Cooperative
ITS Corridor
Joint deployment

Cooperative ITS Corridor

Cross-Border Harmonization

Roadside ITS G5 Profile

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Introduction

The Cooperative ITS Corridor (CITSC) Roadside ITS G5 (R-ITS-G5) Profile defines the common ground for the ITS-G5 communication between roadside and vehicle. The communication directions derived from this are also known as I2V and V2I.

Communication between roadside and center (R2C and C2R) or roadside and web service (R2W and W2R) as well as vehicle and vehicle (V2V) are out of scope. In other words, access technologies other than ITS-G5 are excluded from the scope.

The profile provides descriptions, definitions and rules for all layers (Application, Facilities, Networking & Transport and Access) and entities (Management and Security) of the ETSI ITS station reference architecture/ITS-S host.

Section 2 lists the functional description of supported use cases. Section 3 provides the actual profile.

1 PROVISIONS

1.1 Verbal forms for the expression of provisions

In this document the following verbal forms are used to indicate requirements:

-Shall

-Shall not

Recommendations shall be indicated by the verbal forms:

-Should

-Should not

Permissions shall be indicated by the verbal forms:

-May

-May not

Possibility and capability shall be indicated by the verbal forms:

-Can

-Cannot

Inevitability, used to describe behavior of systems beyond of scope of this deliverable shall be indicated by:

-Will

-Will not

Facts shall be indicated by the verbal forms:

-Is

-Is not

1.2 Provisions from referenced documents

Unless otherwise specified in the present document, the normative requirements included in the referenced documents supporting the required functionality of the ITS system shall apply. The verbal forms for the definition of provisions of referenced documents are defined either inside the document, or generally by the SDO (standardization organization) or the organization providing them. For example normative requirements in ETSI documents are indicated by the verbal form “shall”.

When the requirements defined in the standards published by the various organizations stand in conflict, or contradict the requirements specified inside this document, the ones specified inside this document shall always outweigh the requirements included inside the referenced documents.

2 FUNCTIONAL DESCRIPTION OF USE CASES

This chapter provides a concise functional description of the supported CITSC use cases telling what is done and why is it done. How use cases are applied in CITSC can be found in chapter 3.

Even though CITSC country specific wording exist for (sub-)use cases, a coordinated wording is used starting in chapter 3 Profile. The CITSC country specific wording is used in this chapter to lay stress on country-dependent exceptions.

2.1 CITSC country exceptions

Section 2.1 provides explanatory notes for exceptions that are unique for a particular CITSC country.

2.1.1 Austrian Use Cases

A Use Case is an ITS application from the perspective of the operator of a traffic control center (TCC) or traffic management center (TMC). Since use cases can be of complex nature, they can be divided into Use Case Scenarios (UCS). Each UCS represents an operation mode of the cooperative ITS system (e.g. TCC, C-ITS-S, R-ITS-S, trailer). Working with UCS has the advantage that the use case definition is more clear due to reduced complexity. For instance, after choosing a particular UCS, it is clear what components are part of the system, what are part of the context and what are the interactions.

2.1.2 German Use Cases

No exceptions known.

2.1.3 Dutch Use Cases

The Netherlands distinguishes, based on ETSI TS 102 638 Basic Set of Applications, the following levels:

- Services: An ITS Service is a subset of the ITS Field with a specific generic aim and purpose and with specific overall characteristics. Equivalent to Application Class as defined in ETSI TS 102 638 and 637-1. E.g. the Service ‘Active Road Safety’.
- Applications: System that defines and implements an ITS Service to users of the system (based on ETSI 102 638 and 637-1). E.g. the Application ‘Road Hazard Warning’ (RHW).
- Use cases: Procedure of executing an Application in a particular situation with a specific purpose (based on ETSI 102 638 and 637-1). E.g. the Use case ‘Road Works Warning’.

- (Deployment/Operational) Scenarios: Specific deployment and implementation situations and configurations. E.g. Simple'. Comparable to 'Use Case Scenarios' as used by AT.
- Reference messages.

This leads to the following structure ('Probe Vehicle Data' has been added as a new Application under the Service 'Cooperative Traffic Efficiency'):

Field	Service	Application	Use case	Scenarios	Ref. Mess.
Cooperative Intelligent Transport Systems (C-ITS)	Active Road Safety	Cooperative awareness	Emergency vehicle warning		
			Slow vehicle indication		
			Intersection collision warning		
			Motorcycle approaching indication		
		Road Hazard Warning (RHW)	Emergency electronic brake lights		
			Wrong way driving warning		
			Stationary vehicle - accident		
			Stationary vehicle - vehicle problem		
			Traffic condition warning		
			Signal violation warning		
			Road Works Warning (RWW)	**Basic**	**…**
				Plus	**…**
				Luxe	**…**
			Collision Risk Warning (CRW)		**…**
			Decentralized floating car data - Hazardous location		
			Decentralized floating car data - Precipitations		
			Decentralized floating car data- Road adhesion		
			Decentralized floating car data - Visibility		
			Decentralized floating car data - Wind		
	Cooperative Traffic Efficiency	Speed management	Regulatory / contextual speed limits notification		
			Traffic light optimal speed advisory		
		Cooperative navigation	Traffic information and recommended itinerary		
			Enhanced route guidance and navigation		
			Limited access warning and detour notification		
			In-vehicle signage		
		Probe Vehicle Data (PVD)	**Basic Probe Vehicle Data (bPVD)**		**…**
			Extended Probe Vehicle Data (ePVD)		
	Cooperative local services	Location based services	Point of interest notification		
			Automatic access control and parking management		
			ITS local electronic commerce		
			Media downloading		
	Global internet services	Communities services	Insurance and financial services		
			Fleet management		
			Loading zone management		
		ITS station life cycle management	Vehicle-software / data provision and update		
			Vehicle and RSU data calibration		

The Dutch Cooperative ITS Corridor project focusses on (in bold in the table above):

1. Use case 'Road Works Warning' (RWW), part of the Application 'Road Hazard Warning' (RHW), part of the Service 'Active Road Safety'.
2. Use case 'Collision Risk Warning' (CRW), part of the Application 'Road Hazard Warning', part of the Service 'Active Road Safety'.
3. Use case 'Basic Probe Vehicle Data' (bPVD), part of the Application 'Probe Vehicle Data' (PVD), part of the Service 'Cooperative Traffic Efficiency'.

Note: The Netherlands do not base the definition of the use cases on whether CAM, DENM or IVI is used. Use cases are seen as a functional distinction ('what'). Whether CAM, DENM and/or IVI is used is considered to be implementation ('how'). This is described in chapter 3.

2.2 Probe Vehicle Data

For the Probe Vehicle Data use case, R-ITS-S receive and process continuously and autonomously transmitted CAMs from V-ITS-S. The following sub-sections describe the CITSC country specific understanding of this use case.

2.2.1 CAM Aggregation [AT]

ETSI compliant V-ITS-S transmit CAMs in a continuous and autonomous manner. R-ITS-S receive those CAMs from V-ITS-S within the ITS G5 coverage area. CAM content is further processed by R-ITS-S or the backend.

This use case is subdivided into the following use case scenarios (UCS).

- UCS1: General CAM Traffic Data Aggregation
- UCS2: Single Vehicle Data
- UCS3: Travel Time Estimation
- UCS4: Manual Configuration of CAM Aggregation at C-ITS-S
- UCS5: Self-configuration of CAM Aggregation at R-ITS-S

This classification, however, is relevant for the ECo-AT system, interaction between R-ITS-S, C-ITS-S and TCC, but not for the ITS G5 interface. That is why this profile is not further expanded on those scenarios. Definition can be found at [ECo-AT SWP2.1 UC CAM aggr].

2.2.2 Probe Vehicle Data [DE]

Under construction.

Note: There is currently no decision if an aggregation or a filtering will be done. The processing of CAMs on the trailer doesn't need to be harmonized. It depends on the applications and algorithms in the TCC which can be different in every TCC.

