the lane, without extension information defined in [i.4].
- A single linear relevance zone, i.e. a polyline that starts at the event position. This option can be used for use cases where the event extends with high certainty over an entire stretch of road, such as the Hazardous Location Notification - Traffic Jam use case or the Road Works Warning - Lane Closure and Road Closure use cases, providing extension information, defined in [i.4].

One or more of the following information shall be used as relevance zone information as defined in Table 9:

- *eventPosition*: the position where the receiving ITS-S will encounter the event.
- *awarenessDistance*: always absent in case of relevance zone information.
- *awarenessTrafficDirection*: the traffic direction along which the receiving ITS-S will encounter the event.
- *eventZone:*
  - option with eventDeltaTime ABSENT: a list of waypoints that together represents a linear relevance zone where the receiving ITS-S will encounter the event.

Table 9: relevance zone information

relevance zone type	*eventPosition*	*awarenessDistance*	*awarenessTrafficDirection*	*eventZone*
Point based relevance zone	Present	Absent	Optional	Absent
Single linear relevance zone	Present	Absent	Optional	Present, with eventDeltaTime ABSENT

The eventPosition, awarenessDistance, awarenessTrafficDirection and eventZone shall be as specified in Annex A.

6.1.3.3 Detection zone

Complementary to the awareness area / relevance zone, a DENM provides detection zone information. A receiving ITS-S may compare its own itinerary with the detection zone information in order to detect the entering into a awareness area / relevance zone.

The component *traces* contains up to 7 paths, which represent lists of well-ordered waypoints that forms an itinerary approaching towards the event position, using the Data Frame *PathHistory*.

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

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

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

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

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

6.1.3.4 Destination area

The destination area is used by the ITS networking & transport layer for the DENM transmission. According to ETSI TS 103899 [4], three geometric shapes are defined, each shape being represented by the combination of one or several geographical point and distance information:

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

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

The size and the shape of the awareness area and/or relevance zone are not necessarily identical to the destination area. The DEN basic service shall provide the destination area in the format compliant to the one as specified in ETSI TS 103 899 [4] to the ITS networking & transport layer.

The destination area should be selected in a way that receivers are sufficiently informed in advance. As an example, for an accident on a motorway, the component awarenessTrafficDirection of a DENM related to the event may indicate the upstream direction of the accident location. In such cases, the destination area should cover more of the upstream area than of the downstream area. For an accident that occurred on rural two-way roads, the component awarenessTrafficDirection may indicate both traffic directions (also including the opposite carriageway). For such case, the destination area should be centred at the event to cover upstream and downstream parts equally.

6.1.4 DENM forwarding

6.1.4.1 Packet centric forwarding

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

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

NOTE: The specification of this function is out of scope of the present document. When GeoNetworking/BTP stack is used, this functionality is specified in ETSI TS 103 836-4-1 [1].

6.1.4.2 Keep-alive forwarding

The Keep-Alive Forwarding (KAF) functionality is optional for the DEN basic service.

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

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

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

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

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

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

6.2 DENM dissemination constraints

6.2.1 General confidence constraints

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

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

NOTE: According to the requirements of specific ITS-S application, data contained in a DENM may be obtained from different sources, e.g. from the in vehicle network or from ITS-S users via specific Human Machine Interface (HMI). Corresponding requirements are defined in ITS applications, ITS service and use case specifications such as the C2C-CC Basic System Profile [i.2] and the C-Roads Release [i.4].

6.2.2 General security constraints

6.2.2.1 Introduction

Clause 6.2.2 is applicable to ITS stations that are part of an ecosystem that uses the trust model according to ETSI TS 102 940 [9] and ITS certificates according to ETSI TS 103 097 [8]. The security mechanisms for ITS consider the authentication of messages transferred between ITS-Ss with certificates. A certificate indicates its holder's permissions, i.e. what statements the holder is allowed to make or privileges it is allowed to assert in a message signed by that certificate. The format for the certificates is specified in ETSI TS 103 097 [8]. Permissions are indicated by a pair of identifiers within the certificate, the ITS-AID and the SSP.

The ITS-Application Identifier (ITS-AID) indicates the overall type of permissions being granted: for example, there is an ITS-AID that indicates that the originating ITS-S is entitled to send DENMs, see ETSI TS 102 965 [3].

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

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

6.2.2.2 Service Specific Permissions (SSP)

DENMs shall be signed using private keys associated to Authorization Tickets of type explicit that contain SSPs of type BitmapSsp as specified in ETSI TS 103 097 [8].

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

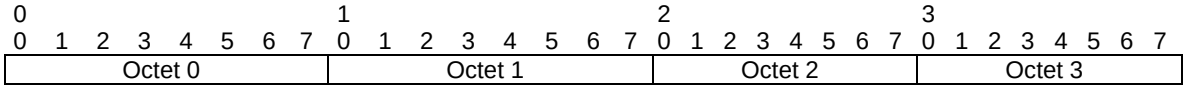

Figure 4: Format for the Octets

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

0	1	2	3	4	5	6	7
1	1	0	0	0	1	1	1

Figure 5: Example of octet presentation

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

0: No version, length 1 octet; the value shall only be used for testing purposes.

1: First version, length 4 octets.

2 to 255: Reserved for Future Usage.

The SSP has a maximum length as specified in ETSI TS 103 097 [8]. The first octet shall reflect the version of the present document. As future versions of the present document are published, the first octet shall be accordingly incremented. The second to fourth octet (octet 1 to octet 3 in Figure 4) is based on the *causeCode* types described in the clause 7.1.4.

Length of SSP is the length of the Octet String. Table 10 presents the octet scheme for DENM SSPs.

When the ITS Application Identifier (ITS-AID) is set for the DEN basic service, the permissions shall be as defined in Table 11.

Table 10: Octet Scheme for DENM SSPs

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

Table 11: SSP Definitions for DENM

Octet Position	Bit Position	CauseCodeType / Container	Bit Value
1	0 (0x80) (MSBit)	trafficCondition(1)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	1 (0x40)	accident(2)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	2 (0x20)	roadworks(3)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	3 (0x10)	adverseWeatherCondition-Adhesion(6)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	4 (0x08)	hazardousLocation-SurfaceCondition(9)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	5 (0x04)	hazardousLocation-ObstacleOnTheRoad(10)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	6 (0x02h)	hazardousLocation-AnimalOnTheRoad(11)	0: certificate not allowed to sign
			1: certificate allowed to sign
1	7 (0x01) (LSBit)	humanPresenceOnTheRoad(12)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	0 (0x80) (MSBit)	wrongWayDriving(14)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	1 (0x40)	rescueAndRecoveryWorkInProgress(15)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	2 (0x20)	adverseWeatherCondition-ExtremeWeatherCondition(17)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	3 (0x10)	adverseWeatherCondition-Visibility(18)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	4 (0x08)	adverseWeatherCondition-Precipitation(19)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	5 (0x04)	slowVehicle(26)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	6 (0x02)	dangerousEndOfQueue(27)	0: certificate not allowed to sign
			1: certificate allowed to sign
2	7 (0x01) (LSBit)	vehicleBreakdown(91)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	0 (0x80) (MSBit)	postCrash(92)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	1 (0x40)	humanProblem(93)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	2 (0x20)	stationaryVehicle(94)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	3 (0x10)	emergencyVehicleApproaching(95)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	4 (0x08)	hazardousLocation-DangerousCurve(96)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	5 (0x04)	collisionRisk(97)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	6 (0x02)	signalViolation(98)	0: certificate not allowed to sign
			1: certificate allowed to sign
3	7 (0x01) (LSBit)	dangerousSituation(99)	0: certificate not allowed to sign
			1: certificate allowed to sign

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

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

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

6.2.3 General priority constraints

The DENM priority is defined by the related use case specified in the C2C-CC Basic System Profile [i.2] and the C-Roads Release [i.4].

Priority information is provided in the PCI across the OSI layers and/or transmitted by lower layers as specified as Traffic Class in ETSI TS 103 836-4-1 [1]. Therefore, it is not included in a DENM.

7 DENM specification

7.1 DENM structure

7.1.1 General structure of a DENM

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

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

The component *denmPayload* represents the DENM payload and consists of four fixed order component:

- The component *management* represents the Management container and contains information related to the DENM management and the DENM protocol.
- The component *situation* represents the Situation container and contains information related to the type of the detected event.
- The component *location* represents the Location container and contains further information about the event location, and the detection zone information.
- The component *alacarte* represents the À La Carte container and contains information specific to the use case which requires the transmission of additional information that is not included in the three previous containers.

For all types of DENM, the ITS PDU header and the Management container shall always be present. The Situation container, the Location container and the À La Carte container are optional containers. For a cancellation DENM or a negation DENM, the Situation container, Location container and À La Carte container shall not be present. If the Situation container is present, the Location container shall be present as well. The À La Carte container is present only when applicable as specified in application specifications, such as the C2C-CC Basic System Profile [i.2] and the C-Roads Release [i.4].

