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Dutch ITS profile

VERSION V0.20

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Intended audience

This document provide insight for decision makers, is expected to be used as reference document for RFQ's (Requests For Quotations) by buyers and management tool by project managers. It is the reference for implementation of ITS use cases. It enables the realization of interoperable ITS products and services.

The extended summary and the context as provided in the scope offer those with a high level interest in the Dutch Profile an introduction. The use case specification as addressed in the Annex of this document provides additional context for business and technical managers. The functional details of these use cases are the reference to the included profiling of message sets and serve those with an interest to gain a deeper understanding in the implementation of these use cases. Finally, the main document contains base requirements and a specified Dutch profile of the technical base standards. It serves as a directory for market players and technical specialists towards technical realization through interoperability and conformity.

Support

The Dutch Profile is maintained by the Profile writing team, any questions, comments or suggested can be forwarded to the members of this writing team.

For this first version of the Dutch Profile the writing team is represented by:

Name	Company	Contribution
Wim Broeders, Jaap Vreeswijk	MAPtm B.V.	Functional Use-Cases and functional specifications and connected to CEN/ISO, SAE ITS standardization, Amsterdam Group and C-ITS Corridor
Paul Spaanderman	PaulsConsultancy B.V.	Technical Use-Cases, Technical concepts and specifications. Connected to CEN.ISO, ETSI, SAE and IEEE standardizations and relation with Amsterdam Group, C2C-CC and EU commission ITS-Platform
Borgert van der Kluit	TNO	Technical Editor of the Dutch Profile, Technical specifications and ETSI standardization.

Legal statement

The current release of the Dutch Profile is a theoretical version. To this release no legal claims can be extracted.

Summary

The Dutch Profile (PD) is to be the single point of reference in the Netherlands to secure the interoperability and conformity in the ITS system between solutions of the participating stakeholders. The Dutch Profile contains an architectural system description with base requirements and profiling of the base ITS standards to support the deployment of ITS use-cases prioritized at the Standardization Table. The profile is aligned with Dutch ITS stakeholders and is supported by Rijkswaterstaat, I&M and Dutch industrial stakeholders.

The Dutch Profile includes the functional and technical specifications relevant for ITS systems realization in the Netherlands. It only specifies those ITS elements being found relevant to commonly agree among the stakeholders in the Netherlands and is harmonized with other profiles in Europe there where relevant. It realizes the specifications by normative referencing to standards mainly although for some it references to internal Dutch specifications in most cases provided by other Dutch organizations.

This is the **theoretical** first release to enable evaluation by key business stakeholders. This release includes some normative references to documents without version number. This is done based on the situation that not all references are published. Therefore it must be noted that final practical release of the Dutch Profile we will have to wait till these are released and published.

The current release is targeted on those aspects related to ITS-G5 communication at 5.9 GHz and its air interface. It includes also relevant system related requirements but in this release none of the other interfaces have been captured. This is also not required for an Vehicle, Personal and Roadside devices, but further detailing to also support in Infrastructural systems where ITS related information is send through between the RSU and Central domain will be needed.

The current release, support a set of initial use cases as prioritized by the stakeholders at the standardization table. These are the Short Term static and Long Term static RWW, Green Light Optimal Speed Advisory, Priority Request, Probe Vehicle Data as discussed in the chapter Use cases.

This release covers the basic Interoperability aspects; further detailing down to the message exchange level in further releases is desired to enhance the interoperability level.

One essential aspect is the implementation of the security and its framework, those are not in place yet. A next version of Dutch Profile needs to incorporate these security and privacy technical interoperable aspects.

The operational requirements as well as the channel usage and radio performance are not yet agreed in this release. In a next version an agreement among the different Dutch projects will need to be accomplished at the Standardization Table.

The Dutch Profile does not include, Compliance and Certification requirements and specifications. These are defined elsewhere.

The DITCM Standardization Table members, Rijkswaterstaat, I&M and Business stakeholders, accept this release.

Contents

Figures

1 Introduction

1.1 Profile overview

This document is the leading part of a multi-part document referring to its other parts, to standards from different standard organizations (SDO's), and additional other specifications when applicable. Related standards and additional specifications are not an integral part of the Dutch Profile document but are separate documents. Standards can't be provided by the organization managing the Dutch Profile documents. Relevant standards can only be obtained by addressing related SDO's through their specific business models.

The Dutch profile and additional specifications are specified from the viewpoint of the information providing (transmitting) entity (e.g. the observable behavior is defined) although in specific cases receiver specific aspects may be additionally specified.

1.2 Profile objective and structure

The aim of the Dutch Profile is to be the single point of reference in the Netherlands to secure the interoperability and conformity between ITS applications and system implementations to support stakeholder common and individual business cases. To that end the Dutch Profile contains an architectural system description with base requirements and profiling of base standards to support the deployment of selected ITS use-cases. Profiling intends to register the use of functional and technical standards required for implementation, if needed completed with additional (regional) specifications. The Dutch Profile considers existing systems as starting point for the additional ITS applications and functionalities.

This profile is aligned with Dutch ITS stakeholders at the DITCM Standardization Table and is supported by Rijkswaterstaat, I&M and Dutch industrial stakeholders to ensure conformity and interoperability required for the Dutch situation. Depending on the Use-Cases, alignment with other European and World ITS deployments are considered.

The current document consists of this main document, and documents specifying the requirements put on use case implementation (see Annexes to this document).

The current document does not include the compliancy assessment required to complement the full development process.

1.3 Current state of this document

This document is a draft version of the Dutch Profile. Many requirements are not yet at the required detail level or are currently still under discussion and may be changed or removed entirely, while new ones may be added.

2 Scope

The Dutch Profile is intended as bases for the deployment and further innovation of ITS use-cases, services, products and systems.

The Dutch Profile provides the minimum set of functional and technical specifications required ensuring conformity and interoperability for those Intelligent Transportation use-cases being deployed in Netherlands. It covers all Connected, Cooperative an Automated use-cases relevant for the Dutch transport business stakeholders and road users. The development of the Dutch Profile is aligned with the Dutch ITS Roadmap as agreed at the Dutch Standardization table and supported by the Stakeholders and relevant projects such as BeterBenutten (I&M) program, het Dutch Corridor project and City oriented projects.

The Dutch Profile only includes specifications required for conformity and interoperability; it therefore does not include all standards and specifications.

The Dutch Profile envisions an agnostic Hybrid Communication approach and covers not only the interfaces between Vehicles (V-ITS), Personal Devices (P-ITS) and Road-Side Units (RSU's, R-ITS) also information exchange en system management/maintenance between for instance Traffic Information Systems (TIS) en Traffic Management Systems (TMS) are specified. Additional it includes communication related interoperability and security related aspects when they are not covered elsewhere, such as radio transmission specifications for IEEE 802.11p/ITS-G5.

The Dutch Profile includes functional technical specifications as result of requirements coming from Business, Privacy & Security, Maintainability & Modifiability, Operability, Portability, Scalability (horizontal, vertical), Stability, Reliability, Reusability, Robustness & Quality, Exploitability, Extensibility and Legal considerations.

The Dutch Profile considers, A2A, A2B, A2C, B2B en B2C business cases (A= Authorities). All transport actors such as road operator, emergency, Infrastructure, Vehicle, Public Transportation, City Traffic controllers, Pedestrians, Fleet manager, Parking are considered..

As communication media generic cellular 3G, 4G, 5G, 5G-Automotive, LTE-Direct, IEEE 802.11p/ITS-G5, IEEE 802,11ab/a.., DAP+ are considered. Further IoT and cloud concepts are considered and an open system architecture and data exchange is envisioned.

The current document provided supports the first set of use-cases as specified in chapter **Error! Reference source not found.** to be deployed via specific 5.9 GHz communication protocol's IEEE802.11p/ITS-G5.

3 References

3.1 Normative references

[1] ETSI Drafting Rules, 20 May 2014

[2] ETSI EN 302 637-2 v1.3.2: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service

[3] ETSI EN 302 637-3 v1.3.2: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service

[4] ETSI EN 302 636-4-1 v1.2.1; Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality

[5] ETSI EN 302 636-5-1 v1.2.1; Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol

[6] ETSI TS 102 894-2 V1.2.1: "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary".

[7] SAE J2735 (2015): Dedicated Short Range Communications (DSRC), Message Set Dictionary.

[8] ISO TS 19321 (2014): Intelligent transport systems -- Cooperative ITS -- Dictionary of in-vehicle information (IVI) data structures.

[9] ISO TS 14823 (2014): Traffic and travel information -- Messages via media independent stationary dissemination systems -- Graphic data dictionary for pre-trip and in-trip information dissemination systems.

[10] ISO TS 17427:2014 Intelligent transport systems -- Cooperative systems -- Roles and responsibilities in the context of cooperative ITS based on architecture(s) for cooperative systems

[11] ETSI EN 302 663 V1.2.0: Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band.

[12] ETSI TS 102 687 V1.1.1: Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part.

[13] ETSI TS 103 175 V1.1.1: Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium.

[14] ETSI EN 302 665 V1.1.1; Intelligent Transport Systems (ITS);. Communications Architecture.

[15] ETSI TS 102 724 1.1.1; Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band

3.2 Informative references

[i.1] Towards an Architecture for Cooperative ITS Applications in the Netherlands; Version 1.0; April 2015; DITM Innovations and Connecting Mobility.

[i.2] ETSI TS 102 637-1 V1.1.1: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 1: Functional Requirements.

[i.3] The development of use cases by the Dutch national ITS Round Tables; Priority based on rolling out C-ITS in the Netherlands; Information for governmental authorities and market players; BeterBenutten, Connecting Mobility and DITCM Innovations.

[i.4] Overview C-ITS standards: http://extern.maptm.nl/standards/

[i.5] ETSI TS 103 097 V1.1.1: Security Header and Certificate Formats.

[i.6] ETSI TS 102 940 V1.1.1: ITS Communications Security Architecture and Security Management.

[i.7] ETSI TS 102 941 V1.1.1: Trust and Privacy Management.

[i.8] Dutch Profile White Paper PKI

[i.9] Dutch Profile White Paper Trust Evaluation and Trust Assurange for Security X2X

[i.10] ETSI TS 103 248 V0.0.4: Intelligent Transport Systems (ITS); GeoNetworking; Port Numbers for the Basic Transport Protocol (BTP)

[i.11] ETSI TS 103 301 V0.0.12: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services.

[i.12] IRSIDD RIS Facilities Interface (12-2015), iVRI working group

[i.13] iTLC Architecture (12-2015), iVRI working group

[i.14] Combined description of top-x use cases selected in the BBV project (12-2015), iVRI working group

[i.15] Compass4D, D2.1 User Requirements and Specifications, v 2.0 (30-1-2015)

[i.16] Kennisplatform Verkeer en Vervoer (KpVV), KAR'en maar!, Korte Afstand Radio voor prioriteit bij verkeerslichten (augustus 2010)

[i.17] DITCM Architecture version 1.0

[i.18] Message Set and Triggering Conditions for Road Works Warning Service, Amsterdam Group, version 1.1, July 2014

[i.19] ETSI EN 302 571 V2.0.2: Intelligent Transport Systems (ITS); Radio communications equipment operating in the 5 855 MHz to 5 925 MHz fre-quency band; Harmonized EN covering the essential re-quirements of article 3.2 of the R&TTE Directive.