2.2.3 Basic Probe Vehicle Data (bPVD) [NL]

The main aim of Probe Vehicle Data (PVD) is to improve insight on the traffic situation by collecting sensor-data (such as speed and direction) transmitted by passing vehicles. PVD will improve information on actual traffic behavior and status, enabling the road operator to improve traffic management.

RSUs will collect relevant messages sent from OBUs from passing vehicles, in both directions, within the communication range of the RSU.

The application PVD is less mature than Road Works Warning (RWW). The PVD application has great potential but needs further research. How to actually use PVD data is not yet clear and there are privacy issues.

The Dutch Cooperative ITS corridor project has divided the PVD application into two use cases:

- basic Probe Vehicle Data (bPVD): based on messages continuously transmitted by vehicles
- extended Probe Vehicle Data (ePVD): based on data stored in vehicles transmitted when passing an RSU.

PVD will be completely dependent on the data that the automotive industry chooses to provide from vehicles to the roadside. In view of the above the Dutch Cooperative ITS Corridor project assumes that basic CAM messages are the only solid basis for PVD for the short term. The Dutch Cooperative ITS Corridor project therefore limits the application to the use-case 'basic Probe Vehicle Data' (bPVD) only.

2.3 Collision Risk Warning [NL]

For the Collision Risk Warning (CRW) use case, V-ITS-S or R-ITS-S transmit DENM to V-ITS-S with information about a particular collision risk. The transmitting V-ITS-S or R-ITS-S has been placed in the vicinity of the situation so that its own position reflects the collision risk. Since CRW is currently only supported in the Netherlands, there is no CITSC country independent description of the use case.

2.3.1 Collision Risk Warning (CRW) [NL]

In the Netherlands the traffic inspector (in Dutch: 'weginspecteur') plays an import role in managing traffic safety. Unfortunately however they are often themselves subject to hazardous situations. It (too) frequently happens that traffic inspector vehicles are hit by others.

The required hazardous warning functionality can be described as: warning road users by means of cooperative communication for a stationary traffic inspectors vehicle marking an incident.

The traffic inspector activates the signal when protecting an incident that renders one or more lanes unavailable. The signal is activated directly after reaching 'fend-off position' by pressing a button. The signal includes information on the position and heading of the vehicle. The traffic inspector is notified by means of a light that the system is active. The signal is consequently converted to a DENM message which is sent from the R-ITS-S to the V-ITS-S.

The Dutch Cooperative ITS Corridor has chosen that this functionality falls within the application Road Hazard Warning (RHW) and the use case Collision Risk Warning (CRW). CRW is incorporated in the DENM standard and specified further in the standard on Longitudinal Collision Risk Warning ([ETSI-LCRW], ETSI TS 539-1).

2.4 Other DENM Application [AT]

For the Other DENM Application (ODENM) use case, R-ITS-S transmit DENM to V-ITS-S with information about a particular traffic situation. Since ODENM is currently only supported in Austria, there is no CITSC country specific description of the use case.

2.4.1 UCS1: Sending Event Information from the TCC to the Vehicles [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC other DENM].

ALERT-C based event information in the TCC is sent to the C-ITS-S. In the C-ITS-S, event information is mapped to DENM and forwarded to geographically relevant R-ITS-S and sent out via ITS-G5. V-ITS-S driving through the coverage area of a relevant R-ITS-S receive these DENMs.

2.4.2 UCS2: Sending Event Information from the Vehicles to the TCC [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC other DENM].

V-ITS-S emit DENM to warn ITS-G5 aware vehicles and infrastructure of dangers perceived based on certain triggering conditions. R-ITS-S receive those DENM if they are within the ITS-G5 communication range of V-ITS-S. They filter out duplicates and send unique DENM to the C-ITS-S. The C-ITS-S extracts relevant event information, maps it to a DATEX II profile and sends it to the TCC .The TCC decides to issue new events based on that information.

2.5 Intersection Safety [AT]

For the Intersection Safety (ISS) use case, R-ITS-S transmit SPAT and MAP messages to V-ITS-S with information about a particular traffic situation. Since ISS is currently only supported in Austria, there is no CITSC country specific description of the use case.

2.5.1 UCS1: Vehicle Speed Optimization Approaching an Intersection [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC ISS].

Vehicles approaching a traffic light will inform the driver in advance about the traffic signal status for crossing the conflict area of an intersection. Based on information from ITS-G5 equipped traffic light, the vehicle can advise an optimal speed to the driver for smoothly approaching the intersection (in case of red) or for passing safely the conflict area of the intersection (in case of green). Information broadcasted by ITS-G5 reflects real-time signal phase & timing status for each lane. Therefore, a vehicle may be able to predict the optimal speed advice on each lane. The accuracy of positioning systems within vehicles can not reach the accuracy for lane based computation and therefore offer the information to the driver based on the intersection approach.

2.5.2 UCS2: Fast Preemption of Traffic on Traffic Light Signal Change from Red to Green [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC ISS].

Vehicles waiting at a red traffic light inform the driver about the traffic light status in travelling direction. If the signal changes to green within approximately five seconds, the driver is informed to prepare for efficient crossing the conflict area on the planned maneuver. This allows a fast preemption, optimizing the vehicle throughput for a signal cycle and reducing potential traffic queues.

2.5.3 UCS3: Red Light Violation [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC ISS].

Vehicles approaching a traffic light inform the driver in advance about the traffic signal status for crossing the conflict area of an intersection. As described in UCS1, the vehicle/driver is aware of traffic light signal status and changes in real-time. Due to driver distraction, a pending change from green to red can not be recognized. Due to the SPAT and MAP broadcasted from the infrastructure, the vehicle is able to detect a potential red light violation and alert the driver.

2.6 In-Vehicle Signage

For the In-Vehicle Signage (IVS) use case, R-ITS-S transmit IVI messages to V-ITS-S with information about a particular traffic sign. The following sub-sections describe the CITSC country specific understanding of this use case.

2.6.1 In-Vehicle Information (IVI) [AT]

Though this use case is called In-Vehicle Information (IVI) in ECo-AT, it corresponds to an In-Vehicle Signage (IVS) service that uses the IVI message for the ITS G5 interface from the IVI standard.

UCS1: Sending Signage Information from the TCC to the Vehicles [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC IVI].

Signage information from the traffic information system in the TCC is sent to the C-ITS-S. In the C-ITS-S, the signage information is mapped from a DATEX II profile to IVI and forwarded to geographically relevant R-ITS-S and broadcasted via ITS-G5. Vehicles driving through the coverage area of relevant R-ITS-S receive these IVI.

2.6.2 In-Vehicle Signage [DE]

Currently not supported.

2.6.3 In-Vehicle Signage [NL]

In-Vehicle Signage (IVS) will in the Netherlands be implemented as part of the Road Works Warning (RWW) use case. In the Netherlands RWW will be implemented by making use of the DENM as well as the IVI standard and by dividing the RWW information over these two message sets. The IVI part can thus be seen as (a first step towards) In-Vehicle Signage (IVS).

The RWW information is transmitted by means of DENM as well as IVI messages. The core of the RWW information is transmitted by means of DENM messages, the supporting information (e.g. on signs) is transmitted by means of IVI messages.

The Dutch Cooperative ITS Corridor project has thus chosen to use DENM for the bare essence of the information needed for RWW (need-to-have-information) and to use IVI for all additional and supplementary information (nice-to-have-information) [NL Profile].

2.7 Roadworks Warning – Short-term roadworks

For the Roadworks Warning use case, R-ITS-S transmit DENM to V-ITS-S with information about a particular traffic situation. The following sub-sections describe the CITSC country specific understanding of this use case.

2.7.1 Overview

This section provides on overview of short-term Roadworks Warning use cases supported in particular CITSC countries.