The general structure of a DENM is illustrated in Figure 6. Each container is composed of a sequence of components, their component type being either a Data Element (DE) or a Data Frame (DF). A component is either optional or mandatory in the DENM Format. If not specified as optional in the present document, a component is considered as mandatory.

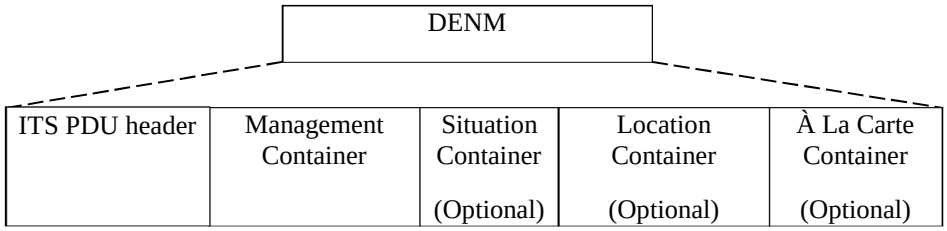

Figure 6: General structure of a DENM

7.1.2 ITS PDU header

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

7.1.3 DENM Management container

The Management container shall include the following information:

- *actionId*: Shall be as defined in clauses 6.1.1 and B.7.
- *detectionTime*: Shall be as defined in clause B.13.
- *referenceTime*: Shall be as defined in clause B.39.
- *termination*: Shall be as defined in clauses 6.1.2 and B.50.
- *eventPosition*: shall be as defined in clause B.15.
- *awarenessDistance:* As specified in clauses 6.1.3.1 and B.8.
- *awarenessTrafficDirection:* As specified in clauses 6.1.3.1 and B.9.
- *validityDuration*: Shall be as defined in clause B.55.
- *transmissionInterval:* Shall be as defined in clause B.53.
- *stationType:* Shall be as specified in clause B.49.

7.1.4 DENM Situation container

The Situation container includes information that describes the detected event. It shall include at least the components: *informationQuality* and *eventType*, and may include the components *linkedCause* and *eventZone*, as follows:

- *informationQuality*: Shall be as defined in clause B.25.
- *eventType:* This component provides a description of the event type being detected. It shall be as defined in clause B.18.
- *linkedCause:* This component indicates an event which may be linked with the eventType. It shall be as defined in clause B.28.

NOTE: 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.

- *eventZone:* It shall be as defined in clause B.19.

7.1.5 DENM Location container

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

- *eventSpeed*: Shall be defined in clause B.17.
- *eventPositionHeading:* Shall be as defined in clause B.16.
- *traces*: Shall be as specified in clauses 6.1.3.2 and B.51.
- *roadType:* Shall be defined in clause B.42.

7.1.6 DENM À La Carte container

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

All information included in the À La Carte container is optional. It shall be present when the data is provided by the ITS-S application.

The present document defines the following use case specific components of the À La Carte container:

- *lanePosition:* This information may be added to indicate the corresponding lane position of the event position. It shall be as defined in clause B.26.
- *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.23.
- *externalTemperature:* This information may be added for the adverse weather condition use case. It indicates the ambient temperature at the event position. It shall be as defined in clause B.20.
- *roadWorks:* This container may be added for the roadwork use case. 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. It indicates the type of positioning solution being used for the resolution of the event position. It shall be as defined in clause B.32.
- *stationaryVehicle:* This container may be added for the stationary vehicle use case. It shall be as defined in clause B.48.

7.2 DENM format specification

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

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

Detailed descriptions of all components of DENM are presented in the normative Annex B of the present document.

Unaligned Packed Encoding Rules (PER) as defined in Recommendation ITU-T X.691/ISO/IEC 8825-2 [6] shall be used for DENM encoding and decoding.

8 Protocol operation of the DEN basic service

8.1 Introduction

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

- originating ITS-S operation (clause 8.2);
- forwarding ITS-S operation (clause 8.3); and
- receiving ITS-S operation (clause 8.4).

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

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

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

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

8.2 Originating ITS-S operation

8.2.1 Protocol data setting rules

8.2.1.1 General requirements

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

8.2.1.2 *actionId*

For the application request type AppDENM_trigger, actionId shall be assigned as defined in clause 6.1.1.1.

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

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

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

8.2.1.3 *referenceTime*

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

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

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

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

8.2.1.4 *termination*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

8.2.1.6 Originating ITS-S message table

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

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

- ACTIVE state: The *termination* data is not set for DENM entry of the *actionId*.

- CANCELLED state: The *termination* value is set to 0 for DENM entry of the *actionId*.
- NEGATED state: The *termination* value is set to 1 for DENM entry of the *actionId*.

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

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

8.2.2 General protocol operation

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

For application request type *appDENM_trigger:*

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

For application request type *appDENM_update:*

1) Calculate expiration time for timer *T_O_Validity* (clause 8.2.1.5):
   a) If expiration time of timer *T_O_Validity is* in the past, send a failure notification to the ITS-S application and omit the execution of further steps.
   b) Otherwise, continue the operation.
2) Compare *actionId* in the application request with entries in the originating ITS-S message table:
   a) If *actionId* provided by the ITS-S application request does not exist in the originating ITS-S message table, send a failure notification to the ITS-S application and omit the execution of further steps.

b) Otherwise, continue the operation.

3) Stop *T_O_Validity*, *T_RepetitionDuration* and *T_Repetition* if applicable.

4) If *transmissionInternval* is provided by the application request:

a) Set transmissionInterval.

b) Otherwise, continue the operation.

5) Set other fields of DENM management container, situation container, location container and À La Carte container (Annex A).

6) Set *referenceTime* to the current time.

7) Generate the DENM.

8) Pass the DENM to the ITS networking & transport layer.

9) Update the entry in the originating ITS-S message table.

10) Start/restart timer *T_O_Validity*.

11) If *repetitionDuration* > 0 and *repetitionInterval* > 0:

a) Calculate and restart timer *T_RepetitionDuration* and *T_Repetition.*

b) Otherwise, continue the operation.

12) Send *actionId* to the requesting ITS-S application.

13) End.

For application request type *appDENM_termination:*

1) Set expiration time for timer *T_O_Validity* (clause 8.2.1.5):

a) If expiration time of timer *T_O_Validity* is in the past, send a failure notification to the ITS-S application and omit the execution of further steps.

b) Otherwise, continue the operation.

4) Compare *actionId* in the application request with entries in the originating ITS-S message table and the receiving ITS-S message table:

a) If *actionId* exists in the originating ITS-S message table and the entry state is ACTIVE, then set *termination* to *isCancellation*.

b) If *actionId* exists in the receiving ITS-S message table and, if applicable, the SSP is valid for that *CauseCode*; the entry state is ACTIVE, then set *termination* to *isNegation*.

c) Otherwise, send a failure notification to the ITS-S application and omit the execution of further steps.

5) Set *referenceTime:*

a) If *termination* is set to 0, set *referenceTime* to the current time.

b) If *termination* is set to 1, set *referenceTime* to the *referenceTime* value of receiving ITS-S message table DENM entry.

6) Stop *T_O_Validity*, *T_RepetitionDuration* and T_*Repetition* if applicable.

7) If *transmissionInternval* is provided by the application request:

a) Set transmissionInterval.

b) Otherwise, continue the operation.

8) Set other fields of the DENM management container (Annex A).

9) Generate the DENM.

10) Pass the DENM to the ITS networking & transport layer.

11) Update the entry:

    a) If *termination* is set to 0, update the entry in the originating ITS-S message table and set the state to CANCELLED.

    b) If *termination* is set to 1, create an entry in the originating ITS-S message table and set the state to NEGATED.

12) Start/restart timer *T_O_Validity*.

13) If *repetitionDuration* > 0 and *repetitionInterval* > 0:

    a) Calculate and restart timer *T_RepetitionDuration* and *T_Repetition.*

    b) Otherwise, continue the operation.

14) Send *actionId* to the requesting ITS-S application.

15) End.

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

1) Stop timer *T_Repetition* if exists.

2) Stop timer *T_RepetitionDuration* if exists.

3) Discard the expired DENM entry from the originating ITS-S message table.

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

1) Stop timer *T_Repetition*.

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

2) Pass the DENM to ITS networking & transport layer.

3) Restart timer *T_ Repetition*.