[i.20] ETSI TR 102 638 v1.1.1: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definition

[i.21] CEN ISO/TS 19091-3 (to be published): "Intelligent transport systems — Co-operative ITS - Using V2I and I2V Communications for Applications Related to Signalized Intersections.

[i.22] SWP2.1 Use Cases, Intersection Safety, WP2-System Definition, v03.00, Eco-AT

[i.23] SWP2.1 Use Cases, Road Works Warning, WP2-System Definition, v03.00, Eco-AT

[i.24] SWP2.3 System Overview, WP2-System Definition, v03.00, Eco-AT

4 Terms and abbreviations

4.1 Terms and definitions

Connected	Connected means that non safety and less critical safety related data/information is exchanged between road users for information and advice by all means but mainly by cellular 3/4G/LTE/5G communication. The information received, in most cases is used by the road user itself.
Cooperative	Cooperative means that non safety, less critical and critical safety data/information, related data/information is exchanged between road users for control, less critical and critical safety as well as traffic management by all means but mainly by short/range V2X IEEE801.11p/ITS-G5 communication. The information received, can be used by the road users itself or via automation such as in vehicle systems (e.g. CACC).
Cooperative-ITS (C-ITS)	C-ITS systems that can bring intelligence for vehicles, roadside systems, operators and individuals, by creating a universally understood communications “language” allowing vehicles and infrastructure to share information and cooperate in an unlimited range of new applications and services
ECo-AT	European Corridor – Austrian Testbed for Cooperative Systems.
OCIT-C	Open Communication Interface for Road Traffic Control Systems, German-speaking countries Center to Center communication protocol. Used at least in German and Austria.
OCIT-O	Open Communication Interface for Road Traffic Control Systems, German-speaking countries Center to Outstation (VRI) communication protocol. Used at least in German and Austria.
V-Log	Verkeerslogging in Verkeersregelautomaten. Open standard, providing Road Traffic light information to be open for traffic controller management.
V-Log-3	Streaming Data version of V-Log.

4.2 Abbreviations

COTS	Common Of The Shelf
ITS	Intelligent Transport Systems
TCC	Traffic Control Center
TIS	Traffic Intersection System

TMS	Traffic Management System
C-ITS-S	Central ITS Station
R-ITS-S	Personal ITS Station
R-ITS-S	Roadside ITS Station
V-ITS-S	Vehicular ITS Station
GN	GeoNetworking
CAM	Cooperative Awareness Message
DENM	Decentralized Environmental Notification Message
SP BO	Service Provider Back-Office

4.3 Verbal forms for the expression of provisions

To distinguish different specification quality status the following definitions are used:

	Template	A full identification of the required content is agreed
-	Early Draft	A first specification including initial content not necessarily for all chapters
-	Full Draft	A specification including all filled chapter content is present for all chapters
-	Mature Draft	A specification is aligned and agreed between the active contributing stakeholders
-	Final Draft	A specification is aligned and agreed with all relevant stakeholders interested
-	Published	Specification is agreed and published

To distinguish between requirements and other provisions the following verbs are used to indicate if a provision is a requirement, recommendation, permission, possibility, inevitability or fact. These are based on the verbal forms used in ETSI see clause 3.2 of the ETSI drafting rules [1].

Requirements are indicated by the verb shall:

- Shall (is required)
- Shall not (is required not to)

Facts shall be indicated by the verbal forms:

- Is
- Is not

Recommendations shall be indicated by the verbal forms:

- Should (is recommended to)
- Should not (is not recommended to)

Permissions shall be indicated by the verbal forms:

- May (is permitted)
- May not (is not permitted)

Possibility and capability shall be indicated by the verbal forms:

- Can (it is possible to)
- Cannot (it is not possible to)

To describe behavior of systems (eg. behavior of cars) shall be indicated by:

- Will
- Will not

5 Use cases

At ETSI the Basic Set of Safety Applications (BSA) [i.2] have been defined. For the deployment of these services in the Netherlands the BSA has been considered and resulted in a detailing of the use cases of interest prioritized by the Dutch stakeholders at the Standardization Table.

The following use cases are supported by this release of the profile:

- Green Ligth Optimal Speed Advisory (Annex A)
- Priority Request (Annex B)
- Road Works Warning (Annex C)
- Probe Vehcle Data (Annex D)

This selection is based on the prioritization adopted by [i.4].
Based on prioritization as mentioned, in next releases of the Dutch profile the following use cases can be expected: Red Light Violation Warning; Shock Waves; Cooperative Adaptive Cruise Control and Autonomous Driving.

6 System description

In this chapter the language used to describe the different ITS elements is defined. The naming conventions used shall be used throughout the profile. This entire chapter needs to be aligned with the architecture-table and industry before detailed specifications can be profiled for the different reference points and interfaces.

6.1 Overview

In Figure 1 the reference architecture from [i.1] is depicted. The main focus of the Dutch ITS profile is on the ITS-G5 air interface VR1 interface between the OBU (V-ITS-S) and RSU (R-ITS-S). At the current moment interfaces identified, as iVRI interfaces are not covered. Also Connected ITS related interfaces, as they make use of cellular technologies are not covered in the current release.

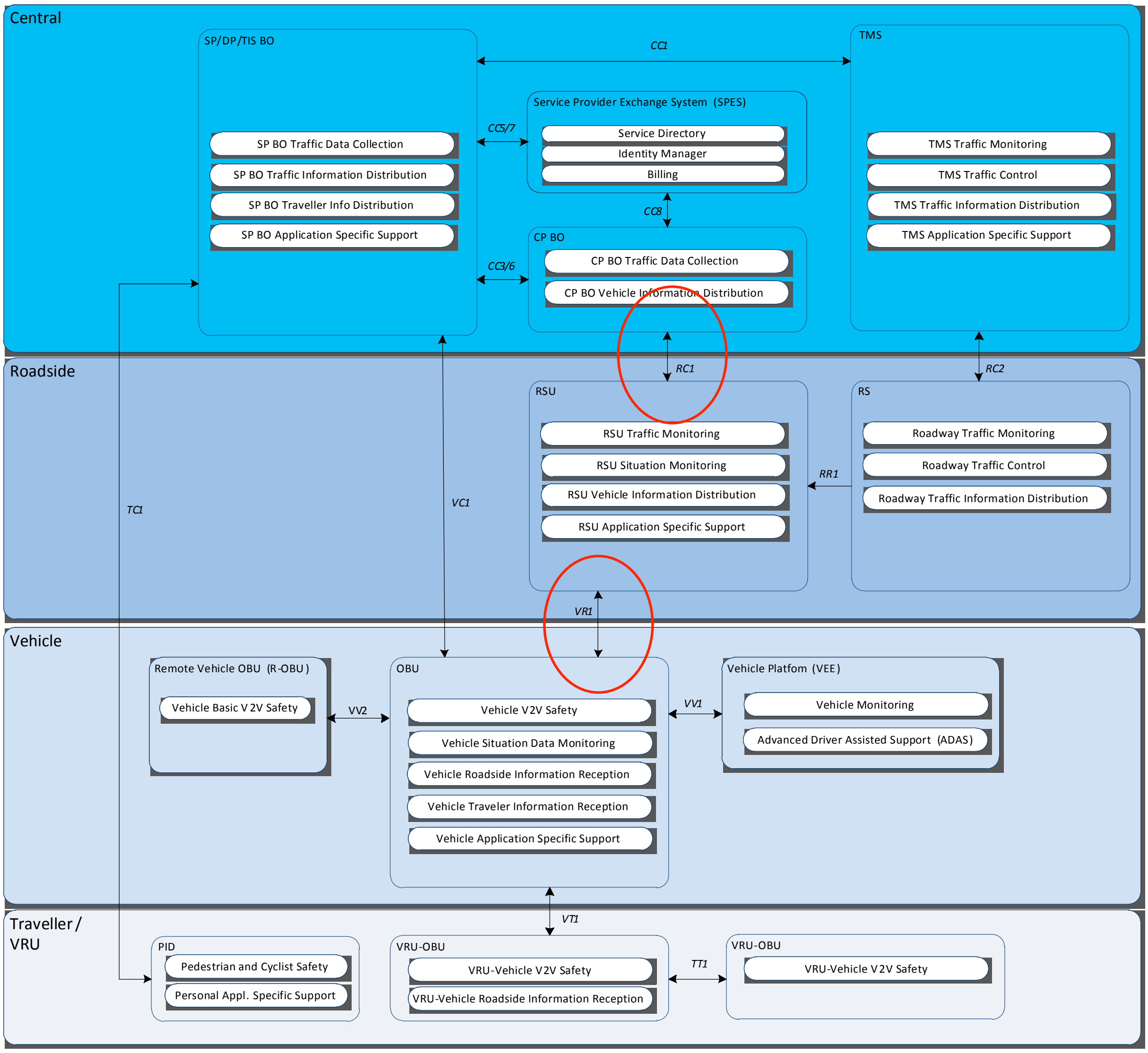

Figure 1: DITCM reference Architecture Functional View [i.17]

This reference architecture is projected on the following deployment (or system) architectures that provide an overview that is tailor towards implementation. The profile takes the following deployment scenarios into account:

- Backhaul connected deployment
  - R-ITS-Ss are typically connected with a wideband connection to a central ITS station and relays messages generated by the C-ITS-S e.g. 'transmit my signed GeoMessage' or 'transmit a DENM with these parameters'
- Remotely managed deployment
  - R-ITS-Ss are typically connected with a small band connection to a central ITS station and receive message generation instructions, e.g. 'transmit this speed advice for the next 5 minutes"
- Standalone deployment
  - R-ITS-Ss run local applications that transmit messages and might be equipped with an interface for remote management.

This requires that the C-ITS-S to R-ITS-S reference point (RC1 in Figure 1) support these three types of communication. Additionally reverse traffic (from the R-ITS-S to C-ITS-S) must be accommodated. Note that a backhaul-connected deployment R-ITS-S might also support the same interfaces for the remotely managed deployment and standalone deployment.

The interfaces are non-exclusive, which makes mixed scenarios possible.

6.2 Backhaul connected deployment

In the Figure 2 the architecture is mapped to the backhaul deployment scenario.