Table 1 RWW Overview in CITSC

Use Case	*Austria [AT]*	*Germany [DE]*	*Netherlands [NL]*
Standalone RWW	Yes	Yes	No
TCC Triggered RWW	Yes	No	Yes
Augmented RWW	Yes	Yes	No

2.7.2 Standalone Roadworks Warning

For the Standalone Roadworks Warning use case, R-ITS-S on a roadworks trailer transmits DENM to V-ITS-S with information about the roadworks situation. Since no common understanding exists currently in CITSC, the following sub-sections describe the CITSC country specific understanding of this use case.

Stand-alone safety trailer [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC RWW].

This scenario is used for short-term roadworks. In this scenario only a minimum of RWW data is available, generated from local trailer data. The scenario allows automatic/autonomous operation, where manual handling or on-site equipment is not necessary.

Standalone Mode [DE]

Only limited information is available (e.g. position of trailer, arrow position) on the trailer. Because of the fact that there is no connection to TCC the trailer don't know if the roadwork is mobile or stationary.

The Roadworks Warning Service is segmented with quality level depicted in DENM – DataElement_InformationQuality with value 2 or 3.

There is currently no distinction between Mobile Standalone Mode and Stationary Standalone Mode.

The physical location of the trailer is the starting point of the roadwork (RWW-position).

Stand-alone safety trailer [NL]

Not supported.

2.7.3 TCC Triggered Roadworks Warning

For the TCC Triggered Roadworks Warning use case, the TCC triggers DENM, the C-ITS-S generates DENM and an arbitrary number of R-ITS-S transmit DENM via ITS G5 to V-ITS-S with information about the roadworks situation. Since no common understanding exists currently in CITSC, the following sub-sections describe the CITSC country specific understanding of this use case.

TCC Triggered (C-ITS based) [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC RWW].

In this scenario, comprehensive RWW information is generated from the Roadwork Management Systems and on-site devices. The scenario supports different options for R-ITS-S: R-ITS-S already available at suitable location (e.g. gantry) as well as temporary installation of R-ITS-S on demand. It doesn't matter whether temporary R-ITS-S are mounted on safety trailers or put in place by other means. The availability of on-site equipment and its handling is seen as mandatory for this scenario. On the other hand, there is no need for equipping safety trailers if for example gantry-mounted R-ITS-S are available in the vicinity of the roadwork area.

TCC Triggered (C-ITS based) [DE]

Not supported.

Basic, Plus or Luxe [NL]

All Dutch scenarios (currently 'Basic', 'Plus' and 'Luxe') are TCC Triggered. The Dutch Cooperative ITS Corridor project assumes that DENM and IVI messages are always centrally generated. The DENM and IVI messages will start and stop based on centrally controlled triggers. These triggers will be derived from the existing Traffic Management Systems of Rijkswaterstaat and/or external triggers from other sources (such as external systems, road workers, contractor, etc.). The current scenarios all assume that the R-ITS-S has a connection to the C-ITS-S. The standalone as well as the TCC augmented mode is currently not in scope.

The Dutch Cooperative ITS Corridor project chooses the physical location of the trailer as starting point of the road works (eventPosition). The situation on Dutch motorways differ. Not all Dutch highways are equipped with the signaling system (MTM2). Road works on non-equipped highways will in many cases make use of mobile lane signaling systems ('Mobiele Rijstrook Signalering', MRS). When neither MTM2 nor MRSs are available, road works are managed solely by means of trailers. Note that this situation will also be the predominant situation on provincial and city roads.

Given these different situations, three so-called 'operational scenarios' (or in short: 'scenarios') are foreseen:

- Operational scenario RWW-Basic. This scenario assumes use of a portable RSU for transmitting DENM message(s) only.
- Operational scenario RWW-Plus. This scenario assumes use of fixed RSU(s) for transmitting DENM as well as IVI messages.
- Operational scenario RWW-Luxe. This scenario assumes use of a portable RSU for transmitting the DENM message(s) and fixed RSU(s) for transmitting the IVI and DENM message(s).

2.7.4 Augmented Roadworks Warning

For the Augmented Roadworks Warning use case, R-ITS-S on a stationary roadworks trailer is placed at the vicinity of a particular roadworks situation. The R-ITS-S transmits DENM to the C-ITS-S. The C-ITS-S augments the R-ITS-S DENM with information from the TCC. Finally, the augmented DENM is returned from C-ITS-S to R-ITS-S and transmitted via ITS G5 by the R-ITS-S. Since no common understanding exists currently in CITSC, the following sub-sections describe the CITSC country specific understanding of this use case.

Safety Trailer Augmented [AT]

The following UCS description is derived from [ECo-AT SWP2.1 UC RWW].

This scenario is applicable for short-term stationary roadworks. The scenario includes switching from initial UCS1 to UCS2 as well as switching between modes if connection (is lost/recovered) to the C-ITS-S. The scenario requires both, connection between R-ITS-S and C-ITS-S as well as R-ITS-S equipped trailer(s), but it provides best data quality, fusing all possible types of input.

Basic Service [DE]

This scenario is used when the R-ITS-S is connected to the TCC and additional information is available in TCC. The DENM is constructed with standalone information plus additional information from a backend system. This use case is segmented with quality level depicted in DENM data element InformationQuality with value 4, 5 or 6.

There is a differentiation in Mobile Basic Mode and Stationary Basic Mode for short-term roadworks depending of the roadwork activity.

- Short-term Mobile Roadworks with DE_CauseCodeType:=3 (roadworks) and DE_RoadworksSubCauseCode:=3 (slowMovingRoadMaintenance)
- Short-term Stationary Roadworks with DE_CauseCodeType:=3 (roadworks) and DE_RoadworksSubCauseCode:=4 (shortTermStationaryRoadworks)

The mode depends on roadworks planned in Roadworks Management System in the TCC. The physical location of the trailer is the starting point of the roadwork (RWW-position).

Augmented Road Works Warning [NL]

The Dutch Cooperative ITS Corridor project currently does not use the augmented scenario. For the Netherlands currently all DENM and/or IVI messages will be generated centrally. Even in those cases where information is collected locally (e.g. the position of the trailer), this information is processed centrally. The central will merge all information and transform this combined information into a DENM or IVI message which is then disseminated to the relevant RSU(s).

2.8 Roadworks Warning – Long-term roadworks

Long-term Roadworks Warning is currently outside the scope of this profile but can be included in later releases.

3 PROFILE

This chapter provides the actual R-ITS-G5 profile. It provides definitions and rules that are valid all over the CITSC and aims for a common ground for the ITS-G5 communication between roadside and vehicle. The structure of this chapter is based on the ITS station reference architecture/ITS-S host [ETSI 302 665].

3.1 Application Layer

3.1.1 Probe Vehicle Data

Vehicles may not provide data for all possible data elements of CAM messages . Some elements within the standard CAM messages may no be transmitted (optional elements) while other elements may have value unavailable(0) (mandatory elements). It is therefore conceivable that vehicle do transmit correct CAM messages but do not provide all information deemed necessary from the CITSC perspective. To resolve this discrepancy, Table 2Table 2 points out how CAM data elements are used in this use case.