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

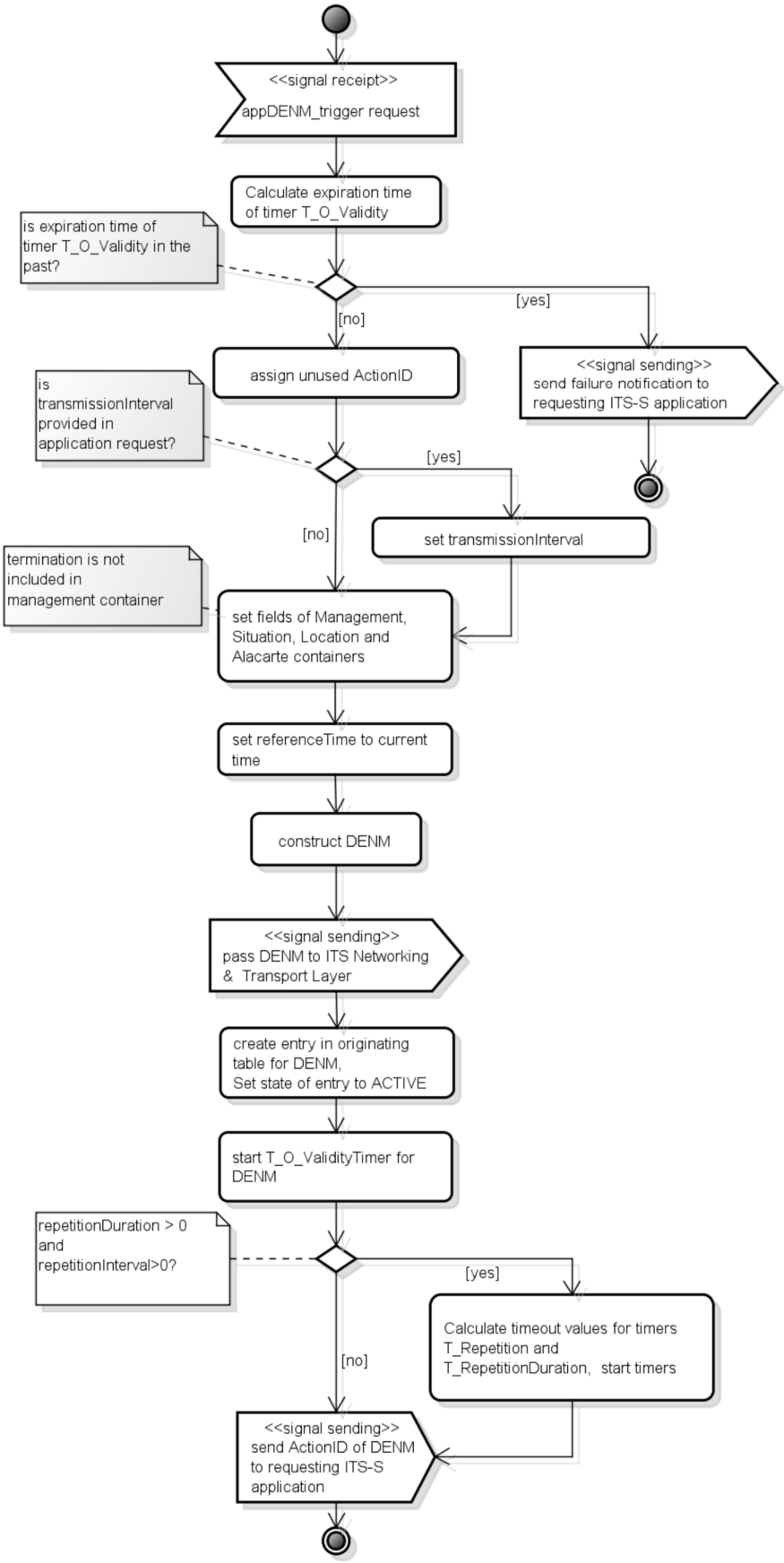

Figure 7: Originating ITS-S activity diagram: appDENM_trigger request

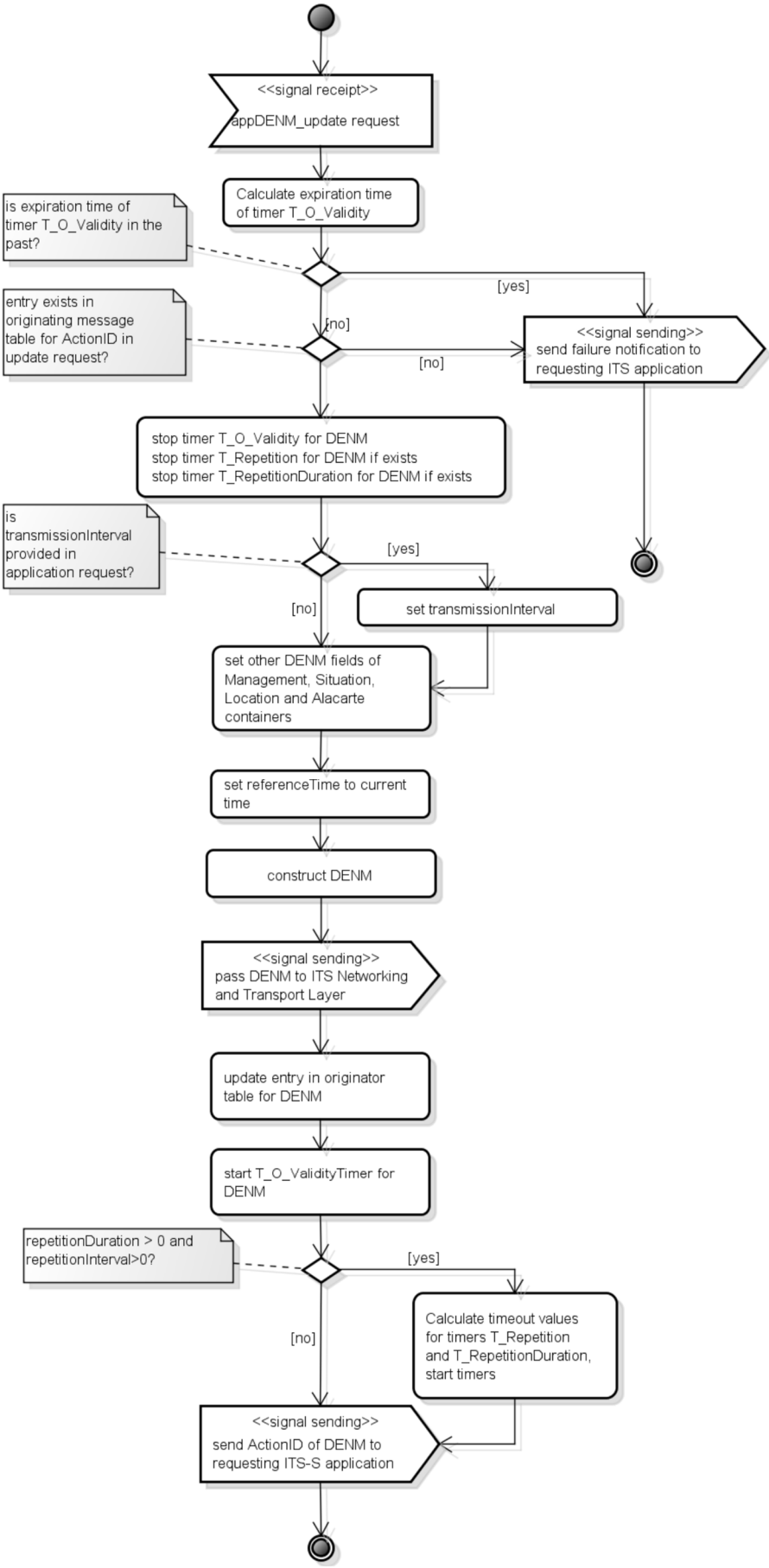

Figure 8: Originating ITS-S activity diagram: appDENM_update request

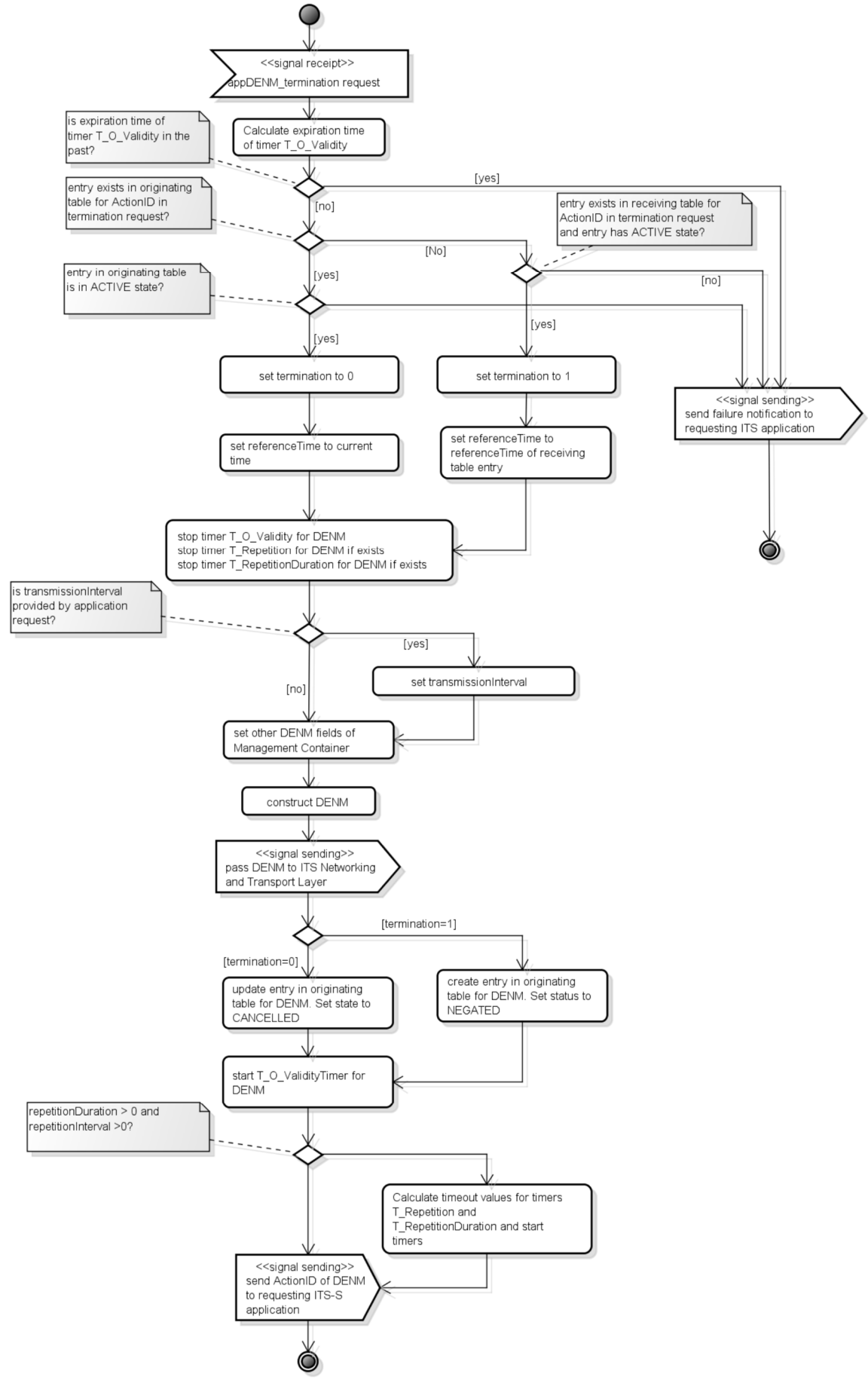

Figure 9: Originating ITS-S activity diagram: appDENM_termination request

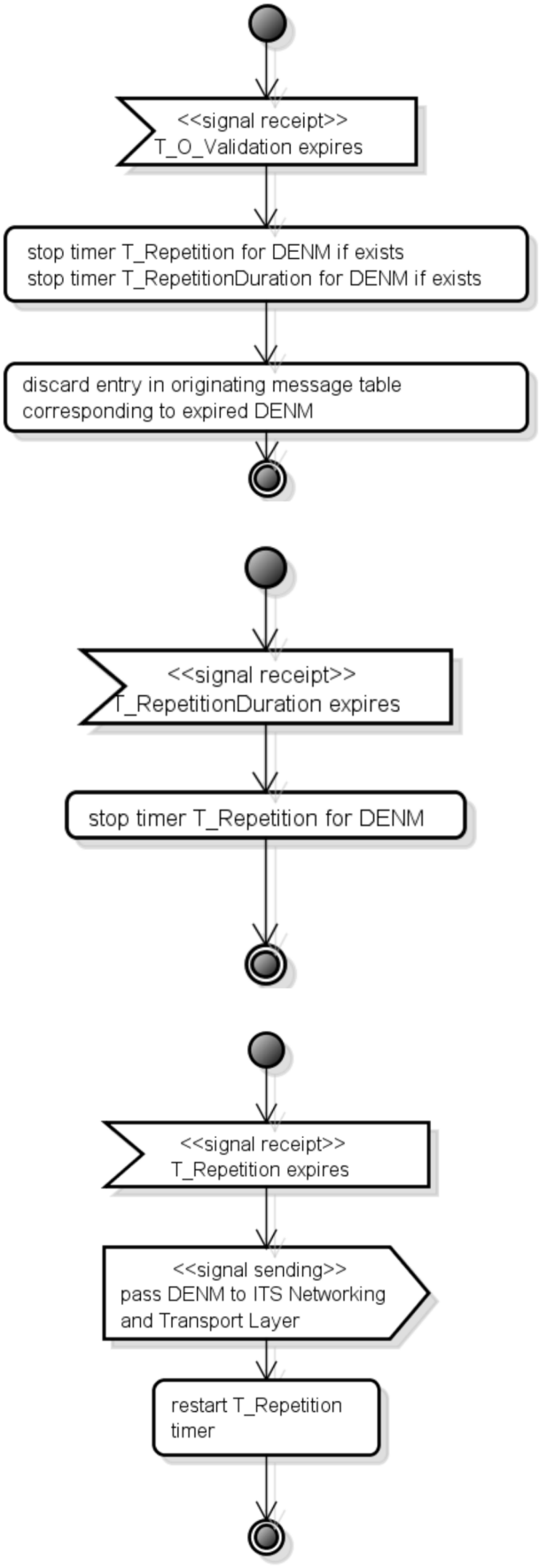

Figure 10: Originating ITS-S activity diagram: timeout management

8.2.3 Exception handling

8.2.3.1 General requirements

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

8.2.3.2 DENM generation exception

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

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

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

8.2.3.3 *actionId* non-existence exception

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

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

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

8.2.3.4 Time operation exception

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

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

8.3 Forwarding ITS-S operation

8.3.1 Introduction

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

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

8.3.2 Protocol data setting rules

8.3.2.1 General requirements

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

8.3.2.2 *actionId*

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

8.3.2.3 referenceTime

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

8.3.2.4 termination

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

8.3.2.5 *T_F_Validity* and *T_Forwarding*

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

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

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

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

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

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

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

NOTE 3: If the timer *T_F_Validity* is set to an invalid value, the DENM is not forwarded. Therefore there is no need to set the timeout value and start/stop the timer *T_Forwarding*.

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

8.3.2.6 Forwarding ITS-S message table

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