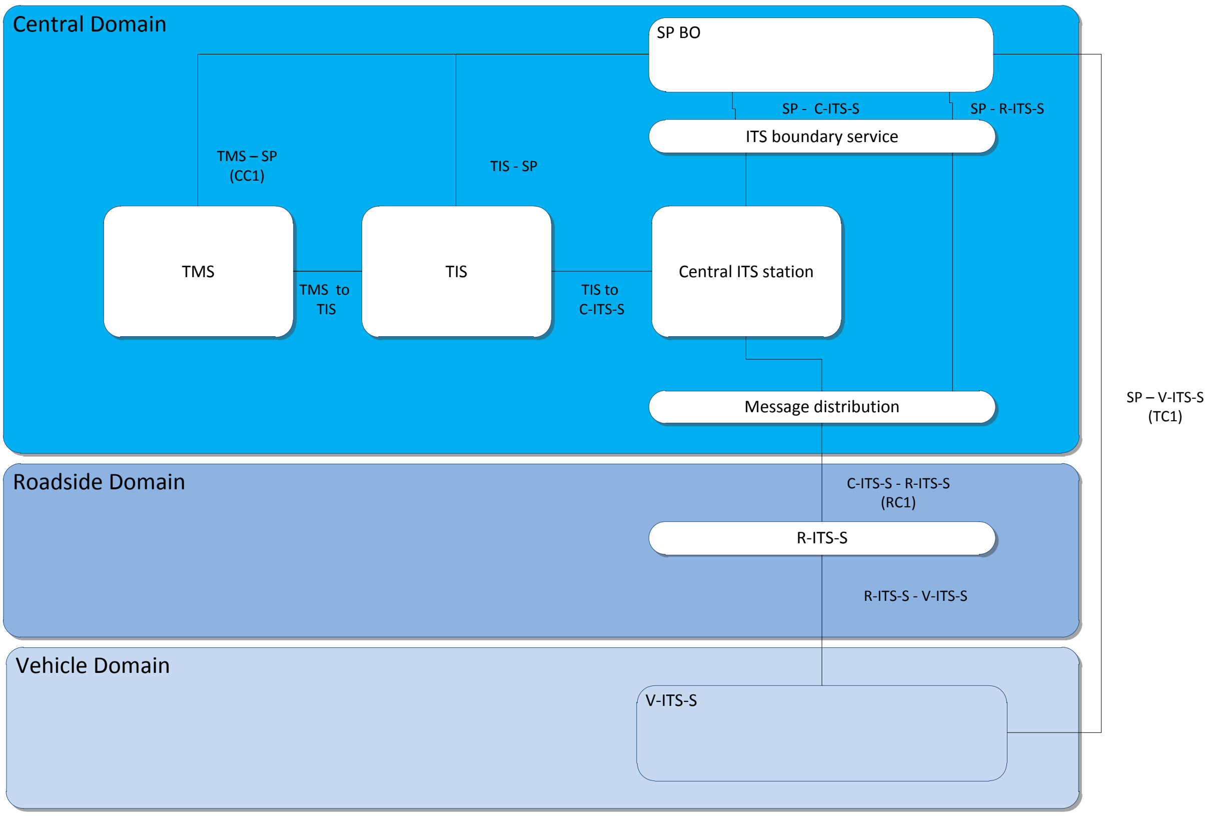

Figure 2: Interfaces for backhaul-connected deployment [i.17]

In this deployment Cooperative applications could reside on:

a) SP BO
b) C-ITS-S
c) R-ITS-S
d) V-ITS-S (Out of scope of this document)

The ITS boundary service is optional, and is there to connect non-C-ITS-S aware service providers to the ITS domain. The ITS boundary service could for example execute translation from standard IP protocols to V-Log-3, OCIT-C/O, GeoNetworking and vice-versa. Additionally the SP may provide sensor data to applications on the C-ITS-S. This scenario is highly similar to the A58 deployment. For simplicity multiplicity is excluded from the above diagram but listed below.

- C-ITS-S to C-ITS-S is a many to many connection
- C-ITS-S to R-ITS-S is a many to many connection
- SP to R-ITS-S is a many to many connection

6.3 Remotely managed deployment

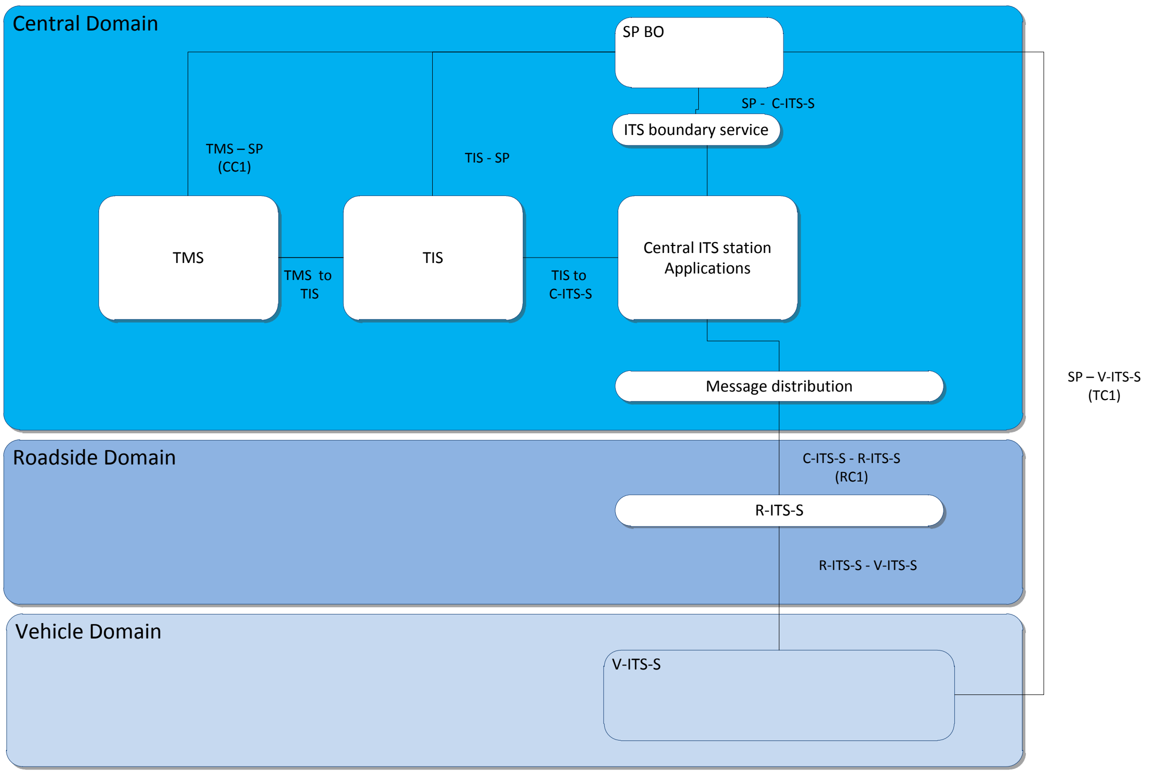

Figure 3: Interfaces for remotely managed deployment

In this deployment Cooperative applications could reside on:

a) C-ITS-S
b) R-ITS-S

c) V-ITS-S (Out of scope of this document)

6.4 Standalone deployment

Figure 4: Interfaces for standalone deployment

In this deployment Cooperative applications could reside on:

- R-ITS-S
- V-ITS-S (Out of scope of this document)
-

6.5 Reference Points

Initial reference points considered

6.5.1 TCC to TCC

[TBD]

6.5.2 TCC to C-ITS-S

[TBD]

6.5.3 C-ITS-S to R-ITS-S

At this reference point different functionality for remote management and message transmission is exposed. Within different European and Dutch deployment projects this issue is tackled in different ways.

In Eco-At OCIT-C is profiled to transport Facility layer messages to R-ITS-Ss, which are then locally generated and encapsulated with a GeoNetworking header and signed. Within the iVRI project data is transferred through the LDM, which in turn generates the transmitted messages via other facility layer functions [i.13][i.12].

In the Converge project a new specification is made to encapsulate GeoNetworking frames in IP and transfer them between the C-ITS-S and R-ITS-S.

At this point industry input is needed to decide on the implementation direction to take. Note that the choice will have impact on:

a) The ability to discern between different service providers transmitting on ITS-G5 via an R-ITS-S
b) The security requirements put on the C-ITS-S to R-ITS-S interface
c) Deployment when GeoForwarding is used, as duplicate message detection at the GeoNetworking level assumes a single message source.
d) R-ITS-S or C-ITS-S cost and performance (signing must be executed by the station adding a GeoNetworking header)

On this topic additional input from the Security Table is needed to examine the risks and mitigations associated with the different implementation options. This should result in a thrust worthy implementation so that third parties have adequate confidence in the Dutch profile solution so peering to or inclusion in their root certificate authority can be established.

6.5.4 R-ITS-S to V-ITS-S (ITS-G5)

On this reference point ETSI TC ITS standardization is available to be used and profiled for the Dutch environment. Communication on this reference point is realized by using the ETSI TC ITS protocol stack standards further detailed in this document.

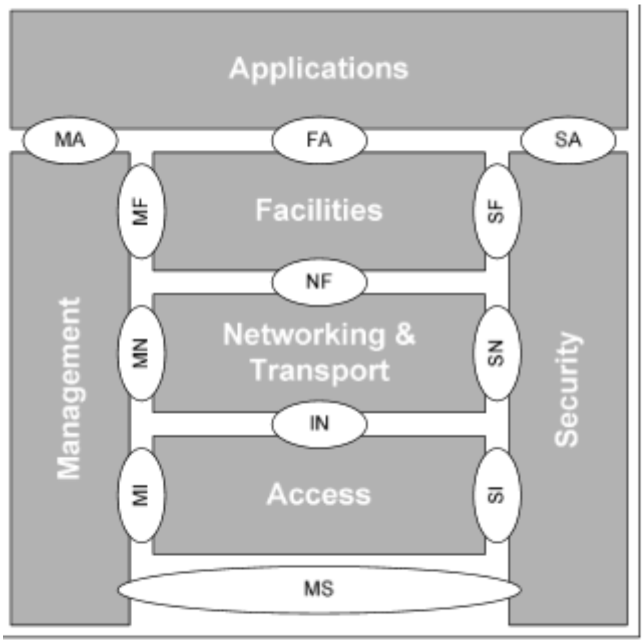

Figure 5: ETSI TC ITS protocol stack (EN 302 665) [14]

The profiling of the ETSI TC ITS standards in this document is structured in the layered approach used in ETSI e.g. a chapter concerning the Access Layer (AL), a chapter concerning the Networking & Transport layer etc.

6.5.5 SP to V-ITS-S

This reference point is currently out of scope of the profile

6.6 Security

In this chapter expert input is required from the security-table.

7 Base Requirements on the R-ITS-S

This chapter details the minimum requirements put on an R-ITS-S that cannot be pinpointed to a single protocol layer or interface. These requirements are here to provide clear information on the quality level of the information distributed by R-ITS-S stations.

7.1 Performance requirements

In this paragraph performance requirements that impact the entire R-ITS-S are specified.

PERF 1: R-ITS-Ss shall be able to decode and process XX messages per second

Reasoning: R-ITS-S should be able to handle a minimum amount of traffic. A clear definition of observable interfaces and testing methodology is needed to measure conformance.

PERF 2: R-ITS-Ss performing security validation shall be able to validate XX messages per second

Reasoning: R-ITS-S should be able to handle a minimum amount of traffic.

PERF 3: R-ITS-Ss shall be able to transmit messages to vehicles within a range of XX m with a PER < X%

Reasoning: A R-ITS-S should be reachable from a minimum distance to support a minimum set of use cases. A clear measurement scenario (e.g. Relative humidity, rain etc.) needs to be specified and parameters need to be adjusted. Additionally R-ITS-Ss should not have unreasonable high coverage ranges as this will result in the hidden terminals on the network (which results in packet loss and congestion) and will break Geo-forwarding with the greedy forwarding algorithm. This is limited by current legislation on maximum output power in EN 302 571 [i.19]Note that a study needs to be done on the effects of antenna placement of R-ITS-Ss as R-ITS-Ss with exceptionally good reception might need different DCC parameters.