Table 2 CAM elements specific to PVD use case

Name	Meaning	AT	DE	NL
header		Used		Used
protocol-Version	Version of the protocol. Current version is 1, thus field is set to 1.	Used		Used
messageID	Indicates the type of message. Examples are denm(1), cam(2), ivi(6), etc. Here 2 is used.	Used		Used
stationID	This is the ID of the station (vehicle) broadcasting the message.	Used		Used
cam		Used		Used
generation-Delta-Time	Timestamp belonging to the referencePosition.	Used		Used
basicContainer		Used		Used
station-Type	This DE can be 0 or 4 – 10. Other values indicate vehicles that are not allowed on the highway.	Used		Used
reference-Position	This DF is of type ReferencePosition (DF A.124 from ETSI TS 102 894-2). It contains the coordinates (WGS 84) of the ITS station (vehicle).	Used		Used
highFrequencyContainer		Used		Used
heading	The (compass) direction of the vehicle, in 1/10th of a degree.	Used		Used
speed	Speed of the vehicle in cm/s.	Used		Used
drive-Direction	The direction the vehicle is travelling in: forward(0), backward(1) or unavailable(2).	Not used		Used
vehicle-Length	Length of the vehicle in steps of 10 cm. 1 ==	Not		Used

Name	Meaning	AT	DE	NL
	10cm.	used		
vehicleWidth		Not used		Not used
longitudinal-Acceleration	The longitudinal (forward / backward) acceleration of the vehicle in steps of 0.1 m/s^2.	Not used		Used
curvature		Not used		Not used
curvature-Calculation-Mode		Not used		Not used
yaw-Rate		Not used		Not used
lowFrequencyContainer		Not used		Used
vehicle-Role		Not used		Not used
exterior-Lights	This DE is a sequence of bits (BIT STRING) of size 8. Each bit holds the status of the exterior light switches of a vehicle (e.g. fogLightOn, leftTurnSignalOn, etc.).	~~Not u~~Used		Used
pathHistory		Not used		Not used

3.1.2 Collision Risk Warning

A warning message about collision risk is broadcasted as DENM message using Basic Transport Protocol and GeoNetworking. Refer to section 3.2.2 (DENM) and 3.3.2**Fehler! Verweisquelle konnte nicht gefunden werden.** (GN) to roadworks specific protocol handling respectively.

The specific usage of DENM service primitives is defined in Table 3**Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 3 DENM service primitives for CRW

Name	*AT*	*DE*	*NL*
DENM Trigger	Not used.	Not used.	The DENM message is generated when the traffic inspector activates a button in his vehicle.
DENM Update	Not used.	Not used.	Identical to RWW. The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time.
DENM Termi-	Not used.	Not used.	A termination message is sent when the traffic inspector de-

nation			activates the button.

Note that the traffic inspectors vehicle, and not the incident itself, is considered to be the obstacle.

3.1.3 In-Vehicle Signage

The In-Vehicle Signage (IVS) use case is implemented using In-Vehicle Information (IVI) messages according to [ISO 19321].

IVI messages are used for the IVI use case in Austria [ECo-AT SWP2.1 UC IVI] whereas IVI messages are used for nice-to-have data distribution for the RWW use case in the Netherlands [NL Profile].

Since both implementations are making use of the IVI standard [ISO 19321], Table 4 describes how respective data elements are applied.

Table 4 IVI elements

IVI standard	**In-Vehicle Signage for road works**				
Field	**Meaning**	**Use**	**AT**	**DE**	**NL**
Header		Shall			
protocol-Version	Version of the protocol.	Shall	currentVersion(1).		Set to 1.
messageID	Indicates the type of message..	Shall	ivi(6).		Set to ivi 6.
stationID	This is the ID of the station broadcasting the message.	Shall	Set by application.		Set by application.
Management container		Shall			
service-ProviderId	Identifies the organization that provided the IVI by using the DE Provider; contains a country code according to ISO 3166−1.	Shall	CountryCode is a bitstring that will be set to the decimal value of 40 (bitstring 0000101000) for Austria according to ISO-3166-1. Provider-Identifier will be set to “10000” for all ECo-AT based IVI messages.		Numbers shall be assigned on national basis. See ISO 14816 for registration.
ivi-Identification-Number	This DE is the identifier of the IVI Structure, as assigned by the Service Provider. This component serves as the ID of the message and can be used by other related messages	Shall	Identifier of the IVI Structure, as assigned by the C-ITS based on information from the TCC in DATEX II.		Set by application.

IVI standard	In-Vehicle Signage for road works				
Field	**Meaning**	**Use**	**AT**	**DE**	**NL**
	as a reference.				
timestamp	This DE is the timestamp of the generation of the IVI message or the last change in information content. The message is valid from this time if validFrom is omitted.	Shall	Mandatory. Timestamp of the generation or last change of information content at the C-ITS-S (based on information incoming from TCC).		Set by application.
validFrom	This component may hold the Start time of the validity period of the message.	Can	Start time of the validity period of the message. Default is absent, will not be provided.		An IVI message should be sent from the moment a sign is valid until it is not valid anymore. When the validity or value of a sign changes this is seen as an update message and not a triggering condition. All signage information should always be received by a vehicle the moment the information is available. An IVI message should have a high interval frequency, similar to DENM.
validTo	End time of the validity period of the message duration.	Shall	End time of the validity period of the message. Will be provided by the C-ITS-S as part of the message management of IVI messages.		For RWW this DE shall always be used to determine the validity. An update shall be sent when the validity of a part of a sign is changed. For example, when the maximum speed limit is reduced during rush hour or when trucks are allowed to overtake during off-peak hours.
connected-IviStructures (1..8)	This component holds a list of other iviIdentificationNumbers identifying other IVI	Can	Shall not be included in the container, because a need for the IVS use case does		This can be used to link various IVI messages to each other. Most RWW

IVI standard	In-Vehicle Signage for road works				
Field	**Meaning**	**Use**	**AT**	**DE**	**NL**
	messages.		not exist.		situations use multiple gantries with dynamic signs. Each gantry is connected to an IVI message. These IVI messages can refer to each other via this component.
iviStatus	This component holds the status of the IVI Structure. This can be set to; new, update, cancellation or negation. Is used for message handling.	Shall	Supported Status are: new, update. It is not intended to use iviStatus cancellation or negation.		Set by application.
Geographic Location Container		Shall			
reference-Position	This component holds the starting point of the relevance zone (RZ).	Shall	Position of the start of the Relevance Zone, measured at the transversal centre of the carriageway. Altitude will not be available.		It is also used as a reference point for the detection zone (DZ). It is the main reference point for other positions within the IVI message.
Parts (1..16)	GlcPart (1..16). Up to 16 zones can be defined in one Geographic Location Container.	Shall			
zondId	Identifier of the definition of the zone, using the DE Zid. Up to 32 IDs can be defined within one IVI structure. There shall be at least 1 zone (i.e. the detection zone).	Shall	Value 1 for Detection Zone, Value 2…n for Relevance Zone(s).		ZoneId 1 is used to refer to the detection zone (DZ). The direction of the DZ is in the opposite direction with respect to the referencePosition. IVI does not enable the explicit definition of the direction of DZ. It is therefore required to explicitly define a zone as the DZ and to define the order of the points within. This will enable vehicles to use this zone as a trace to determine

IVI standard	In-Vehicle Signage for road works				
Field	**Meaning**	**Use**	**AT**	**DE**	**NL**
					relevance.
LaneNumber		Can	Optional: Mandatory if single lanes are described in this location container. Default is absent (no lane information).		Set by application.
zone	Definition of a zone using the DF Zone consisting of the choice DF Segment, DE PolygonalLine or DF ComputedSegment.	Shall	Mandatory. Only DF Segment is used.		For RWW the DF Segment is used.
segment/ polygonal/ deltaPositions	A sequence of delta points with respect to the previous position, with latitude and longitude, as coded by the data element DeltaPosition, the first position being the referencePosition in the locationContainer.	Shall	All positional data is based on information provided by the TCC. DeltaPosition: Measured at the transversal centre of the carriageway or of the lane		This sequence of points is defined on carriageway level and shall be in the middle of the carriageway. The string of points defined in this component defines a zone (e.g. RZ or DZ). IVI allows four choices for defining a polygonalLine with respect to a reference position. In order to be similar to the DENM profile, IVI will use deltaPositions. This allows zones in IVI to be equivalent to traces in DENM.
segment/ laneWidth	The data element LaneWidth contains the width of the lane in centimetres measured at the reference point. Only used when a single lane is referenced within the zone.	Can	Optional: Mandatory if single lanes are described. Default is absent (no lane information).		Set by application.
General IVI Application Container (1..16 GicParts)		Shall			
detection-ZoneIds (1..8)	List of Identifier(s) of the definition(s) of the Detection Zone(s), using	Shall	Mandatory: Value 1.		This is the area in which an IVI message should be detected