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

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

8.3.2.7 DENM regeneration

When a DENM is being forwarded, the DEN basic service shall regenerate the DENM before forwarding it to the ITS networking & transport layer. For this regeneration, the management container, situation container, location container and À La Carte container of the DENM shall not be modified. The ITS PDU header shall be replaced by the ITS PDU header generated by the forwarding ITS-S.

NOTE: Especially for DENMs with an eventZone component, it is recommended to buffer the original DENM's destination area for possible reuse in KAF forwarding.

8.3.3 General protocol operation

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

1) Check if the *termination* exists in received DENM:
   a) If yes, continue the operation.
   b) Otherwise, omit execution of further steps.
2) Check if the *referenceTime* of the received DENM is equal or greater than the *referenceTime* value of the DENM entry in the forwarding ITS-S message table of the same *actionId*:
   a) If the received *referenceTime* is equal to the entry *referenceTime*, start/restart *T_F_Forwarding* and omit execution of further steps.
   b) If the received *referenceTime* is less than the entry *referenceTime*, discard the received DENM and omit execution of further steps.
   c) Otherwise, continue the operation.
3) Calculate expiration time of timer *T_F_Validity* (clause 8.3.2.5):
   a) If timer *T_F_Validity* is set to invalid value, omit execution of further steps.
   b) Otherwise, continue operation.
4) Calculate timeout value for timer *T_ Forwarding* (clause 8.3.2.5):
   a) If timer *T_ Forwarding* is set to invalid value, omit execution of further steps.
   b) Otherwise, continue operation.
5) Start/restart timer *T_F_Validity* and *T_ Forwarding*.
6) Regenerate DENM by replacing the ITS PDU header.
7) Update DENM entry in forwarding ITS-S message table.
8) End.

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

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

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

1) Check if the forwarding ITS-S is located in the awareness area / relevance zone or the destination area:
   a) If not, omit execution of further steps.
   b) Otherwise, continue operation.
2) Pass the regenerated DENM to ITS networking & transport layer.

3) Restart timer *T_Forwarding*.