7.2 Positioning and time

In this paragraph requirements about time and position accuracy are specified.

POTI 1: The difference between the actual R-ITS-S position and the transmitted R-ITS-S position shall be below XX m.

Reasoning: The transmitted position information is used for GeoNetworking forwarding decisions and possibly for plausibility checking.

Note: Positioning for R-ITS-Ss is an open issue; which position do we advertise, the ITS-G5 antenna position, the GPS antenna position, the median position measured over multiple ITS-G5 antennas in a multi-transceiver system? In some deployments distances might become significant.

POTI 2: The R-ITS-S clock shall not drift more than XX ms. from ITS time [6]

Reasoning: R-ITS-S clock drift could cause un-deterministic behavior of both R-ITS-Ss and V-ITS-Ss and therefore needs to be limited as this will break most safety applications.

7.3 Security requirements

In this paragraph the basic security requirements are specified. In future versions of this document references will be included to the output of the security-table.

SEC 1: R-ITS-Ss shall not change pseudonyms

Reasoning: A R-ITS-S does not need privacy protection.

SEC 2: Private keys stored on a C-ITS-S or R-ITS-S shall be stored securely according to the hostility of the deployment environment.

Reasoning: The unauthorized acquisition of valid R-ITS-S private key material will allow attackers to transmit malicious information. *Note: On this subject input from the security-table is needed and requires analysis of the different deployment environments encountered (e.g. RWW-trailer, traffic light etc.)*

7.4 Upwards compatibility requirements

None at the time of writing.

8 Profiling of base standards

8.1 Reference point Roadside ITS-S – Vehicle ITS-S

In this chapter requirements on the communication between R-ITS-S and V-ITS-S are detailed.

8.1.1 Application layer

Individual application (use case) profiling is done in the use case descriptions included in the Annexes of this document. .

8.1.2 Facility layer

FAC1: Roadside units shall implement DENM as specified in ETSI EN 302 637-3 [3]

Reasoning: DENM messaging shall be used to transmit events in order to align with the current developments within the Car industry

FAC2: DENM keep Alive Forwarding shall be disabled

Reasoning: DENM keep alive forwarding results in repetition of DENMs within their validity period. Events that are canceled via a cancelation DENM might still be repeated by stations that did not receive the cancellation further propagating an invalidated event. Note that this subject needs further investigation.

FAC3: The DENM repetition interval shall not be set lower than 100ms

Reasoning: Prevent DENM from creating transmit queues on the ITS station. Eg. The message rate should nog exceed the rate permitted by DCC.

FAC4: Roadside units shall implement CAM as specified in ETSI EN 302 637-2 [2]

Reasoning: CAM messaging shall be used to transmit awereness messages in order to align with the current developments within the Car industry

FAC5: Roadside units shall not generate more than 10 CAMs per second (e.g max cam rate is set to 10Hz)

Reasoning: Prevent CAM from creating queues on the ITS station. Eg. The message rate should nog exceed the rate permitted by DCC

FAC6: Fixed Roadside units shall not generate more than 1 CAM per second (e.g max cam rate is set to 1Hz) as defined in TS 103 301 [i.11]

Reasoning: Fixed roadside systems do not require a high update rate.

FAC7: R-ITS-S facilities shall use the well known BTP port numbers for BTP packet transport as defined in [i.10]

Reasoning: Fixed roadside systems do not require a high update rate.

FAC8: R-ITS-S supporting the GLOSA use case shall implement SPaT and MAP by a combination of [7], [i.11], [i.21]

Reasoning: Fixed roadside systems do not require a high update rate.

FAC9: R-ITS-S supporting the Priority Request use case shall implement SPaT and MAP by a combination of[7], [i.11]

Reasoning: Fixed roadside systems do not require a high update rate.

Note: Additional profiling is needed for the transport of the different message sets. E.g. Which channel to use and which GeoNetworking traffic class.

8.1.3 Networking & Transport layer

NET1: Roadside units shall implement GeoNetworking as specified in EN 302 636-4-1 [4]

Reasoning: n/a.

NET2: Roadside units shall implement BTP as specified in EN 302 636-5-1 [5]

Reasoning: n/a.

NET3: GeoNetworking parameters not explicitly defined in the Dutch ITS profile shall be set as defined in annex G of EN 302 636-4-1 [4]

Reasoning: Annex G contains the default GeoNetworking parameters

NET4: R-ITS-Ss shall only participate in GeoForwarding if the POTI performance requirements specified in 7.2 are met

Reasoning: GeoNetworking relies on GPS position and accurate time information to function correctly

NET5: The GeoNetworking traffic class (TC) shall be equal to the DCC profile (DP) used at the access layer

Reasoning: Currently there is no relation specified between the GN TC and the AL DP for traceability assume a one to one relationship for traceability

NET6: GeoNetworking security shall be set to enabled/disabled at all times

Reasoning: The security-table has to provide input on this requirement; the standard does not require security to be enabled.

NET7: itsGnStationType shall be set to 15 (RoadSideUnit)

Reasoning: n/a.

NET8: Fixed R-ITS-Ss shall set itsGNIsMobile to 0 (fixed)

Reasoning: n/a.

NET9: itsGnMaxPacketLifeTime shall be set to 600

Reasoning: GeoNetworking contains functionality similar to the DENM keep alive function.

NET10: itsGnLocalAddrConfMethod shall be set to 1 (MANAGED)

Reasoning: R-ITS-Ss are expected to use a preconfigured (static) GN address.

8.1.4 Access Layer

ACC 1: Roadside units shall be able to receive and transmit messages on the CCH channel specified in EN 302 571 [i.19]

Reasoning: Roadside units shall be able to communicate on the Control channel (CCH).

ACC 2: Roadside units shall be able to receive and transmit messages on the SCH channel specified in EN 302 571 [i.19]

Reasoning: Roadside units shall be able to communicate on the service channel (SCH)

ACC 3: R-ITS-Ss shall implement DCC methods as specified in TS 102 724 [15]

Reasoning: The current EN 302 571 [i.19] does not require DCC implementation. The new version will require DCC implementation and will turn into law as soon as the standard turns into an HEN (Harmonized European Norm)

8.2 Reference point Central ITS-S – Roadside ITS-S

This chapter specifies the data exchange between roadside ITS-S and Central ITS-S. Note that in this chapter assumptions are made on the system architecture that have yet to be verified with the architecture-table.

8.2.1 R-ITS-S management interface

The R-ITS-S management interface exposes the following functions allows the control of C-ITS-S applications, e.g. starting / stopping the application, controlling the parameters send by the applications. The current standardization does not specify any of these functions. In the Eco-AT project some effort has been done on the management interface.

Input from the architecture-table is needed to define the required functionality on this interface. Possibilities include but are not limited to: Remote updates, Statistics gathering, Configuration of data aggregation functionality, configuration of security functionality etc.

Additionally already available (COTS) protocol implementations such as SNMP can be used to provide non ITS specific management functionality.

R-MGMT1: A R-ITS-S implementing SNMP shall expose at minimum the following MIBs:

- IETF IF-MIB (RFC 2863)

- IETF Host Resources MIB (RFC 2790)

And optionally the:

- IEEE802dot11-MIB

Reasoning: Statistics on the amount of packets and bytes on both the ITS-G5 and management interfaces ease the debugging of connectivity issues. Additionally the Host resources MIB provides insight in the load experienced by the RSU.

R-MGMT2: A R-ITS-S implementing RFC 2863 shall provide statistics for management network interface(s), data interfaces(s) and ITS-G5 interface(s).

Note: The management interface and data interface might reside on the same logical or physical interface. In this case statistics may be provided as a single interface in SNMP.

8.2.2 R-ITS-S data interface

The R-ITS-S data interface allows a C-ITS-S to send a locally generated message on the ITS-G5 network. This interface could be implemented in two ways:

a) As a gateway function
b) As a router function

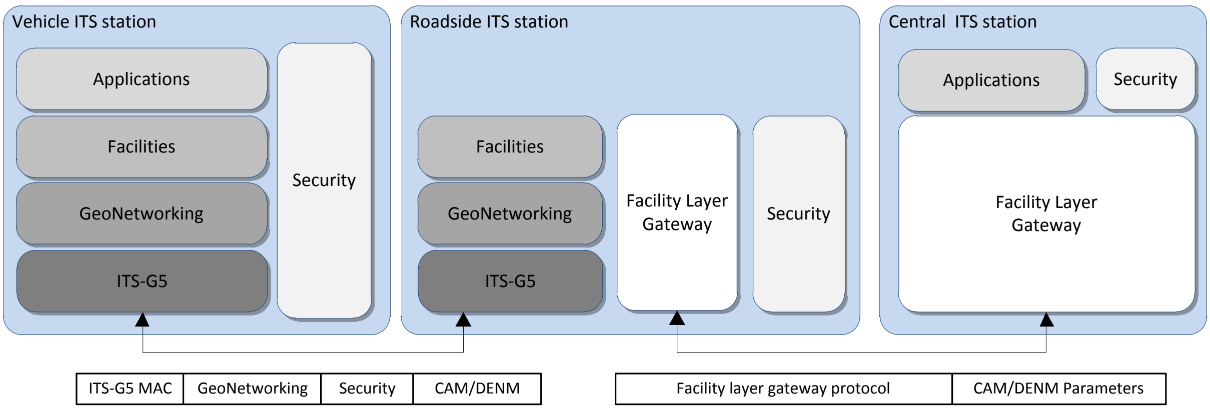

Figure 6: Scenario A V-ITS to C-ITS-S communication

In implementation scenario A, a C-ITS-S generates the parameters for a specific ITS message (e.g. a DENM). These parameter are send to the R-ITS-S or intermediary system and this station or system generates the DENM message based on the input received from the C-ITS-S and signs it with its local certificate. This implementation scenario is similar to the solution proposed in iVRI where data transferred through the LDM [i.13][i.12] and Eco-AT where OCIT-C is used for message transfer.

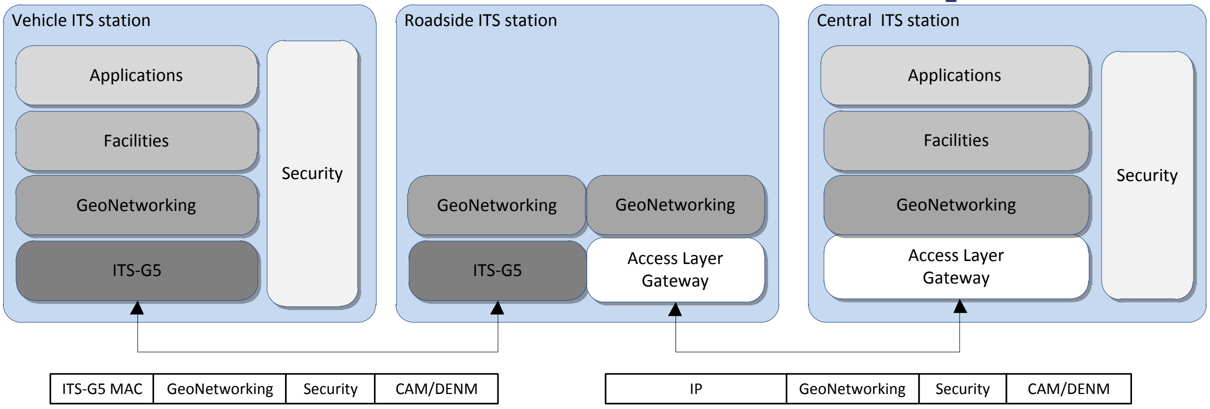

Figure 7: Scenario B V-ITS-S to C-ITS-S communication

In implementation scenario B, a C-ITS-S generates the entire message that is to be transmitted by the R-ITS-S and signs it with its own certificate. This message is transported to the R-ITS-S via traditional IP networks and then transmitted. This implementation scenario is similar to the solution proposed in Converge.