IVI standard	In-Vehicle Signage for road works				
Field	**Meaning**	**Use**	**AT**	**DE**	**NL**
	the DE Zid.				
revelance-ZoneIds (1..8)	List of Identifier(s) of the definition(s) of the Relevance Zone(s), to which the IVS Container applies, using the DE Zid.	Shall	Mandatroy: Value 2…n; the information may apply to one or more consecutive relevance zones.		This is the area in which an IVI message is applicable. It starts at the referencePosition.
direction	Direction of relevance within the relevance zone using the DE direction.	Shall	Fixed to: sameDirection(0).		Is always set to sameDirection(0).
minimum-Awareness-Time	Time in tenths of seconds before the vehicle enters the relevance area, in which the IVI should be available as a minimum.	Can	To be provided as a guideline for the receiving ITS-S, Default is absent.		Can be only included as a suggestion to the receiving ITS station.
applicable-Lanes (1..8)	List of identifiers of the lane(s) to which the IVS Container applies using the DE LaneNumber/LanePosition.	Can	All lanes to which the IVI, and/or lane status applies. To be used only if IVI or lane status information is lane specific.		If applicable to all lanes on a carriageway this DE may be absent. The road signs included in RSCode below apply to these lanes.
iviType	Priority of the Container information within the overall context of IVI. This DE is used to determine the priority of the IVI message.	Shall	Values in accordance to the information transmitted, e.g. “1” for Regulatory Messages.		This shall be set to 1 which is regulatory information. Immediate danger would be 0. For RWW IVI is however by defintion used as supporting information, additional to DENM.
iviPurpose	This informes the receiving ITS-S on how the message should be used. This can be, Safety, Environmental or TrafficOptimisation.	Shall	Shall not be included in the container.		Altough IVI is used for supporting information, the purpose is safety. The value is therefore set to Safety (0).
laneStatus	Indicates the lane status (e.g. open, closed, mergeR) of the applicableLanes.	Can	Status of the lane(s) if different from "open".		This field may be set at ‘closed’ for lanes closed with a red cross sign, at ‘mergeR’ for lanes with an arrow sign pointing right, etc.
complete-Vehicle-	Characteristics of vehicle, for which the IVI is	Can	To be provided if IVI is applicable to specific		Set by application.

IVI standard	In-Vehicle Signage for road works				
Field	**Meaning**	**Use**	**AT**	**DE**	**NL**
Characteristics	applicable. The applicable regulations, such as limits, are defined as part of the roadSignCode component. Can be used to communicate vehicle restrictions within the relevance zone.		types of vehicles only.		
roadSign-Codes (1..4)	The data frame RSCode shall contain the definition of the road sign code. It allows different options pointing to different pictogram catalogues. This component specifies which road signs are applicable for a Relevance Zone. Road sign codes are dependent on the referenced classification scheme. A sending ITS-S should select the road sign from a catalogue which is known to be supported by a receiving ITS-S. Additional attributes to the road sign code can be added as provided by the options in the Data Frame RSCode.	Shall	Ordered list of Road Sign codes using the ISO TS 14823 coding (see examples) corresponding to the signs displayed on the road by ASFINAG.		In order to link a roadSigncode to the correct roadsign, a common library should be used. Within IVI the DF RSCode can be used to set the library. Prechosen libraries are; Vienna Convention, ISO14823, SAE J2540. For RWW ISO14823 is chosen. For RWW the following signs will be included: red cross, arrow pointing right, arrow pointing left, arrow pointing down, speed limit 50, speed limit 70, speed limit 90, end of restrictions.
extraText (1..4)	List of text lines associated to the ordered list of road sign codes. Each piece contains language code plus extra, limited-size text in the selected language using the DF text.	Can	List of text lines associated to the ordered list of road sign codes corresponding to the text displayed on the road by ASFINAG.		Can be used to send a message for clarification or additional information.
Other DFs / DEs	All other DFs and DEs in the IVI standard, not mentioned above.	Not used			

3.1.4 Roadworks Warning – Short-term

A warning message about roadworks is broadcastes as DENM message using Basic Transport Protocol and GeoNetworking. Refer to section 3.2.2 (DENM) and 3.3.2**Fehler! Verweisquelle konnte nicht gefunden werden.** (GN) to roadworks specific protocol handling respectively.

The specific usage of DENM service primitives is defined in Table 5.

Table 5 DENM service primitives for RWW

Name	*AT*	*DE*	*NL*
DENM Trigger	Augmented RWW: The DENM is triggered by the C-ITS-S if all information from the trailer are available. RWW always starts with Standalone RWW. If a connection to TCC is possible and additional information in TCC exist, then the Augmented RWW starts when the DENM is augmented. Standalone RWW: The DENM is triggered at the moment the trailer board reaches the open state. TCC Triggered RWW: The DENM is triggered by the TCC depending on the availabiliy of on-site information.	Augmented RWW: The DENM is triggered at the moment the trailer board reaches the open state. Standalone RWW: The DENM is triggered at the moment the trailer board reaches the open state. RWW always starts with Standalone RWW. If a connection to TCC is possible and additional information in TCC exist, then the Augmented RWW starts when the DENM is augmented.	TCC Triggered RWW: The DENM is centrally triggered as the (best estimate for the) moment the physical blockage of the lane is physically blocked due to the roadworks.
DENM Update	Augmented RWW: The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time. Standalone RWW - Mobile: The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time. Additionally, change of position and change of arrow sign is used as update trigger. Standalone RWW - Stationary:	Augmented RWW - Mobile: The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time. Additionally, change of position and change of arrow sign is used as update trigger. Augmented RWW - Stationary: The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time.	TCC Triggered RWW: The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time.

	The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time. TCC Triggered RWW: The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time.	Standalone RWW: The DENM is updated when its age (current system time minus DENM detection time) is greater than or equal to half of its validity time. TCC Triggered RWW: Not supported	
DENM Termi-nation	Not used.	Not used.	Used.

3.2 Facility Layer

3.2.1 Common Data Dictionary

The Common Data Dictionary (CDD) shall be applied according to the ETSI document [ETSI 102 894-2] and the following definition in this section.

Table 6 CDD elements in general

Name	*Kind*	*Rule*	*Usage*
DrivingLaneStatus	Data Element	Shall	The definition of data element DE_DrivingLaneStatus shall be extended in the following way. Due to the matching of bit string numbers to DE_LanePosition, the first bit of DE_DrivingLaneStatus (2 to 0 equals 1) is not used (don't care). The value outermostDrivingLane(1) from DE_LanePosition is encoded by the second bit of DE_DrivingLaneStatus (2 to 1 equals 2) and so on. Note: It is assumed, that the ETSI change request number 7296 (http://forge.etsi.org/mantis/view.php?id=7296) is accepted. As a consequence the bit string has always a constant length. Trailing zeros are not omitted.

3.2.2 DEN Basic Service

DEN Basic Service (DEN BS) shall be applied according to the ETSI document [ETSI 302 637-3] and the following definition in this section.

The DENM repetition shall be done by the DEN basic service as specified in [ETSI 302 637-3]. Refer to Table 8 for the definition of the parameters for repetition duration and interval.

The traffic class value for DENM messages shall be as set as defined inTable 7.

Table 7 Mapping of Use Cases to Traffic Classes

Use Case (DENM Cause Code)	*Traffic Class*
Roadworks Warning (3)	1

Data elements, data frames and service parameters shall be used according to the definitions in Table 8.