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

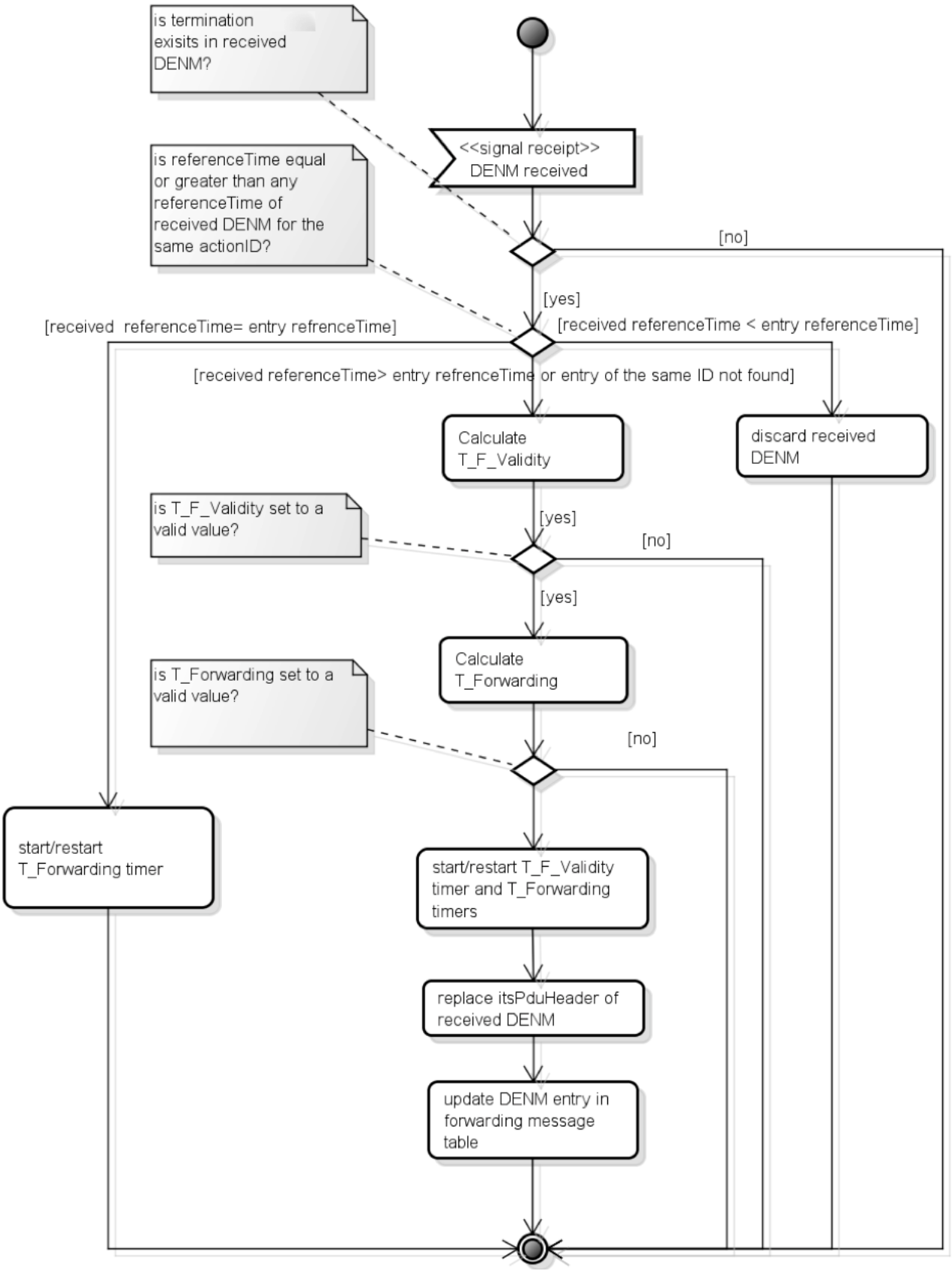

Figure 11: Forwarding ITS-S activity diagram

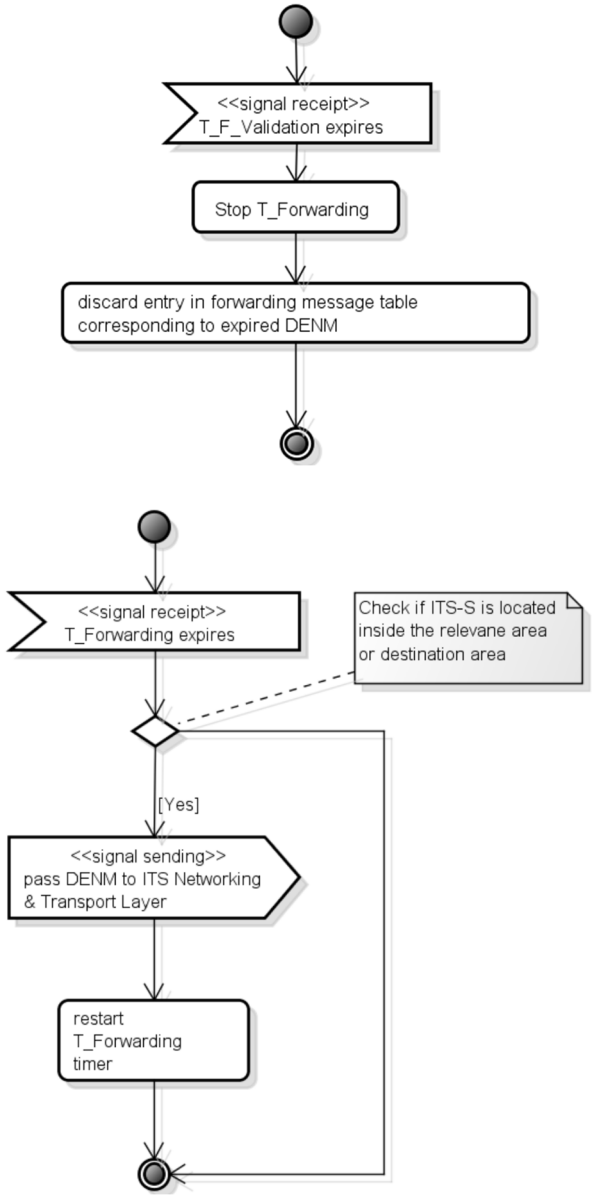

Figure 12: Forwarding ITS-S activity diagram: timeout management

8.3.4 Exception handling

8.3.4.1 General requirements

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

8.3.4.2 DENM generation exception

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

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

8.4 Receiving ITS-S operation

8.4.1 Protocol data setting rules

8.4.1.1 General requirements

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

8.4.1.2 *actionId*

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

8.4.1.3 referenceTime

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

8.4.1.4 termination

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

8.4.1.5 T_R_Validity

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

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

8.4.1.6 Receiving ITS-S message table

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

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

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

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

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

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

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

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

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

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

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

8.4.2 General protocol operation

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

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

When the timer *T_R_Validity* expires, the DEN basic service may execute the following operations:

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

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

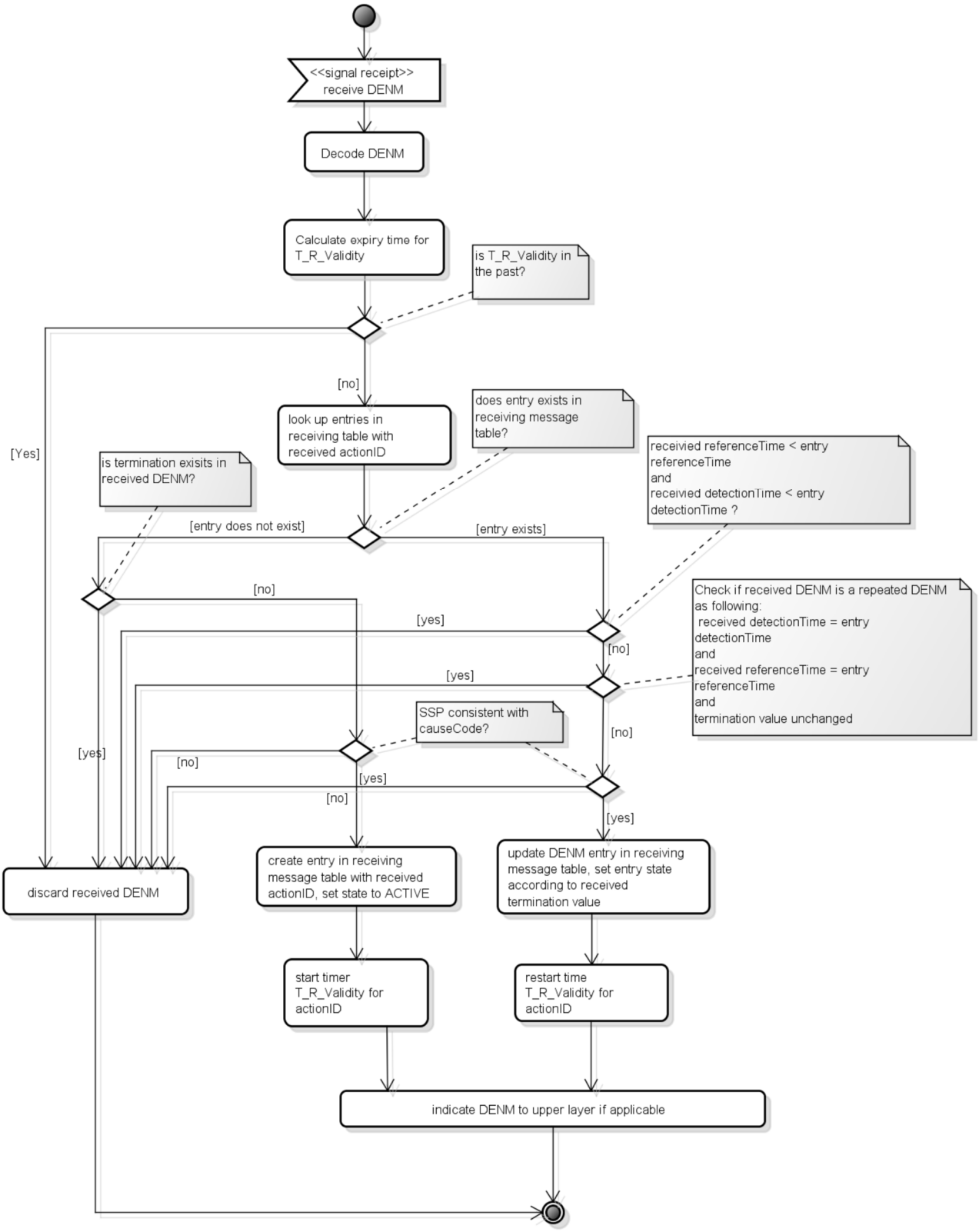

Figure 13: Receiving ITS-S activity diagram

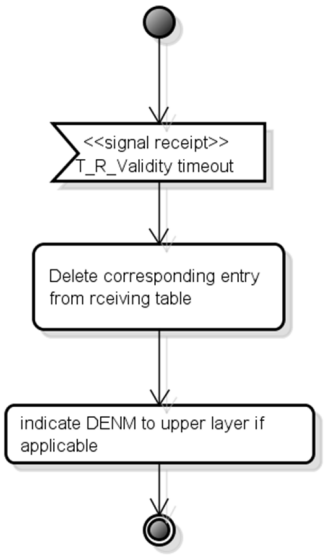

Figure 14: Receiving ITS-S activity diagram: timeout management

8.4.3 Exception handling

8.4.3.1 General requirements

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

8.4.3.2 DENM decoding exception

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

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

This clause provides the normative ASN.1 module containing the syntactical definitions of the DENM PDU, its containers, and the data frames, and data elements defined in the present document.

The DENM-PDU-Descriptions module is identified by the Object Identifier {itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) denmPduRelease2 (103831) major-version-2 (2) minor-version-1 (1) }. The module can be downloaded as a file as indicated in table A.1. The associated SHA-256 cryptographic hash digest of the referenced file offers a means to verify the integrity of that file.

Table A.1: ETSI TS 103 831 ASN.1 module information

Module name	DENM-PDU-Descriptions
OID	{itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) denmPduRelease2 (103831) major-version-2 (2) minor-version-1 (1) }
Link	https://forge.etsi.org/rep/ITS/asn1/denm_ts103831/-/blob/v2.1.1/DENM-PDU-Descriptions.asn
SHA-256 hash	701f3ff1af47436436f80e71cd768f96f3421840e782461c0f9f2720b58f95d3

Annex B (normative): Specification of DENM PDU components

B.1 header

Description	*header* is the first component of the DENM and represents the ITS PDU header of a DENM. This component includes the protocol version of the DENM *protocolVersion*, the DENM message type identifier *messageID* and the station identifier *stationId* of the originating ITS-S or ITS-S that optionally forwards the DENM. The *protocolVersion* is used to select the appropriate protocol decoder at the receiving ITS-S.
Data setting and presentation requirements	This component shall be of type *ItsPduHeader* as specified in ETSI TS 102 894-2 [5]. The value of *protocolVersion* shall be set to 2. The value of *messageID* shall be set to 1. If the DENM is originated at the ITS-S, *stationId* shall be set to the value received from the ITS Application or, if this is not provided, it is set per default to the station ID of the originating ITS-S. If the DENM is forwarded, *stationId* shall be set to the station ID of the forwarding ITS-S, if the DENM is forwarded.

B.2 denmPayload

Description	*denmPayload* is the second component and contains the DENM payload. It includes the mandatory component *management* and the optional components *situation*, *location* and *alacarte*.
Data setting and presentation requirements	This component shall be of type *DenmPayload* as specified in Annex A.

B.3 management

Description	*management* is the first component of *DenmPayload* and represents the Management container of a DENM as described in clause 7.1.3. It contains information required for the DENM protocol processing.
Data setting and presentation requirements	This component shall be of type *ManagementContainer* as specified in Annex A.

B.4 situation

Description	*situation* is the second component of the *DenmPayload* and represents the Situation container of a DENM as described in clause 7.1.4. It contains information of the event type and event detection quality.
Data setting and presentation requirements	This component is OPTIONAL. It shall not be present in cancellation DENM and negation DENM. This component shall be of type *SituationContainer* as specified in Annex A.

B.5 location

Description	*location* is the third component of the *DenmPayload* and represents the Location container of a DENM as described in clause 7.1.5. It contains information of the location referencing.
Data setting and presentation requirements	This component is OPTIONAL. It shall not be present in cancellation DENM and negation DENM. This component shall be of type *LocationContainer* as specified in Annex A.

B.6 alacarte

Description	*alacarte* is the fourth component of the *DenmPayload* and represents the À La Carte container of a DENM as described in clause 7.1.6. It contains use case specific information that has not been provided in other DENM containers.
Data setting and presentation requirements	This component is OPTIONAL. It shall not be present in cancellation DENM and negation DENM. It shall be present in a new DENM or update DENM, if the information is required by the ITS application. This component shall be of type *AlacarteContainer* as specified in Annex A.

B.7 actionId

Description	*actionId* is the first component of the *ManagementContainer* and represents an identifier generated by the DEN basic service for new DENM. The *actionId* differs from the *actionIds* generated by other ITS-Ss and from the *actionIds* generated by the same ITS-S for other detected events. It is used by a receiving ITS-S to process information for DENMs that are multiply received. The *actionId* is maintained by the originating ITS-S.
Data setting and presentation requirements	The data setting rules of *actionId* are as specified in clause in 6.1.1.1. This component shall be of type *ActionId* as specified in ETSI TS 102 894-2 [5].

B.8 awarenessDistance

Description	*awarenessDistance* is the sixth component of *ManagementContainer* and represents the radius of the circular awareness area, with centre at the event position or at any of the event history points as defined in clause 6.1.3.1.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *StandardLength3b* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *StandardLength3b* is the same as that of the data type *RelevanceDistance* previously used in [i.13].

B.9 awarenessTrafficDirection

Description	*awarenessTrafficDirection* is the seventh component of *ManagementContainer* and represents the traffic direction along which the receiving ITS-S may encounter the event, as defined in clause 6.1.3.1.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *TrafficDirection* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *TrafficDirection* is the same as that of the data type *RelevanceTrafficDirection* previously used in ETSI EN 302 637-3 [i.13].

B.10 carryingDangerousGoods

Description	*carryingDangerousGoods* is the third component of the *StationaryVehicleContainer* included in the À La Carte 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 component is OPTIONAL. It shall be present when the information is required by the ITS application. This component shall of type *DangerousGoodsExtended* as specified in ETSI TS 102 894-2 [5].

B.11 closedLanes

Description	*closedLanes* is the second component of the *RoadWorksContainerExtended* in the À La Carte container. It indicates whether the roadwork has caused the closure of one or several driving lanes. Optionally, it may indicate whether a hard shoulder lane is closed to traffic or can be used for specific usage (e.g. for stopping).
Data setting and presentation requirements	This component is OPTIONAL. It shall be present when the information is required by the ITS application. This component shall be of type *ClosedLanes* as specified in ETSI TS 102 894-2 [5].

B.12 defaultValidity

Description	*defaultValidity* is the default value for DENM validity duration used for DENM protocol operation, as specified in clause 8.2.1.5.
Data setting and presentation requirements	This value shall be as specified in Annex A.

B.13 detectionTime

Description	*detectionTime* is the second component of *ManagementContainer* and represents the time at which the event is detected. For the DENM repetition, detectionTime shall remain unchanged. For the DENM update, this component shall be the time at which the event update is detected. For the DENM termination, this component shall be the time at which the termination of the event is detected.
Data setting and presentation requirements	This component shall be of type *TimestampIts* as specified in ETSI TS 102 894-2 [5].

B.14 energyStorageType

Description	*energyStorageType* is the sixth and last component of *StationaryVehicleContainer* and provides the vehicle energy storage type information of the stationary vehicle, such as electric, diesel, etc.
Data s etting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *EnergyStorageType* as specified in ETSI TS 102 894-2 [5].

B.15 eventPosition

Description	*eventPosition* is the fifth component of the *ManagementContainer* and represents a geographical position used in the definition of the awareness area / relevance zone, see clause 6.1.3
Data setting and presentation requirements	When the event position corresponds to the position of a vehicle ITS-S (i.e. the (component stationType is set to one of the values in the range 3 - 9), the *eventPosition* shall be set to the reference position of the vehicle ITS-S at *detectionTime* as defined in clause 6.2 of ETSI EN 302 890-2 [7]. This component shall be of type *ReferencePosition* as specified in ETSI TS 102 894-2 [5].

B.16 eventPositionHeading

Description	*eventPositionHeading* is the second component of *LocationContainer* and represents the heading of a dynamic event and the confidence of the heading information, if applicable.
Data setting and presentation requirements	When the *eventPosition* corresponds to the position of a vehicle ITS-S, the *eventPositionHeading* shall be set to the vehicle heading, i.e. to the orientation of the horizontal velocity vector of the vehicle at *detectionTime*. This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *Wgs84Angle* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *Wgs84Angle* is the same as that of the data type *Heading* previously used in ETSI EN 302 637-3 [i.13].