Scenario A and B result in different behavior on the R-ITS-S to V-ITS-S reference point. For example in scenario A, duplicate packet detection at the Networking layer will not work if additional measures are not taken (for example source address spoofing). This also has the effect that the original data source (the C-ITS-S station or Service provider) is not identifiable.

In scenario B the C-ITS-S is required to implement almost the entire ETSI protocol stack and latency requirements put on the backhaul connection to the R-ITS-S could become more stringent. Input from Industry, security-table and architecture-table is needed before further specification work is done on this interface.

9 Gap analysis

This chapter contains a shortlist of elements that need to be resolved either in base specs or the Dutch profile.

- Deployment:
    - Handling identifiers in big R-ITS-S deployments (for example a big intersection like the 'Berenkuil' in Eindhoven) a single transceiver deployment will not result in adequate coverage.
    - Currently the channel usage is not covered within this profile. In detailing phase this needs to be agreed among the stakeholders and aligned at EU stakeholder level.
    - Currently operational requirements have not been agreed. In detailing phase this needs to be agreed.
- SPAT/MAP:
    - Priority request is covered by the ISO TS 19091 in combination with ETSI TS 103 301. Analyses of KAR are required to see gaps in these standards.
- Security:
    - Privacy as agreed at ITS-Platform to result in an privacy field in the CAM and DENM.
      Change of Base Spec
    - Decision required to which Root CA (SDK) will be used (decision at Standardisation Table with support of Security Table).
- BTP Port Numbering
    - Now incorrect referencing in the current EN 302 636-5-1 Well know port numbers had to change in referencing to TS 103 249 including correct Port Numbers and referencing.
- Normative referencing to some standards is not yet possible as they are still in drafting phase. At the moment that these are published these currently informatively referenced standards need to be made normative.
- CAM/DENM: Members to report bugs in standards so far one found and reported at ETSI this needs to be captured by a Bug management process at the Standardisation Table.
- GeoNetworking:
    - Interworking of different forwarding algorithms
    - Multi-transceiver systems
- DCC:
    - Forwarding of messages from a C-ITS-S
    - Multi-transceiver systems
- Access Layer
    - Antenna patterns to support fair channel access for all ITS stations have not been established for Infrastructural solutions.

- How to realize coverage of large area crossings by ITS-G5 is not identified. Needs to be covered in a next release.

10 Document History

Document History			
BvdK	V0.01	21-5-2015	Document template
BvdK	V0.02	22-5-2015	Initial content
BvdK	V0.08	24-8-2015	Expanded content for discussion
BvdK	V0.10	28-8-2015	First distributed version
PS	V0.11	25-9-2015	Remarks, Introduction and Scope
BvdK	V0.12	25-9-2015	Additional remarks an highlighting to foster discussion
BvdK	V0.13	27-10-2015	
JDV	V0.14	23-11-2015	Editing and integrating inputs
PS	V0.15	10-12-2015	Editing, document use clarification and Summary
PS	V0.16	29-01-2016	Total review update after workshop
JDV, BvdK	V0.17	04-02-2016	Total corrections based on feedback
PS	V0.18	04-02-2016	Combining comments from V 0.1.7 and improved summary
PS, BvdK	V0.19	05-02-2016	General update
PS, JDV	V0.20	05-02-2016	General update

Annex A:
Use Case Green Light Optimal Speed Advisory

Introduction Use-Case

Use case ID

GLOSA

Background

Vehicles approaching a traffic light will inform the driver in advance about the traffic signal status for crossing the conflict area of an intersection. The vehicle (V-ITS-S) may advise an optimal speed to the driver for smoothly approaching the intersection (in case of red) or for safely passing the conflict area of the intersection based on the signal phase and timing (SPAT) and intersection topology (MAP) information received from the infrastructure (R-ITS-S). The SPAT / MAP information broadcasted from the R-ITS-S among others reflects the real-time signal phase & timing status for each lane. Therefore, a vehicle may be able to calculate or derive the optimal speed advice on each lane [Eco-AT].

Objective

Smoother approaching and passing of intersection resulting in improved traffic safety, increased traffic flow for vehicles and increased energy efficiency by reducing vehicle stops.

Sources

ECO-AT [i.22], CEN/ISO TS 19091-3 [i.21], ETSI-TS103 301 v0.0.12 [[i.11], SAE-J2735 (2015) [7], ETSI TS 102 894-2 V1.2.1 [6], iVRI working group [i.14].

Description Use-Case and sub-Use-Cases

The R-ITS-S periodically broadcasts the intersection layout and signal phase and timing information. This information is received by approaching vehicles equipped with a V-ITS-S. The V-ITS-S may advise an optimal speed to the driver for safely passing the conflict area of the intersection or for smoothly approaching the intersection (in case of red). Three sub-use cases can be distinguished:

1. **Time to Green**: The V-ITS-S can calculate an approach speed at which the vehicle will reach the intersection during a green phase. This calculated approach speed is presented to the road user who can then avoid an unnecessary stop. Alternatively, when waiting at the traffic light the V-ITS-S can offer idling stop support and start delay assistance to prevent unnecessary reaction delays at the transition of the traffic light to green.
2. **Time to Red**: The V-ITS-S can calculate an approach speed at which the vehicle will reach the intersection during a green phase. This calculated approach speed is presented to the road user who can then avoid an unnecessary stop. Additionally, a stationary vehicle queueing at the traffic light can decide to either accelerate to benefit from the current green phase or choose to wait for the next green phase. Thus enabling a smoother approach to the intersection or increasing the amount of vehicles that benefit from the current green phase.
3. **Cooperative Green Wave**: a green wave algorithm determines the green wave status and timing along a signalized corridor. Based on green wave information included in the signal

phase and timing message the V-ITS-S is capable of indicating to the driver the presence and status of the green wave as well as corresponding green wave speed.

Target System (as applicable)

V-ITS-S and R-ITS-S

Implementation environment (as applicable)

Signalised intersections.

Actors (as applicable)

Traffic light controller (TLC) to provide the necessary signal status data.

Driver to act on the speed advice provided.

Pre-conditions (if any)

- TLC is connected to R-ITS-S and can provide information on the current and next phase.
- Special precautions should be taken to connect dynamically timed TLCs.
- R-ITS-S is able to send information on the topology of the signalised intersection. Optionally topology information is provided to V-ITS-S in another way.
- R-ITS-S supports I2V services and can send information on signal phase and timing.
- V-ITS-S supports I2V services and can receive information on signal phase and timing.

Triggers conditions (if any)

No trigger conditions, information is broadcasted periodically

Use-Case Diagram (if any)

No use case diagram at present.

Normal Flow (as applicable)

In normal flow there are two implementation options for GLOSA:

1. Speed advice is calculated by R-ITS-S (RIS), based on signal phase and timing information, queue information, etc. and sent to V-ITS-S (VIS) or;
2. Speed advice is calculated by VIS itself, based on signal phase and timing information from RIS.

The signal phase and timing information can also be used by other types of applications like red light violation, whereas for green wave applications, speed advice can be used. The figure below shows the normal flow of GLOSA.

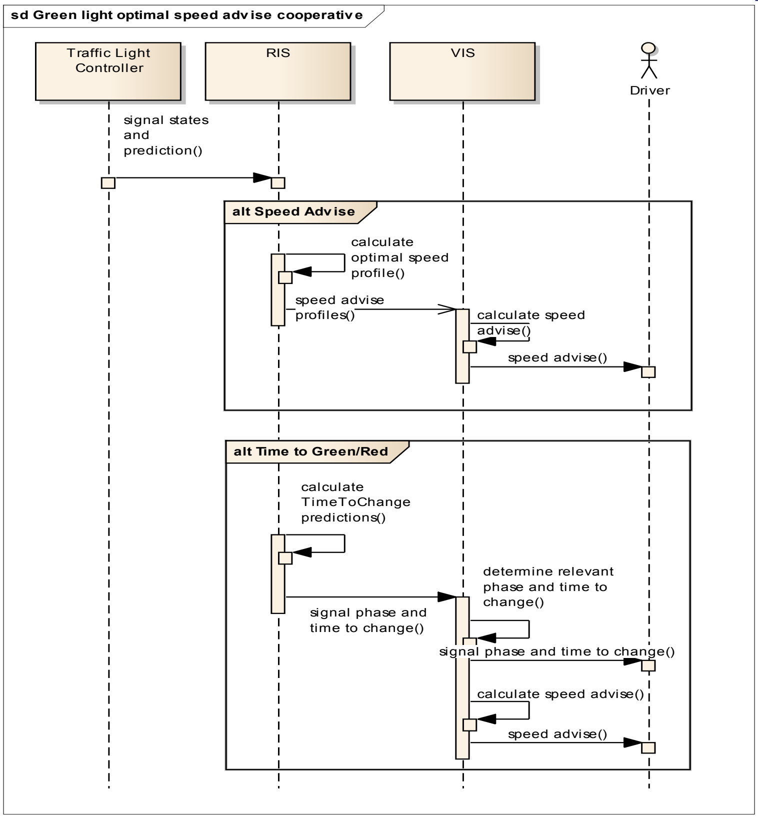

Figure 8: Sequence diagram for GLOSA via cooperative communication

Alternative flow (if any)

As an alternative to cooperative communication (ITS-G5) signal phase and timing information can be transmitted via connected communication. The figure below shows this alternative flow of GLOSA.