Table 8 DENM elements in general

Name	*Kind*	*Rule*	*Usage*
ActionId	Data Element	Shall	Set by DEN Basic Service according to [ETSI 302 637-3].
ClosedLanes	Data Frame	Can	See use case specific part in the sub-sections at the end of this section. Note: Check ETSI change request number 6504 (http://forge.etsi.org/mantis/view.php?id=6504) for information about the closed leanes concept.
Detection-Time	Data Element	Shall	*Austria* The data element DetectionTime is used in a use case scenario specific manner. General: The data element shall be set based on the respective system time. If the RWW event duration exceeds the validity duration, the DENM shall be updated with a new DetectionTime. There shall be no time gaps in the distribution of DENM. If the RWW event duration exceeds the validity duration, the R-ITS-S shall update the DENM with a new DetectionTime. There shall be no time gaps in the distribution of DENM. Specific: In the TCC Triggered RWW use case scenario, the trigger to set this value is on-site information from e.g. operating personal. In the Augmented RWW use case scenario, the trigger to set this value is the message generation by the C-ITS-S. In the Standalone RWW use case scenario, the trigger to set this value is based on the trailer board. The time is set at the moment the board reaches the open state. The data element value shall come from the local time source of R-ITS-S. *Germany* The data element DetectionTime is always set by the R-ITS-S on the trailer. The trigger to set this value is the position of the sheet metal arrow sign. *Netherlands* The data element DetectionTime is always set by TCC or C-ITS-C. The trigger to set this value is centrally determined as the (best estimate for the) moment the physical blockage of the lane is physically blocked

			due to the roadworks.
EventHistory	Data Frame	Can	See use case specific part in the sub-sections at the end of this section.
EventPosition	Data Frame	Shall	It represents the position where the physical blockage on the lane of the carriageway starts. See **Fehler! Verweisquelle konnte nicht gefunden werden.**~~Table 7~~ in section 3.2 Use Case Specific Part for the use case specific implementation. For instance, it depends on the CITSC country whether the blockage is a trailer or a cone.
EventPosition Heading	Data Frame	Can	See use case specific part in the sub-sections at the end of this section.
EventSpeed	Data Frame	Can	See use case specific part in the sub-sections at the end of this section.
EventType	Data Frame	Shall	See CauseCodeType and SubCauseCode Type in the use case specific part in the sub-sections at the end of this section.
External-Temperature	Data Element	-	Not used
Impact-Reduction	Data Frame	-	Not used
Incident-Indication	Data Frame	-	Not used
Information-Quality	Data Element	Shall	The definition of values for the data element informationQuality is compliant with the document [AG RWW]. See **Fehler! Verweisquelle konnte nicht gefunden werden.**~~Table 7~~ in section 3.2 Use Case Specific Part for the use case specific implementation. For instance, it depends on the CITSC county what values are applied.
LightBar-SirenInUse	Data Element	-	Not used
Linked Cause	Data Frame	-	Not used
Positioning-Solution	Data Element	-	Not used
Recommen-dedPath	Data Frame	-	Not used
Reference-Denms	Data Frame	Can	Used, if the use case (scenario) consists of multiple DENM messages. Not used, if the use case (scenario) consists of a single DENM message e.g. Short-term Standalone Roadworks Warning.
Reference-Time	Data Element	Shall	See use case specific part in the sub-sections at the end of this section.
Relevance-Distance	Data Element	Shall	The TCC furnishes this value or the default value of lessThan5km(5) is used.
Relevance-Traffic-Direction	Data Element	Shall	upstreamTraffic (1)
Repetition-Duration	Service Para-meter	Shall	Equal to the value of data element DE_ValidityDuration. Note: Shall be discussed with other stakeholders.
Repetition-Interval	Service Para-meter	Shall	See use case specific part in the sub-sections at the end of this section. Note: Shall be discussed with other stakeholders.

Restriction	Data Element	-	Not used
RoadType	Data Element	-	Not used
SpeedLimit	Data Element	Can	See use case specific part in the sub-sections at the end of this section.
Starting-PointSpeed-Limit	Data Element	Can	See use case specific part in the sub-sections at the end of this section.
StationType	Data Element	Shall	RoadSideUnit (15)
Stationary-Vehicle	Data Frame	-	Not used
SubCause-CodeType	DataEle ment	Shall	See use case specific part in the sub-sections at the end of this section. This data element shall be used since it is specified as mandatory by ETSI stadards. Use the value unavailable(0) in case it is impossible to find a suitable value.
Transmission-Interval	Data Element	-	Not used
Traces	Data Frame	Shall	See use case specific part in the sub-sections at the end of this section.
TrafficFlow-Rule	Data Element	Can	Used with values: passToRight(2) and passToLeft(3). The actual value depends on the situation on the carriageway.
Termination	Data Element	Can	Can be used. But, if it is not used, the data element DE_ValidityDuration, shall be set to a reasonable value according to the respective use case scenario.
Validity-Duration	Data Element	Shall	See use case specific part in the sub-sections at the end of this section.

Collision Risk Warning

The Collision Risk Warning specific usage of DENM data elements and frames is defined in Table 9.

Table 9 DENM elements specific to CRW

Name	Use	AT	DE	NL
Header	Shall			
protocol-Version	Shall			Set to 1
messageID	Shall			Set to 1.
stationID	Shall			Set by application.
management container	Shall			
actionID	Shall			Set by application.

Name	Use	AT	DE	NL
detection-Time	Shall			detectionTime set by application. repetitionDuration equal to validityDuration. repetitionInterval between 0.1 and 0.25 sec.
reference-Time	Shall			Following the DENM standard, the referenceTime shall be set to the time the DENM message is encoded by the DEN Basic Service.
termination	Shall			In order to end the communication a termination message will be sent.
event-Position	Shall			DENM messages focus on the safety related aspects. DENMs thus primarily communicate the position of obstacles. Similar to RWW, this will for this use case be the point where a lane is physically closed and thus the position of the traffic inspectors vehicle. The accuracy shall be on the level of a lane (not carriageway). For this use case this will generally be the hard shoulder.
relevance-Distance	Shall			Set to 'lessThan5km(5)'.
relevance-Traffic-Direction	Shall			Set to 1 (upStreamTraffic).
validity-Duration	Shall			Set to 720 (seconds).
transmission-Interval	-			Not used
station-Type	Shall			Set to roadSideUnit (15) because the generating and sending station is a Roadside ITS-Station (R-ITS-S).
situation container	Shall			
information-Quality	Shall			The DE information-Quality shall be set as follows: Not defined (0), simple GNSS (2), differential GNSS (3), Not defined (7).
event-Type	Shall			causecode set to 97. subCauseCode set to 1.
event-History	Not used			This DF is not used since this use case warns for a dangerous point rather than a dangerous stretch.
location container	Shall			
event-Speed	-			The Flister application currently does not provide this information. This DF is therefore not used.
event-Position-	Can			The Flister application uses the 'driving direction' as an information element. This information element may be

Name	Use	AT	DE	NL
Heading				conveyed in DENM as eventPositionHeading. This is however not Shall since the DENM message, contrary to the Flister application, also includes traces.
traces	Shall			The end trace point is, equivalent to traces for RWW, defined as the point parallel to the eventPosition (traverse position) in the middle of the carriageway. The start trace point (carriage way level) is recommended to be at least 1.5 km upstream of the event position. Points will be defined on the accuracy level of a carriage way. See also the RWW profile.
Other DFs / DEs	-			Not used

Roadworks Warning – Short-term

The Roadworks Warning specific usage of DENM data elements and frames is defined in Table 10**Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 10 DENM elements specific to RWW