B.17 eventSpeed

Description	*eventSpeed* is the first component of *LocationContainer* and represents the speed of a detected dynamic event and the confidence of the speed information.
Data setting and presentation requirements	When the *eventPosition* corresponds to the position of a vehicle ITS-S, the *eventSpeed* shall be set to the vehicle speed at *detectionTime*. This component is OPTIONAL. It shall be present if required by the ITS application. This component shall be of type *Speed* as specified in ETSI TS 102 894-2 [5].

B.18 eventType

Description	*eventType* is the second component of *SituationContainer* and represents the description for the event type, including direct cause and sub cause and the specification in in clause 7.1.4 of the present document.
Data setting and presentation requirements	This component shall be of type *CauseCodeV2* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *CauseCodeV2* is the same as that of the data type *CauseCode* previously used in ETSI EN 302 637-3 [i.13].

B.19 eventZone

Description	*eventZone* is the fourth component of *SituationContainer* and consists of a list of *eventPoints*. There are two options for the *eventPoint* inside the *eventZone:* All *eventPoints* with *eventDeltaTime* PRESENT means that the component represents the centre points of multiple circular awareness areas, as defined in clause 6.1.3.1: this is for example the case of an event detected by a vehicle ITS-S, where the *eventZone* consists of a list of event detection points along the path that the detecting ITS-S has travelled over some past time and/or distance. Each event point corresponds to a point at which the same event was detected along the path and includes the component eventDeltaTime. All *eventPoints* with *eventDeltaTime* ABSENT means that the component represents either: • A linear awareness area, as defined in clause 6.1.3.1: this is for example the case of a not precisely localized (dynamic) event detected by a roadside ITS-S or by a central entity, where each event point corresponds to a point in the linear awareness area. • A linear relevance zone, as defined in clause 6.1.3.2: this is for example the case of an extended event detected by a roadside ITS-S or by a central entity, where each event point corresponds to a point in the linear relevance zone. In the present document up to 23 *EventPoint* may be present in this component. The generation requirements of each *EventPoint* are specified in the related ITS application requirements.

Data setting and presentation requirements	In case of all *eventPoints* with *eventDeltaTime* PRESENT, the *EventPoint* closest to the current detected event point with respect to the *detectionTime* shall be put as the first point. It represents an offset delta position and an offset delta detection time with regards to the current detected event point. Other event points shall be structured in ascending order according to the *eventDeltaTime*. Each event point represents an offset delta position with respect to the previous *EventPoint*. In case of all *eventPoints* with *eventDeltaTime* ABSENT, the *EventPoint* closest to the current detected event point with respect to the *eventPosition,* following the course of the zone, shall be put as the first point. It represents an offset delta position with regards to the current detected event point. Other event points shall be structured in ascending order according to the *eventPosition,* following the course of the zone. Each event point represents an offset delta position with respect to the previous *EventPoint*. This component is OPTIONAL, it shall be present if required by the ITS application. This component shall be of type *EventZone* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *EventZone* is the same as that of the data type *EventHistory* previously used in [i.13].

B.20 externalTemperature

Description	*externalTemperature* is the third component of the *alacarte* container and indicates the ambient temperature at the event position.
Data setting and presentation requirements	This component shall be of type *Temperature* as specified in ETSI TS 102 894-2 [5].

B.21 heightLonCarrLeft

Description	*heightLonCarrLeft* is the first component of the *ImpactReductionContainer* and represents the height of the left longitudinal carrier of the vehicle from base to top.
Data setting and presentation requirements	This component shall be of type *HeightLonCarr* as specified in ETSI TS 102 894-2 [5].

B.22 heightLonCarrRight

Description	*heightLonCarrRight* is the second component of the *ImpactReductionContainer* and represents the height of the right longitudinal carrier of the vehicle from base to top.
Data setting and presentation requirements	This component shall be of type *HeightLonCarr* as specified in ETSI TS 102 894-2 [5].

B.23 impactReduction

Description	*impactReduction* is the second component of the *AlacarteContainer* and contains the vehicle detailed information required for mitigating the consequences of a collision.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *ImpactReductionContainer* as specified in Annex A.

B.24 incidentIndication

Description	*incidentIndication* is the fifth component of *RoadWorksContainerExtended* and indicates the incident related to the roadworks to provide additional information of the roadworks zone.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *CauseCodeV2* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *CauseCodeV2* is the same as that of the data type *CauseCode* previously used in ETSI EN 302 637-3 [i.13].

B.25 informationQuality

Description	*informationQuality* is the first component of the *SituationContainer* and represents the quality level of the information provided by the ITS-S application of the originating ITS-S: It indicates the probability of the detected event being truly existent at the event position.
Data setting and presentation requirements	This component is set according to the ITS application requirements. If the information is unknown, the component shall be set to 0. This component shall be of type *InformationQuality* as specified in ETSI TS 102 894-2 [5].

B.26 lanePosition

Description	*lanePosition* is the first component of the *AlacarteContainer* and represents the lane position of the event position. If this data is provided, the originating ITS-S is required to determine the lane position with a predefined confidence level as defined by the ITS applications (e.g. 95 %).
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *LanePosition* as specified in ETSI TS 102 894-2 [5].

B.27 lightBarSirenInUse

Description	*lightBarSirenInUse* is the first component of *RoadWorksContainerExtended* and indicates whether a roadwork vehicle has switched on the light bar or siren. It is used when the roadwork involves a specific roadwork vehicle.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *LightBarSirenInUse* as specified in ETSI TS 102 894-2 [5].

B.28 linkedCause

Description	*linkedCause* is the third component of *SituationContainer* and provides the description for a linked event of the provided *eventType*, including direct cause and sub cause of the linked event.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *CauseCodeV2* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *CauseCodeV2* is the same as that of the data type *CauseCode* previously used in ETSI EN 302 637-3 [i.13].

B.29 numberOfOccupants

Description	*numberOfOccupants* is the fourth component of the *StationaryVehicleContainer* and provides the estimated number of occupants involved in the stationary vehicle event.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *NumberOfOccupants* as specified in ETSI TS 102 894-2 [5].

B.30 posCentMass

Description	*posCentMass* is the sixth component of *ImpactReductionContainer*
Data setting and presentation requirements	This component shall be of type *PosCentMass* as specified in ETSI TS 102 894-2 [5].

B.31 posFrontAx

Description	*posFrontAx* is the nineth component of *ImpactReductionContainer*. Perpendicular distance between the front wheel axle and front bumper. This component is included in the *impactReduction* component.
Data setting and presentation requirements	This component shall be of type *PosFrontAx* as specified in ETSI TS 102 894-2 [5].

B.32 positioningSolution

Description	*positioningSolution* is the fifth component of *AlacarteContainer* and indicates the technical solution being used by the originating ITS-S to estimate the event position. Typically, this component may be included for events that are caused by vehicle ITS-S.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *PositioningSolutionType* as specified in ETSI TS 102 894-2 [5].

B.33 positionOfOccupants

Description	*positionOfOccupants* is the tenth component of *ImpactReductionContainer.* This component indicates whether a in vehicle seat is occupied at the moment when the *impactReduction* is generated.
Data setting and presentation requirements	This component shall be of type *PositionOfOccupants* as specified in ETSI TS 102 894-2 [5]

B.34 positionOfPillars

Description	*positionOfPillars* is the fifth component of *ImpactReductionContainer* and contains information about the vertical support of the vehicle in which the originating ITS-S is mounted. It is included for passenger vehicles only.
Data setting and presentation requirements	This component shall be of type *PositionOfPillars* as specified in ETSI TS 102 894-2 [5]. Each pillar distance shall be presented as specified in ETSI TS 102 894-2 [5] *PosPillar*.

B.35 posLonCarrLeft

Description	*posLonCarrLeft* is the third component of the ImpactReductionContainer and represents the distance from the centre of vehicle front bumper to the front of the left longitudinal carrier of vehicle. This component is included in the *impactReduction* component.
Data setting and presentation requirements	This component shall be of type *PosLonCarr* as specified in ETSI TS 102 894-2 [5].

B.36 posLonCarrRight

Description	*posLonCarrRight* is the fourth component of the *ImpactReductionContainer* and represents the distance from the centre of vehicle front bumper to the front of right longitudinal carrier of vehicle. This component is included in the *impactReduction* component.
Data setting and presentation requirements	This component shall be of type *PosLonCarr* as specified in ETSI TS 102 894-2 [5] *PosLonCarr*.

B.37 recommendedPath

Description	*recommendedPath* is the sixth component of *RoadWorksContainerExtended* and indicates the recommended itinerary in order to contour the roadworks zone. A recommended path is presented with a list of path points in the order from the starting point closest to the roadworks zone to the end point of the recommended path.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *ItineraryPath* as specified in ETSI TS 102 894-2 [5].