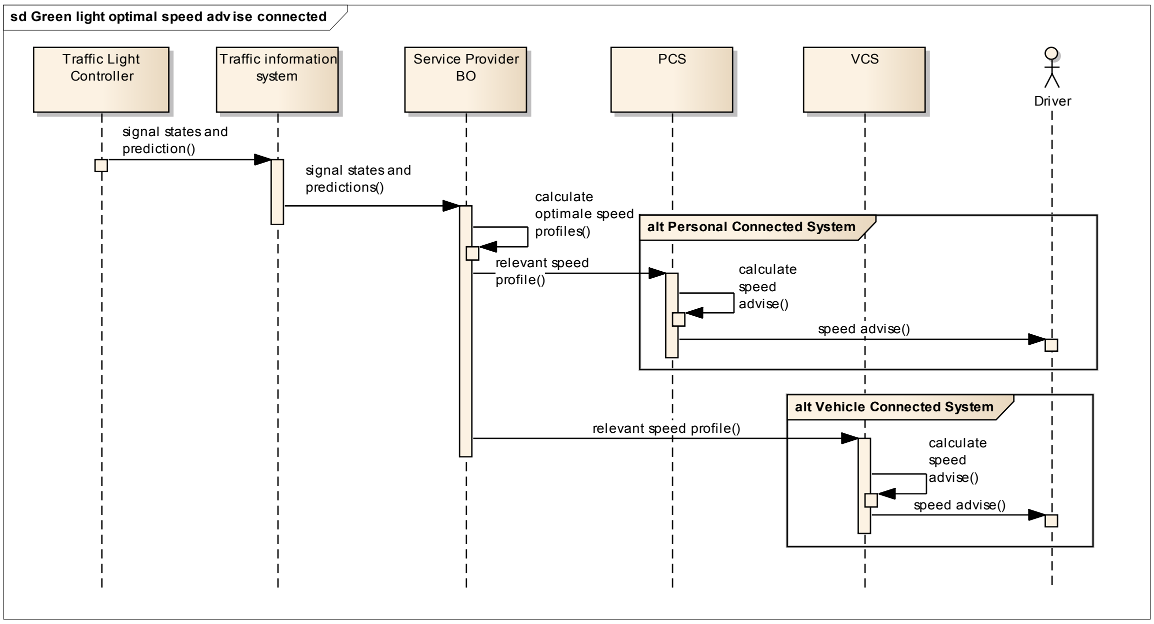

Figure 9: Sequence diagram for GLOSA via connected communication

10.1.1 Post-conditions (if any)

The driver can anticipate to the signal phase and timing information provided.

10.1.2 Termination conditions (if any)

Given the nature of the DSRC communications, the GLOSA use case described herein relies on the replication of messages and the probability that the target ITS-S will receive the message in time to take appropriate action. Additionally, subsequent signal phase and timing information replaces previously transmitted information. For example, a priority treatment can be immediately terminated to accommodate an emergency vehicle of higher priority and considerably affect previously broadcasted signal phase and timing information. Thus the entity must continuously monitor the messages received and act accordingly, for example, whether it is to modify signal timing or provide driver warnings. Finally, signal phase and timing information is cancelled if the vehicle has passed the intersection.

10.1.3 Use-Case Illustration (as applicable)

The following use case illustration is derived from CEN/ISO TS 19091-3 [i.21].

1. V-ITS-S equipped vehicle enters R-ITS-S range.
2. R-ITS-S transmits MAP and SPAT information.
3. V-ITS-S verifies that R-ITS-S (RSE) messages are acceptable (authentic, valid, etc.).
4. V-ITS-S matches vehicle location to intersection geometry/lane and associated signal phase, intersection speed limit, vehicle routing, turn signal status, vehicle type, and queue length (by lane) information.
5. V-ITS-S determines if vehicle is expected to arrive at intersection during red interval or if the queue length is excessive.
6. If arrival at/near red interval is expected, V-ITS-S determines optimal deceleration profile to stop at intersection, or acceptable acceleration profile, and provides information to driver. If the queue length is excessive, the V-ITS-S alerts driver of the situation and recommends a change in speed or a change in lanes.

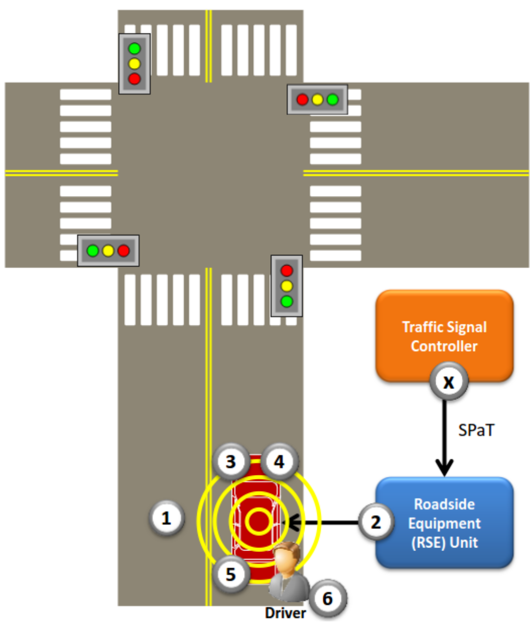

Figure 10: illustration GLOSA (source CEN/ISO TS 19091-3 [i.21])

SPAT Data Frames

The main data frames and data elements used for the description of the traffic light signal phase and timing are shown in the figure below. For a detailed description see the documents [6-8,16]. Due to publication restrictions of SAE-J2735 [7] only a general description is provided below.

SPAT may contain the *IntersectionState* of up to 32 intersections. Each *IntersectionState* contains the *MovementState* for each manoeuvre. For each manoeuvre the *MovementState* contains a *SignalGroupID* and a *MovementEvent*. *SignalGroupID* is used to match the SPAT message data to the MAP message data. *MovementEvent* forms the core of the SPAT message by means of *eventState*, *timing* (TimeChangeDetails - optional) and *speeds* (AdvisorySpeed - optional). *evenState* includes the phase state (i.e. green, red or amber) as a directional, protected or permissive state. *Timing* consists of *TimeMarks*, at least the expected shortest end time of the phase (minEndTime) and optionally completed with the expected longest end time, the best predicted end time (including confidence value) and a rough estimate of time when this phase may next occur again. *Speeds* includes among others *SpeedAdvice* (optional) and the distance (described by *ZoneLength* - optional) for which the advised speed is recommended.

Additionally, the regional extension *activePrioritizations* as part of *IntersectionState* reflects the state of the priority request on each of the relevant signal groups which is how priority states can be acknowledged. *ManeuverAssistList* as part of either *IntersectionState* or *MovementState* contains information about the dynamic flow or traffic, e.g. the length of queues per lane (described as *ZoneLength*), for manoeuvres in question.

SpatMessage
- *timeStamp*
- *name*
- intersections (list) → intersectionState
  - *name*
  - id
  - revision
  - status
  - *moy*
  - *timeStamp*
  - *enabledLanes*
  - states (list) → MovementState
    - *movementName*
    - signalGroup
    - state-time-speed (list) → MovementEvent
      - eventState
      - *timing*
      - *speeds*
      - regional (not used)
    - *maneuverAssistList*
    - regional (not used)
  - *maneuverAssistList*
  - regional
  - • *activePrioritizations*
- regional (not used)

Figure 11: main DF and DE SPAT message

It is important to consider that the SPAT message is not designed to transmit time windows (e.g. the green window), but is designed to transmit the current state of each movement and the expected duration of this state until the next state. As such it provides a cross-cut of a signal phase diagram at the time it is transmitted. However, for each *SignalGroup* up to 16 *MovementEvents* can be included, which allows conveying multiple predictive phase and timing of the current signal group. For example, in the example below and assuming pre-timed control, if *MovementEvent* of signal group 5 would be transmitted at t = 15 seconds, the *eventState* would indicate 'Movement-Allowed' (either permissive or protected) and the *timing* would indicate a *minEndTime*, *maxEndTime* and *likelyTime* of 9 seconds (in *TimeMark* coding). A second *MovementEvent* would indicate: 'protected-clearance' for the amber phase and *minEndTime*, *maxEndTime* and *likelyTime* would indicate 12 seconds. Similarly, a third *MovementEvent* would indicate: 'stop-and-remain' and 38 seconds.

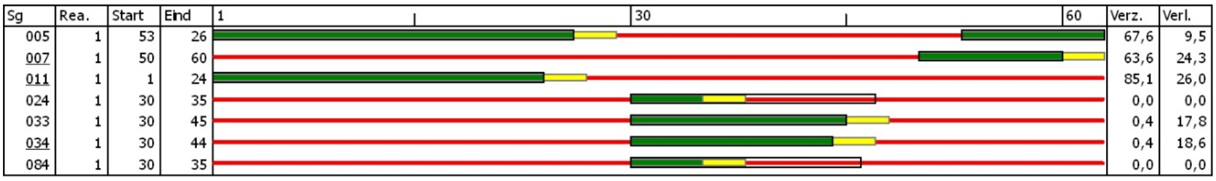

Figure 12: example phase diagram

Infrastructure services

In scope of the GLOSA use case, ETSI-TS103 301 [i.10] specifies the application support facilities provided by the facility layer that construct, manage and process messages distributed from infrastructure to end-users or vice-versa based on payload received from the application. Within the scope ETSI-TS103 301 [i.10], the term message refers to the facilities layer; the term payload refers to the applications layer. The payload is generated by the application and provided to the corresponding service of the Facilities layer. The Facilities service merges the "ItsPduHeader" (ETSI TS 102 894-2 [6]**Error! Reference source not found.**) with the SPAT or MAP payload (as specified in CEN/ISO TS 19091-3 [i.21], in order to construct a message. These message are then referred to as "SpatMessage" or Intersection Status Service (ISS) and "MapMessage" or Road Topology Service (RTP) respectively (ETSI-TS 103 301 [i.11]).

Potential requirements (as applicable)

- R-ITS-S shall support I2V services and can send information on signal phases and timing and intersection topology.
- V-ITS-S shall support I2V services and can receive information on signal phases and timing and intersection topology.
- The static topology of the signalised intersection, including road segments, lanes and traffic light layout shall be available for the V-ITS-S.

- Reliable information on current and expected signal phase and timing shall be available from the TLC.
- V-ITS-S shall receive the signal phase and timing information timely.
- For ITS-G5:
  - R-ITS-S at the traffic light controller shall broadcast the Signal Phase and Timing (SPAT) message at 1 Hz (once per second). to indicate the current (and future) signal state information.
  - R-ITS-S at the traffic light controller shall broadcast at 0.5 Hz (once every two seconds). information that describes the geometrics of the intersection in MAP format. Changes to the base geometry are flagged, to allow a vehicle receiving the MAP information message to only process the changes if the version for the base geometric is different from what is currently stored in the vehicle.

Linked use cases (as applicable)

- Priority Request (for emergency, public transport and freight vehicles)
- Red Light Violation Warning
- Dilemma Zone Protection
- Turning Assistant
- Green Wave
- Continuous Speed Advice (Corridor Speed Guidance)
- GLOSA / Green Wave for Cyclists
- Idling Stop Support
- Start Delay Prevention

Annex B: Use Case Priority Request

Introduction Use-Case

Use case ID

PR

Background

Priority Request addresses the generation and transmission of signal requests message and signal request status messages. Priority Request supports prioritization of public transport and public safety vehicles (ambulance, fire brigade, etc.) to traverse a signalized road infrastructure (e.g. intersection) as fast as possible or using a higher priority than ordinary traffic participants. The corresponding signal request messages are sent by an V-ITS-S to the traffic infrastructure environment (e.g. R-ITS-S, C-ITS-S) in a signalized environment (e.g. intersection) for requesting traffic light signal priority (typically for public transport) or signal pre-emption (typically for public safety vehicles). The Priority Request may not only be requested for the approaching signalized environment but also for a sequence of e.g. intersections along a defined path covering several intersections. In response to the request the infrastructure (single traffic controller R-ITS-S or traffic control centre C-ITS-S) will acknowledge with a status information if the request has been granted, cancelled or changed in priority due to a more relevant signal request (e.g. ambulance).