Name	*Kind*	*Use*	*AT*	*DE*	*NL*
Closed-Lanes	Data Frame	Can	Optional and its usage depends on the particular use case scenario. Standalone RWW: not used Augmented and TCC Triggered RWW: provided by the TCC as precise as possible if information is available.	Optional and its usage depends on the particular use case scenario. Standalone RWW: not used Augmented RWW: provided by the C-ITS-S as precise as possible if information is available.	Optional in NL.
Event-History	Data Frame	Can	This is a list of event points starting at the event reference position. The last event point in the list is also the end of the event. The list always consists of the maximum number of 23 points equally distributed over the distance between event start and end. The TCC has no	Not used for day one of ITS-G5.	Optional in the NL profile. It covers the area from the beginning to the end of the roadworks, but defines the start and end of the roadworks at the minimum. The points are located at the middle of the carriageway. The list consists of variable number of points. If necessary

			carriage lane specific data. The right most lane of the carriageway is mostly used. Standalone & Augmented RWW: not used. TCC Triggered RWW: used.		(e.g. a curved road) the list may include intermediate points.
Event-Position	Data Frame	Shall	Standalone RWW: position of the trailer. Augmented RWW: Position of the trailer. TCC Triggered RWW: position of the cone.	Position of the trailer.	Position of the physical blockage (e.g. the trailer).
Event-Position-Heading	Data Frame	Can	Moving Standalone RWW: used. Stationary Standalone, Augmented and TCC Triggered RWW: not used.	Used.	Not used.
Event-Speed	Data Frame	Can	Moving Standalone RWW: used. Stationary Standalone, Augmented and TCC Triggered RWW: not used.	Used.	Not used.
CauseCode Type	Data Element	Shall	CauseCodeType: roadworks (3)	CauseCodeType: roadworks (3)	CauseCodeType: roadworks (3)
Informa-tion-Quality	Data Element	Shall	Standalone RWW: 2 for simple GNSS and 3 for differential GNSS. Augmented and TCC Triggered RWW: 4.	Standalone RWW: 2 for simple GNSS and 3 for differential GNSS. Augmented RWW: 4, 5 or 6.	Value depends on the use case scenario.
Reference-Time	Data Element	Shall	Moving and Stationary Standalone RWW: Is the time the DENM is encoded in the R-ITS-S. Augmented and TCC Triggered RWW: Is the time the DENM is encoded in the C-ITS-S.	Is the time the DENM is encoded in the R-ITS-S.	Is the time the DENM is encoded in the C-ITS-S.

Repetition-Interval	Service Para-meter	Shall	Standalone RWW: 0.5 seconds. Augmented and TCC Triggered RWW: 1 second.	0.2 seconds.	Between 0.1 and 0.25 seconds.
SpeedLimit	Data Element	Can	Moving and Stationary Standalone RWW: Not used. Augmented and TCC Triggered RWW: Used if information is available.	Not used.	Optional. IVI messages containing speed limits may be supplied additional to DENM.
Starting-Point-SpeedLimit	Data Frame	Can	Moving and Stationary Standalone RWW: Not used. Augmented and TCC Triggered RWW: Used if information is available.	Not used.	Optional. IVI messages containing speed limits may be supplied additional to DENM.
SubCause-CodeType	Data Element	Shall	TCC Triggered & Augmented RWW: Depends on roadworks. Moving and Stationary Standalone RWW: Not used.	Augmented RWW: Depends on roadworks: Short-term mobile roadworks: slowMovingRoadMaintenance(3), short-term stationary roadworks: shortTermStationaryRoadworks(4). Standalone RWW: unavailable(0).	Depends on roadworks: Short-term mobile roadworks: slowMovingRoadMaintenance(3), short-term stationary roadworks: shortTermStationaryRoadworks(4)..
Traces	Data Frame	Shall	Mandatory in AU profile TCC Triggered RWW: Generated in the TCC/GIP from known event location information (potentially originating from a trailer) and provided to C-ITS-S. The data frame shall consist of at least 10 data elements of type PathPoint with a steady distance of 50m. Augmented RWW: Based on uplink information from R-	Mandatory in DE profile Always set by the R-ITS-S on the roadworks trailer.	Mandatory in NL profile In principal, the middle of the carriageway is used for the generation. It includes at least the start point of the trace as well as the end next to the event position. If necessary (e.g. a curved road) the list may include intermediate points.

			ITS-S Standalone RWW: Generated in R-ITS-S or trailer (without any manual interaction; GNSS required).		
Validity-Duration	Data Element	Shall	Standalone RWW:20 seconds. Augmented and TCC Triggered RWW: 720 seconds.	20 seconds	TCC Triggered RWW: 720 seconds.

Note: Harmonization of data elements Traces, EventHistory und RepetitionInterval in Table 10 is in progress. CITSC is striving for a harmonized understanding and implementation. Discussion with other stakeholdes is desired.

3.3 Network & Transport Layer

3.3.1 Basic Transport Protocol

Basic Transport Protocol shall be applied as transport protocol according to the ETSI document [ETSI 302 636-5-1] and the following definition in this section.

BTP-B headers shall be employed. Consequently, the GN common header shall use a value 2 for the Next Header (NH) field.

The destination port info field shall be set to the value 0.

3.3.2 GeoNetworking

GeoNetworking (GN) shall be applied as networking protocol according to the ETSI document [ETSI 302 636-4-1] and the following definition in this section.

Default parameters of the GN protocol not overwritten in this profile shall be set as specified in Annex G of [ETSI 302 636-4-1]. Table 11 provides an overview of GN configuration for this profile; protocol parameter as well as header fields. The explanation follows afterwards.

Table 11 GN configuration overview

Key	*Value*	*Type*
itsGnLocalAddrConfMethod	ANONYMOUS (2)	Parameter

itsGnSecurity	ENABLED (1)	Parameter
itsGnMaxGeoAreaSize	80	Parameter
itsGnIfType	ITS-G5 (1)	Parameter
SHB LT	1	Header Field
GBC LT	Min(of ValidityDuration, RepetitionInterval)	Header Field
SCF bit	1	Header Field
Offload bit	0	Header Field
PAI	1	Header Field
EtherType	0x8947	Header Field

"Anonymous address" shall be chosen for GN address configuration (itsGnLocalAddrConfMethod = ANONYMOUS (2)) [C2CCC BSP].

GN security shall always be enabled (itsGnSecurity = ENABLED (1)) [C2CCC BSP].

80 km² shall be the maximum size of geographical areas in GBC or GBA to avaoid Deny Of Service (DOS) attacks (itsGnMaxGeoAreaSize = 80) [C2CCC BSP].

GN paket repetition shall be disabled [C2CCC BSP].

GN shall be used with itsGnIfType = ITS-G5 (1) [C2CCC BSP].

The packet header type Single Hop Broadcasting (SHB) shall be used on all CAM packets (HT = 5, HST = 0) [C2CCC BSP].

The packet header type GeoBroadcast (GBC) shall be used on all DENM packets (HT = 4, HST = 0, 1 or 2) [C2CCC BSP][ECo-AT SWP2.3 system overview].

The LifeTime (LT) field of all SHB packets shall be set to 1 second [C2CCC BSP].

The LifeTime (LT) field of all GBC packets shall be set to the minimum of ValidityDuration and RepetitionInterval, but shall not exceed the itsGnMaxPacketLifetime parameter, specified in Annex G of [ETSI 302 636-4-1]. [C2CCC BSP].

"Store-carry-forward" shall be enabled. In other words, the SCF bit in the Traffic Class (TC) field shall be set to 1. That way, packets are buffered if no neighbors are available [C2CCC BSP].

"Channel offload" shall always be disabled. In other words, the channel offload bit in the TC field shall be set to 0 [C2CCC BSP].

The multi-hop operation mode shall be supported by implementing the forwarding algorithm specified in the Annex E.3 [ETSI 302 636-4-1]. [C2CCC BSP].

Duplicate packet detection shall be used. Consequently, the algorithm specified in A.2 and A.3 of [ETSI 302 636-4-1] shall be used for detecting duplicate packets [C2CCC BSP].

A R-ITS-S may send beacons with the Position Accuracy Indicator (PAI) set to 1 [C2CCC BSP].

GN frames shall use the EtherType value 0x8947 as listed by the IEEE Registration Authority at http://standards.ieee.org/develop/regauth/ethertype/eth.txt [C2CCC BSP].

Other DENM Application

The specific usage of GN for the use case Other DENM Application (ODENM) is defined in this section. ODENM uses the Geo Broadcast (GBC) packet. Respective GBC parameters shall be used in the following way [ECo-AT SWP2.3 system overview].