B.38 referenceDenms

Description	*referenceDenms* is the nineth and last component of *RoadWorksContainerExtended* and indicates a sequence of *actionId*s for different DENMs that describe the same event. If it is available, it indicates the *actionId*s of all other DENMs describing this event.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component is of type *ActionIdList* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *ActionIdList* is the same as that of the data type *ReferenceDenms* previously used in ETSI EN 302 637-3 [i.13].

B.39 referenceTime

Description	*referenceTime* is the third component of *ManagementContainer* and represents the time at which a new DENM, an update DENM or a cancellation DENM is generated.
Data setting and presentation requirements	The *referenceTime* is maintained by the originating ITS-S, the data setting rules are as specified in clause 8.2.1.3. This component shall be of type *TimestampIts* as specified in ETSI TS 102 894-2 [5].

B.40 requestResponseIndication

Description	*requestResponseIndication* is the last component of the *ImpactReductionContainer* and indicates whether the originating ITS-S transmitting the *impactReduction* component is requesting the receiving ITS-S to provide also its *impactReduction* component. On reception of a DENM with this component set to 0, the receiving ITS-S may in turn transmit a DENM with its *impactReduction* component as response to the request.
Data setting and presentation requirements	This component shall be of type *RequestResponseIndication* as specified in ETSI TS 102 894-2 [5].

B.41 restriction

Description	*restriction* is the third component of *RoadWorksContainerExtended* and indicates the types of vehicles that are restricted to access the road work zone. More than one vehicle types may be provided by this component if the restriction apply to multiple vehicle types.
Data setting and presentation requirements	This component is OPTIONAL. This component shall be of type *RestrictedTypes* as specified in ETSI TS 102 894-2 [5].

B.42 roadType

Description	*roadType* is the fourth component of *LocationContainer* and indicates the road type information at the event position.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *RoadType* as specified in ETSI TS 102 894-2 [5].

B.43 roadWorks

Description	*roadWorks* is the fourth component of *AlacarteContainer* and is included in for the road work use case. It includes information of the road work zone and specific access conditions.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *RoadWorksContainerExtended* as specified in Annex A.

B.44 speedLimit

Description	*speedLimit* is the fourth component of *RoadWorksContainerExtended* and indicates the speed limitation applied to the roadwork zone.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *SpeedLimit* as specified in ETSI TS 102 894-2 [5].

B.45 startingPointSpeedLimit

Description	*startingPointSpeedLimit* is the seventh component of *RoadWorksContainerExtended* and indicates the effective starting position of a speed limit being applied to the roadwork zone. Generally speaking, the speed limit applies at a certain distance prior to the roadwork zone starting position. It is defined as a delta position with regards to the *eventPosition* of the DENM.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *DeltaReferencePosition* as specified in ETSI TS 102 894-2 [5].

B.46 stationaryCause

Description	*stationaryCause* is the second component of the *StationaryVehicleContainer* and provides additional information to describe causes of the stationary vehicle event such as human problem.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *CauseCodeV2* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *CauseCodeV2* is the same as that of the data type *CauseCode* previously used in ETSI EN 302 637-3 [i.13].

B.47 stationarySince

Description	*stationarySince* is the first component of *StationaryVehicleContainer* and provides the time duration of the stationary vehicle being stationary.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *StationarySince* presented as specified in ETSI TS 102 894-2 [5].

B.48 stationaryVehicle

Description	*stationaryVehicle* is the sixth component of *stationaryVehicle* and may be included for the stationary vehicle use case. It provides information about the stationary vehicle.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *StationaryVehicleContainer* as specified in Annex A.

B.49 stationType

Description	*stationType* is the tenth component of *ManagementContainer* and provides the station type information of the originating ITS-S.
Data setting and presentation requirements	This component shall be of type *StationType* as specified in ETSI TS 102 894-2 [5].

B.50 termination

Description	*termination* is the fourth component of *ManagementContainer* and indicates if the type of generated DENM is a cancellation DENM or a negation DENM.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the generated DENM is a cancellation DENM or negation DENM as requested by the ITS-S application of the originating ITS-S. The data setting rules of this component are as specified in clause 8.2.1.4. This component shall be presented as specified in Annex A.

B.51 traces

Description	*traces* is the third component of the *LocationContainer* and represents the detection zone information. It includes a list of paths as defined in clause 6.1.3.2. Each path describes a set of consecutive *PathPoint* positions leading to the event position. Multiple paths may be defined in case multiple road sections or traffic flows are leading to the event position. In the present document, up to seven traces may be added in a DENM.
Data setting and presentation requirements	Within one path, the *PathPoint* closest to the event position with respect to the *detectionTime* shall be put as the first waypoint, it presents an offset delta position with regards to the *eventPosition*. Other *PathPoint*s shall be structured in ascending order according to the *detectionTime* along the trace path. Each *PathPoint* presents an offset delta position and optionally an offset travel time with regards to the previous *PathPoint.* The component *pathDeltaTime* as defined in *PathPoint* in ETSI TS 102 894-2 [5] is OPTIONAL, it shall be present if the information is provided by the ITS application. When the event position corresponds to the position of a vehicle ITS-S, the first path in the component *traces* shall represent the vehicle's recent movement over some past time and/or distance. The component *traces* shall be of type *Traces* as specified as in ETSI TS 102 894-2 [5]. Each path shall be presented as specified in ETSI TS 102 894-2 [5] *PathHistory.*

B.52 trafficFlowRule

Description	*trafficFlowRule* is the eighth component of *RoadWorksContainerExtended* and indicates the side of the road to which the traffic should flow around a roadwork. This component is included in *roadWorks* component in the *alacarte* container.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *TrafficRule* as specified in ETSI TS 102 894-2 [5].

B.53 transmissionInterval

Description	*transmissionInterval* is the nineth component of *ManagementContainer* and indicates the time interval for DENM transmission as defined by the originating ITS-S. This component informs the receiving ITS-Ss about the intended transmission interval of two consecutive DENM transmissions. It is used for the forwarding ITS-S operation.
Data setting and presentation requirements	This component is OPTIONAL. If the ITS-S application of the originating ITS-S does not provide this information to the DEN basic service, the component shall not be included in DENM. In this case, the DENM shall not be forwarded by the forwarding ITS-S. This component shall be of type *DeltaTimeMilliSecondPositive* as specified ETSI TS 102 894-2 [5]. NOTE: The encoding of *DeltaTimeMilliSecondPositive* is the same as that of the data type *TransmissionInterval* previously used in ETSI EN 302 637-3 [i.13].

B.54 turningRadius

Description	*turningRadius* is the eighth component of *ImpactReductionContainer* and indicates the turning radius of the vehicle in which the originating ITS-S is mounted. When a trailer is present, this component shall provide the turning radius of the vehicle.
Data setting and presentation requirements	This component shall be of type *TurningRadius* as specified in ETSI TS 102 894-2 [5].

B.55 validityDuration

Description	*validityDuration* is the eighth component of the *ManagementContainer* and indicates the validity duration of a DENM. The *validityDuration* is set by the originating ITS-S. Therefore it represents an estimation of how long the event may persist. It implies the duration over which the DENM should be kept at the DEN basic service of the receiving ITS-S and the DENM dissemination be maintained, until the expiration of *validityDuration*. In case the expiry time of the event cannot be estimated at the originating ITS-S, a default value is used for the DENM protocol operation. This component may be renewed by the originating ITS-S, if the pre-set expiry time has reached to its limit and the originating ITS-S detects that the event persists.
Data setting and presentation requirements	This component represents a time offset in the unit of second since *detectionTime*. This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. If the component is not present in DENM, a default value *defaultValidity* is assumed. This component shall be of type *DeltaTimeSecond* as specified in ETSI TS 102 894-2 [5]. NOTE: The encoding of *DeltaTimeSecond* is the same as that of the data type *ValidityDuration* previously used in ETSI EN 302 637-3 [i.13].

B.56 vehicleIdentification

Description	*vehicleIdentification* is the fifth component of *StationaryVehicleContainer* and provides the vehicle identification of the stationary vehicle.
Data setting and presentation requirements	This component is OPTIONAL. It shall be present if the information is provided by the ITS-S application of the originating ITS-S. This component shall be of type *VehicleIdentification* as specified in ETSI TS 102 894-2 [5].

B.57 vehicleMass

Description	*vehicleMass* is the eleventh component of *ImpactReductionContainer* and indicates the mass of the unloaded vehicle.
Data setting and presentation requirements	This component shall be of type *VehicleMass* as specified in ETSI TS 102 894-2 [5].

B.58 wheelBaseVehicle

Description	*wheelBaseVehicle* is the seventh component of *ImpactReductionContainer* and represents the wheel base of the vehicle in which the originating ITS-S is mounted.
Data setting and presentation requirements	This component shall be of type *WheelBaseVehicle* as specified in ETSI TS 102 894-2 [5].

History

Document history		
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