The following messages are used in this use case description:

- Cooperative Awareness Message (CAM) [2]
- Signal Phase and Timing message (SPAT) [7-8]
- Intersection topology message (MAP) [7-8]
- Signal Request Message (SRM) [7-8]
- Signal Status Message (SSM) [7-8]

Objective

To improve safety, environment, traffic flow or for other reasons it can be advantageous to give priority to specific classes of vehicles.

Source

Compass4D [i.15], CEN/ISO TS 19091-3 (2015) [i.21][7], ETSI-TS103 301 v0.0.12 [i.11], SAE-J2735 (2015) [7], ETSI TS 102 894-2 V1.2.1 [6], ETSI EN 302 637-2 v1.3.2 [2], iVRI working group [i.14], Kennisplatform Verkeer en Vervoer [i.16].

Description Use-Case

For emergency, safety, environmental, traffic flow efficiency and business reasons it is advantageous to give priority to specific classes of road users (at the moment no other than road users are considered but waterway crossings with roads may be considered at some time). The level of priority will depend on the type of user. At this moment an initial prioritization is recognized resulting in the following:

- Emergency vehicles
- Public transport vehicles
- Heavy goods vehicles

The priority in each of the classes is further defined depending on the class. For instance emergency vehicles do have active emergency and passive emergency states while public transport may have more states: active duty or not and on time or not (possibly with a severity indicator).

In this use case, all types of vehicles can request priority for an intersection or road section, and the traffic (light) controller determines in what way it can and will honour the request (e.g. pre-emption, priority or green extension). Optionally, the requesting vehicle is informed about the action taken by the traffic light based on the request. This reply can be used to assist emergency vehicles in passing an intersection, but would also allow for heavy goods vehicles to calculate their fuel consumption reduction and advise the driver accordingly.

Target Systems (as applicable)

- R-ITS-S (linked to Traffic Light)
- C-ITS-S (linked to Traffic Control Centre)
- V-ITS-S (Priority requesting vehicle)

Implementation environment (as applicable)

Typically signalized intersections. Potentially also applied for restricted access bollards and barriers, special lane access or possibly even water bridges.

Actors (as applicable)

Traffic light controller (TLC) to process the priority request and to provide the necessary signal status data to the R-ITS-S.

Driver of priority requesting vehicle, for example: emergency vehicle, public transport vehicle, heavy goods vehicle.

Road operator, fleet operator, asset operator (e.g. restricted area or bridge).

Pre-conditions (if any)

- TLC is connected to R-ITS-S and can provide information on current and next phase, and signal status (i.e. priority) information.
- TLC is programmed with a variety of priority control schemes (e.g. early green, phase rotation, phase skipping, etc.), and with an intelligent algorithm for providing priority signal timing for priority requests.
- R-ITS-S is able to send information on the topology of the signalised intersection. Optionally this information is provided to V-ITS-S in another way.
- V-ITS-S supports V2I services and can send information on priority request.

- R-ITS-S supports I2V services and can send information on signal (priority) status.
- R-ITS-S supports validation and prioritization of requests from V-ITS-S's.
- V-ITS-S supports I2V services and can receive information on signal phase and timing.
- V-ITS-S supports transmission of priority request.
- The road operator has established a policy for priority control.

Triggers conditions (if any)

Current prioritizing techniques require a trigger point (x, y location). This is for example done within KAR [i.16] for Public Transport and Emergency Vehicles priority requests to determine from what location a message is to be broadcasted. Depending on the choice of communication protocol (CAM or SRM) a location can be determined based on the included geolocation (CAM) or id number of the intersection the message is directed at. An predefined geolocation (fictional loop) is not needed.

Use-Case Diagram (if any)

This use case can be used via ETSI ITS-G5 and/or mobile internet (i.e. 3G/4G). For emergency vehicles the use case is safety related and therefore it is recommended to use ETSI ITS-G5 to ensure a fast and accurate message handling. For public transport the use case is more comfort orientated. Therefore message handling via mobile internet can suffice, though ETSI ITS-G5 could be advantageous. This profile focusses on Priority Request using ETSI ITS-G5).

Normal Flow (as applicable)

This profile defines two approaches for prioritization: legacy protocol migration based on CAM and SPAT and new style protocol (based on SRM and SSM).

The former supports smooth migration from legacy prioritization systems (e.g. KAR) to cooperative systems. This allows to include old data messages, transported by CAM which includes the "publicTransport" container that allows the inclusion of legacy prioritization request data to be sent to the traffic light controller. For the prioritization status response the R-ITS-S uses a "SPAT" data extension. The latter offers a more sophisticated procedure for signal request defined by the messages SRM and SSM which allows prioritization and pre-emption along one or more intersections.

In both approaches the V-ITS-S transmits relevant data such as the status of the vehicle, punctuality, line number and a reference to a signal group to a R-ITS-S. The R-ITS-S connected to the TLC receives this information and the TLC can decide the alter the signal phase timing in order to accommodate the request. To acknowledge the priority request the R-ITS-S will transmit a response including information that the request is granted or not.

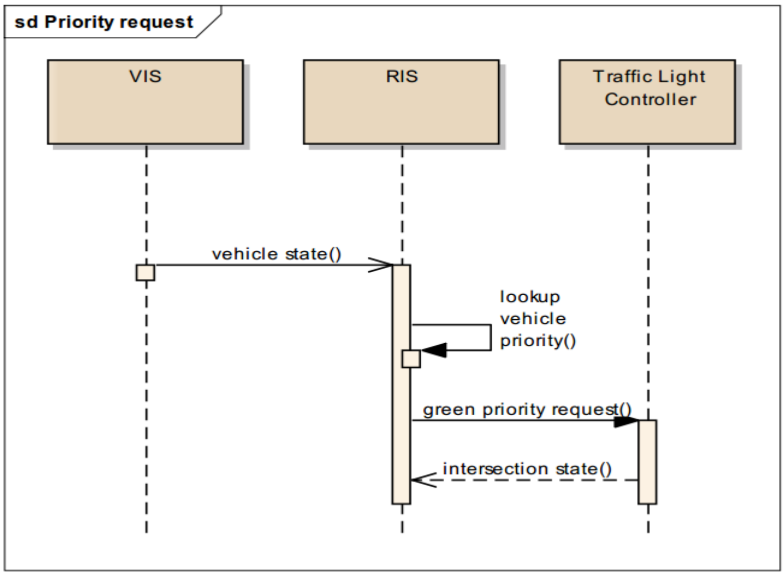

Figure 13: Sequence diagram Priority Request via cooperative communication.

Alternative flow (if any)

As an alternative to cooperative communication priority request information and signal phase and timing information can be transmitted via connected communication. This flow is outside the scope of this version of the use case description.

Post-conditions (if any)

Under the best conditions the priority requesting vehicle can traverse the signalized intersection without any interruption. As a means to cancel or close a priority request the V-ITS-S transmits information that allows the R-ITS-S connected to the TLC to determine that the vehicle has passed the intersection and can resume its normal operations.

At that moment the TLC initiates recovery operations to restore normal timing operation which might include appropriate coordination. Some recovery may include split time compensation to clear queues which might have formed on the phases that were adversely affected by the priority request. Notably, both the handling of priority requests and the recovery operations affect the accuracy of signal phase and timing information.

Termination conditions (if any)

There are a few termination conditions to be defined;

1. An Emergency Vehicle has changed its priority status when it no longer needs to use the light bar and siren and thus the made request isn't needed anymore.
2. A granted request for a Public Transport of Heavy Goods Vehicle is conflicted by a request with a higher priority (for example, from an Emergency Vehicle).
3. The TLC has a technical failure resulting in a reset or shutdown of the TLC while a granted priority request is pending from an Emergency Vehicle. It is foreseen that an "Approaching Emergency Vehicle" message shall warn approaching vehicles as a backup.

Use-Case Illustration (as applicable)

Most information in this section is taken from [8]. Due to publication restrictions of SAE-J2735 only a general description of SRM is provided. For a detailed description see the documents [6-8,16].

Priority request by CAM

For the request of signal prioritisation the CAM message contains the "publicTransportContainer" with the "ptActivation" data frame [2]. This data frame is intended to include legacy prioritization protocols like the R09.16 used in Germany, Austria and Switzerland. As this data frame is defined as a "blob", other countries may include regional legacy protocols for public transport prioritization (e.g. KAR). In addition to the ptActivation data frame the CAM message also includes its ordinary data elements such as the position of the approaching vehicle its vehicle class, and its identity ("stationID").

* KAR (Korte Afstand Radio) – Current system usage in the Netherlands for priority requests for Public Transport and emergency vehicles [i.16]. A short study comparing KAR and message sets mentioned here should indicate what aspects of KAR are already allocated within C-ITS and which are not. On the basis of this study further action should be taken to achieve this use-case.

Priority response by SPAT

In existing legacy public transport prioritization systems, based on analogue radio communication, the only way for a response to the driver is the traffic light signal. For bidirectional information exchange the data frame "PrioritizationResponse" has been included to the European content of the regional extension.

The "PrioritizationResponse" contains a list of prioritisation responses, which includes the information if the request is successfully assigned. The response contains the "stationID" of the requestor, the status of the traffic light prioritisation ("priorState") and the corresponding "signalGroupID" identifier, which relates to driving permission for the related manoeuvre.

Priority request by SRM

The Signal Request Message is a message sent by a V-ITS-S to the R-ITS-S at a signalized intersection. It is used for either a priority signal request or a pre-emption signal request depending on the way each request is set. Each request defines a path through the intersection, which is desired in terms of lanes and approaches to be used. Each request can also contain the time of arrival and the expected duration of the service. Multiple requests to multiple intersections are supported. The requestor identifies itself in various ways (using methods supported by the RequestorDescription data frame), and its current speed, heading and location can be placed in this structure as well. The specific request for service is typically based on previously decoding and examining the list of lanes and approaches for that intersection (sent in MAP messages). The outcome of all of the pending requests to a signal can be found in the Signal Status Message (SSM), and may be reflected in the SPAT message contents if successful. The main data frames and data elements of the SRM message are shown in the figure below.

SrmMessage
- *timeStamp*
- second
- sequenceNumber
- requests (list) → SignalRequestPackage
  - request
    - id
    - requestType
    - inBoundLane
    - *outBoundLane*
    - *regional*
  - *minutes*
  - *second*
- Requestor → →
  - id
  - *type*
  - *position*
  - *name*
  - *routeName*
  - *transitStatus*
  - *transitOccupancy*
  - *transitSchedule*
  - *regional (not used)*
- regional (not used)

Figure 14: main DF and DE SRM message

Priority response by SSM

The Signal Status Message is a message sent by an R-ITS-S at a signalized intersection. It is used to relate the current status of the signal and the collection of pending or active pre-emption or priority requests acknowledged by the controller. It is also used to send information about pre-emption or priority requests which were denied. This in turn allows a dialog acknowledgment mechanism between any requester and the signal controller. The data contained in this message allows other users to determine their "ranking" for any request they have made as well as to see the currently active events. When there have been no recently received requests for service messages, this message is not sent. While the outcome of all pending requests to a signal can be found in the Signal Status Message, the current active event (if any) will be reflected in the SPAT message contents. The main data frames and data elements of the SRM message are shown in the figure below.