- Common Header: Header type = GEOBROADCAST (4)
- Common Header: Header subtype = GEOANYCAST_CIRCLE (0)
- Common Header: Maximum Hop Limit = 1
- GBC: Source Position Vector: GN Address: Station Type = Road Side Unit (15)
- GBC: Source Position Vector: GN Address: Country Code = "country specific"
- GBC: Source Position Vector: Lat/Long = "position of the R-ITS-S"
- GBC: Lat/Long = "position of the R-ITS-S"
- GBC: Distance A = 1000m
- GBC: Distance B = 0m
- GBC: Angle = 0°

Intersection Safety

The specific usage of GN for the use case Intersection Safety (ISS) is defined in this section. ISS uses the Single-hop Braodcast (SHB) packet. Respective SHB parameters shall be used in the following way [ECo-AT SWP2.3 system overview].

- Common Header: Header subtype = Single Hop (0)
- Common Header: Maximum Hop Limit = 1
- TSB: Source Position Vector: GN Address: Station Type = Road Side Unit (15)
- TSB: Source Position Vector: GN Address: Country Code = “country specific”
- TSB: Source Position Vector: Lat/Long = “position of the R-ITS-S”

In-Vehicle Signage

The specific usage of GN for the use case In-Vehicle Signage (IVS) is defined in this section. IVS uses the Geo Broadcast (GBC) packet. Respective GBC parameters shall be used in the following way [ECo-AT SWP2.3 system overview].

- Common Header: Header type = GEOBROADCAST (4)
- Common Header: Header subtype = GEOANYCAST_CIRCLE (0)
- Common Header: Maximum Hop Limit = 1
- GBC: Source Position Vector: GN Address: Station Type = Road Side Unit (15)
- GBC: Source Position Vector: GN Address: Country Code = “country specific”
- GBC: Source Position Vector: Lat/Long = “position of the R-ITS-S”
- GBC: Lat/Long = “position of the R-ITS-S”
- GBC: Distance A = 1000m
- GBC: Distance B = 0m
- GBC: Angle = 0°

Roadworks Warning – Short-term

The specific usage of GN for the use case Roadworks warning (RWW) is defined in this section. RWW uses the Geo Broadcast (GBC) packet. Respective GBC parameters shall be used in the following way [ECo-AT SWP2.3 system overview].

- Common Header: Header type = GEOBROADCAST (4)
- Common Header: Header subtype = GEOANYCAST_CIRCLE (0)
- Common Header: Maximum Hop Limit = 1
- GBC: Source Position Vector: GN Address: Station Type = Road Side Unit (15)
- GBC: Source Position Vector: GN Address: Country Code = “country specific”
- GBC: Source Position Vector: Lat/Long = “position of the R-ITS-S”

- GBC: Lat/Long = “position of the R-ITS-S”
- GBC: Distance A = 1000m
- GBC: Distance B = 0m
- GBC: Angle = 0°

3.3.3 Geographical Area Definition

Geographical areas shall be applied according to the ETSI document [ETSI 302 931] and the following definition in this section.

Circular, rectangular and ellipsoidal geographical areas shall be supported. Each use case defined in this profile shall specify one of the above geographical area types and indicate it through the GN header as specified in [ETSI 302 636-4-1]. [C2CCC BSP].

If a R-ITS-S calculates the distance between two positions using GNSS coordinates (e.g. for PathDeltaPoints or in case of circular relevance area), it is recommended that the great-circle or orthodromic distance method is used. Thereby, care shall be taken to avoid large rounding errors on low-precision floating point systems; these can be avoided, e.g., with the haversine formula. In case the relevance area is an ellipse or a rectangle, then the cartesian coordinates of the area center and of the current position need to be calculated for assessing whether to hop the packet as specified in [ETSI 302 931]. For this purpose, it is recommended to use the Local Tangent Plane method, or another method delivering the same accuracy [C2CCC BSP].

3.4 Access Layer

3.4.1 Radio Communication Equipment

Equipment for radio communication shall be applied according to the ETSI document [ETSI 302 571] and the following definition in this section [C2CCC BSP].

The control channel G5-CCH shall be used to send messages necessary for the use cases covered by this profile [C2CCC BSP].

3.4.2 Access Layer Specification

ITS G5 access layer shall be applied according to the ETSI document [ETSI 302 663] and the following definition in this section [C2CCC BSP].

A transfer rate of 6 Mbit/s shall be used on the control channel G5-CCH [C2CCC BSP].

To be future-proof, the transfer rates 3 Mbit/s and 12 Mbit/s shall be supported on the control channel G5-CCH [C2CCC BSP].

The broadcast mode shall be supported [C2CCC BSP].

3.4.3 Mitigation Technique for CEN DSRC

Mitigation techniques shall be applied according to the ETSI document [ETSI 102 792] and the following definition in this section [C2CCC BSP].

At least the detect-and-avoid method based on the tolling zone announcement messages shall be applied [C2CCC BSP].

3.4.4 5 GHz Channel Specification

Channels in the 5 GHz frequency band shall be applied according to the ETSI document [ETSI TS 102 724] and the following definition in this section [C2CCC BSP].

The following DCC-Profiles defined inside [ETSI 102 724] shall be supported: DP0, DP1, DP2 and DP3. These four DCC-Profiles shall use the following DCC-Profile Identification (DPID) values [C2CCC BSP]:

- DP0, used only for DENMs with TC = 0
- DP1: used for DENMs with TC = 1
- DP2: used for CAMs with TC = 2
- DP3: used for forwarded DENMs and other low priority messages

3.5 Management Entity

To be added in later releases.

3.6 Security Entity

To be added in later releases.

4 TABLE OF REFERENCES

Table 12 Table of references

#	Abbreviation	Reference
	[ETSI 102 894-2]	ETSI TS 102 894-2 V1.2.1 (2014-09) - Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary
	[ETSI 302 637-2]	ETSI EN 302 637-2 V1.3.2 (2014-11) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service
	[ETSI 302 637-3]	ETSI EN 302 637-3 v1.2.2 (2014-11) Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service
	[ETSI 302 636-4-1]	ETSI EN 302 636-4-1 V1.2.1 (2014-07) GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality
	[ETSI 302 636-5-1]	ETSI EN 302 636-5-1 V1.2.1 (2014-08) Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol
	[ETSI 102 724]	ETSI TS 102 724 V1.1.1 (2012-10) Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band
	[ETSI 302 931]	ETSI EN 302 931 V1.1.1 (2011-07) Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition
	[ETSI 302 571]	Draft ETSI EN 302 571 V2.0.0 (2016-03) Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
	[ETSI 302 663]	ETSI EN 302 663 V1.2.1 (2013-07) Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band
	[ETSI 102 792]	ETSI TS 102 792 V1.2.1 (2015-06) Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range
	[ETSI 302 665]	ETSI EN 302 665 V1.1.1 (2010-09) Intelligent Transport Systems (ITS); Communications Architecture
	[AG RWW]	Amsterdam Group – Road Works Warning Functional Description, Version 1.0 Amsterdam Group – Message Set and Triggering Conditions for Road Works Warning Service, Version 2.0
	[ECo-AT SWP2.1 UC CAM aggr]	ECo-AT_SWP2.1_CAM_Aggregation_v03.60.pdf
	[ECo-AT SWP2.1 UC other DENM]	ECo-AT_SWP2.1_DENM_Applications_v03.60.pdf
	[ECo-AT SWP2.1 UC ISS]	ECo-AT_SWP2.1_IntersectionSafety_v03.60.pdf
	[ECo-AT SWP2.1 UC IVI]	ECo-AT_SWP2.1_InVehicleInformation_v03.60.pdf
	[ECo-AT SWP2.1 UC RWW]	ECo-AT_SWP2.1_RoadWorksWarning_v03.60.pdf
	[ECo-AT SWP2.3 system	ECo-AT_SWP2.3_SystemOverview_v03.60.pdf

	overview]	
	[C2CCC BSP]	Draft C2C-CC Basic System Standards Profile Version 1.1.0
	[ISO 19321]	ISO/TS 19321:2015 (2015-04-15) - Intelligent transport systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structures
	[NL Profile]	DUTCH C-ITS CORRIDOR PROFILE Version 2.0