SsmMessage
- *timeStamp*
- *second*
- *sequenceNumber*
- status (list) → SignalStatus
  - sequenceNumber
  - id
  - sigStatus (list) → SignalStatusPackage
    - *Requestor* →
      - id
      - request
      - sequenceNumber
      - *role*
      - *typeData*
    - inBoundOn
    - *outBoundOn*
    - *minutes*
    - *second*
    - *duration*
    - status
    - *regional (not used)*
  - *regional (not used)*
- regional (not used)

Figure 15: main DF and DE SSM message

Illustration

The following use case illustration is derived from [7].

1. V-ITS-S equipped vehicle enters R-ITS-S range.
2. V-ITS-S transmits CAM or CAM and SRM.
3. R-ITS-S verifies that V-ITS-S messages are acceptable (authentic, valid, etc.).
4. R-ITS-S receives and monitors the vehicle position using CAM.
5. R-ITS-S manages and prioritizes requests (either CAM or SRM).
6. TLC determines the best signal timing plan to accommodate the active priority requests and executes plan (if it can be accommodated).
7. R-ITS-S broadcasts MAP and SPAT information or/and SSM.
8. V-ITS-S receives the SPAT or SSM and determines if and when the request will become active at the intersection.
9. V-ITS-S determines that the priority requesting vehicle has cleared the intersection and sends a new SRM to cancel the priority request.
   a. *OR*: R-ITS-S determines that the time to live for the request has expired and terminates the priority action.
   b. *OR*: R-ITS-S determines that the vehicle has cleared the intersection based on receipt of the CAM and terminates the priority action.
10. R-ITS-S receives the cancel SRM (or timeout) and terminates the priority action

11. R-ITS-S initiates the configured recovery procedures to normal signal timing operation.

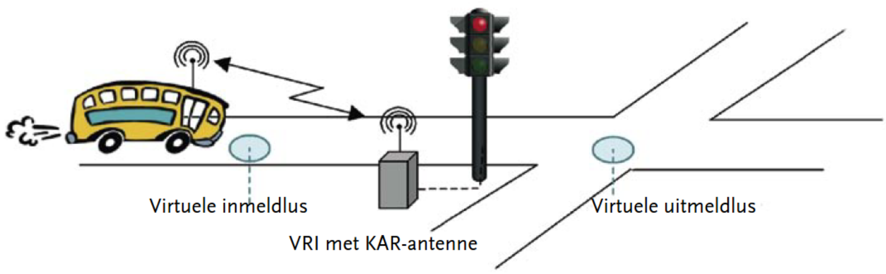

Figure 16: illustration priority request based on KAR

Infrastructure services

In scope of the Priority Request use case, ETSI-TS 103 301 [i.11] specifies the application support facilities provided by the facility layer that construct, manage and process messages distributed from infrastructure to end-users or vice-versa based on payload received from the application. Within the scope ETSI-TS 103 301 [i.11], the term message refers to the facilities layer; the term payload refers to the applications layer. The payload is generated by the application and provided to the corresponding service of the Facilities layer. The Facilities service merges the "ItsPduHeader" (ETSI-TS 102 894-2 [6]) with the SPAT, MAP, SRM or SSM payload (as specified in CEN/ISO TS 19091-3 [i.21], in order to construct a message. These message are then referred to as “SpatMessage” or Intersection Status Service (ISS), “MapMessage” or Road Topology Service (RTP), “SrmMessage” or Intersection Signal Control Service (ISC) and “ SsmMessage” or Intersection Signal Status Service (ISS) respectively (ETSI-TS 103 301 [i.11]).

Potential requirements (as applicable)

- R-ITS-S shall support I2V services and can send SPAT, MAP and SSM.
- V-ITS-S shall support I2V services and can send CAM and SRM.
- The static topology of the signalised intersection, including road segments, lanes and traffic light layout shall be available for the V-ITS-S.
- Reliable information on current and expected signal phase and timing, including prioritization status shall be available from the TLC.
- V-ITS-S shall receive the signal phase and timing information timely.
- For ITS-G5:
  - R-ITS-S at the traffic light controller shall broadcast the Signal Phase and Timing (SPAT) message at 1 Hz. (once per second) to indicate the current (and future) signal state information and priority response.
  - R-ITS-S at the traffic light controller shall broadcast at 0.5 Hz. (once every two seconds) information that describes the geometrics of the intersection in MAP format. Changes to the base geometry are flagged, to allow a vehicle receiving

the MAP information message to only process the changes if the version for the base geometric is different from what is currently stored in the vehicle.
  - V-ITS-S shall broadcast CAM and/or SRM message to indicate vehicle identify, status and priority activation.

Linked use cases (as applicable)

- Green Light Optimal Speed Advisory
- Approaching Emergency Vehicle
- Priority Request (for emergency, public transport and freight vehicles)
- Red Light Violation Warning
- Dilemma Zone Protection
- Green Wave
- Continuous Speed Advice (Corridor Speed Guidance)
- GLOSA / Green Wave for Cyclists
- Idling Stop Support

Annex C:
Use Case Road Works Warning

Introduction Use-Case

Use case ID

RWW

Background

Information on (planned and actual) road works is provided today in the Netherlands by NDW. Several research projects have been working on RWW with cooperative communication on motorways. Today the ITS Corridor project (with ECo-AT) is the deployment project which focuses on RWW on the motorway.

Objective

Reduce the risk of accident at the level of roadworks.

Sources

ECo-AT [i.22][i.23], ETSI TC ITS, ITS Corridor, Amsterdam group

Description Use-Case

From [i.17]: Construction sites and temporary maintenance working areas are accident black spots, because static traffic signs are ignored, overlooked or acknowledged by the driver too late. In V2V enabled systems, the road operator can communicate directly with a driver by I2V communication about traffic information, road works, restrictions, instructions, advice etc. I2V communication enhances the operational integration of local traffic management and in-car systems to improve safety, traffic efficiency and helps to protect the environment. A Road Works Warning message is sent by a roadside unit (or road works trailer) to approaching vehicles via cooperative communication. Road Works Information (RWI) is a related application used by road operators to inform road users – via service providers - on planned and actual road works for pre-trip and on-trip navigation.

From Amsterdam Group: the application is described in detail in a white paper with a functional specification [i.18]. In this document different types of road works are described with a reference to the specific road situation (with objects, road infrastructure, traffic control measures and traffic signs) and a translation to the corresponding I2V DENM message sets. The road works types are:

- Short term mobile road works
- Short term stationary road works
- Long term stationary road works

The roadside systems support either a stand-alone service where only limited information is available (e.g. position of trailer, arrow position etc.) and no connection to a back-end is used, or a basic service where information like reduced maximum speed, status of hard shoulder, position of work area (length, closed lane information, position of trailer) is available via a back-end system.

NOTE 1: In the document no explanation is given how the back-end of the roadside systems is connected to back-office systems. This is left to the road operator / road authority.

NOTE 2: For now, this document focusses on Road Works Warning on motorways. Cities and regional roads are out of scope.

Target System (as applicable)

This depends on the scenario. The driver is always warned via the V-ITS-S. The warning can be sent from different systems:

- Pre-warner
- Road Works Safety Trailer
- R-ITS-S
- V-ITS-s
- SP-BO (cellular mode)

Integration of road side equipment with back-office systems like C-ITS-S, Traffic Management System (or Traffic Control Centre), Traffic Information System and SP-BO is optional.

Implementation environment (as applicable)

The RWW scenarios have to be matched to existing RWW procedures and layouts.

For the Netherlands the following RWW procedures and layouts have to be matched to the scenarios:

- NL: Werk in Uitvoering Pakket 96a/96b with
    - Deelpublicatie 970: ‘Beleid, proces en basisinformatie’
    - **Deelpublicatie 514: ‘Maatregelen op autosnelwegen’**
    - Deelpublicatie 972: ‘Maatregelen naast de rijbaan’
    - Deelpublicatie 973: ‘Maatregelen op de rijbaan’
    - Deelpublicatie 974: ‘Maatregelen op fietspaden en voetpaden’
    - Deelpublicatie 975: ‘Maatregelen op kruispunten en rotondes’
    - Deelpublicatie 976: ‘Omleidingen en tijdelijke bewegwijzering’
    - Deelpublicatie 515: ‘Specificaties voor materiaal en materieel’
    - Deelpublicatie 990: ‘Maatregelen bij spoorwegovergangen’
    - Deelpublicatie 991: 'Verkeersregelaars bij wegwerkzaamheden'

ECo-AT Release 2 has been specified to cover the layouts for

- Ad-hoc road works (S-type layouts from RVS 05.05.42)
- Short term road works (K-type layouts from RVS 05.05.42)
- Moving road works (A-type layout)

Long term road works (D, E and U-type layouts from RVS 05.05.42) will be addressed in later releases.

In [20140714 AG RWW MessageSet.pdf] the use cases are differentiated via mobile or stationary and short-term or long-term (similar to the Amsterdam Group). The following use cases are distinguished:

- Short term mobile road works (section 5.3): *"Road Works can be moving activities like cutting grass or renewing lane markings. In this case, a slowly moving trailer is securing the mobile road works. Mobile Road Works are always short-term."*
- Short term stationary road works (section 5.1): *"In general short-term Road Works are secured by a Road Works Safety Trailer and an optional Pre- Warner. In this version of the white paper, the Pre-Warner is assumed to be not equipped with C2X hardware. Therefore, details with regards to Pre-Warner C2X behaviour are not considered. On day one, only the Road Works Safety Trailer will be transmitting information about the Road Works to approaching vehicles / nomadic devices*." This scenario can be implemented as stand-alone (trailer only) or as a basic service (i.e. with additional information from backend, e.g. closed lane, type of Road Work)
- Long term stationary road works: "Long-term Road Works are not always secured by a Road Works Safety Trailer. Nevertheless, there will be one or more ITS-Stations transmitting information about the Road Works to approaching vehicles / nomadic devices."

Actors (as applicable)

Depends on scenario: driver, road workers contractor, pre-warner vehicle, road works safety trailer, road operator, single point of access Traffic Data platform (like the National Data Warehouse (NDW)).

Currently it is unclear which actors will be responsible for creating (filling) the road works warning message(s). This could be the contractor or perhaps the traffic control centre. In addition, it is possible to directly generate the content of the message, but it is more likely some source will be used to read the content from. Which source that could be is still unclear.

Both the procedure and the way road works warning messages are filled are very important to successfully develop the Road Works Warning use case.

Pre-conditions (if any)

Depends on the scenario. The start, stop and update of transmission of RWW messages should be an extension of an existing working process for RWW.

The prepared content of the road works warning messages matches the deployed road works (if applicable).

Triggers conditions (if any)

- See section 7 of [i.18]for mobile short-term, stationary short term and stationary long term:
  - Road Works Warning Message shall be triggered when sign board on the Road Works Safety Trailer is opened or when the attenuator of the Truck Mounted Attenuator is lowered. In case that a pre- warner is used, the activation of the pre-warner shall serve as a Triggering Condition. The setup of other visible (physical = signs, flash lights) warnings for the Road Works may serve as an additional Triggering Condition. *On the Dutch motorway, that means usually the activation of a red cross to close off a lane, is the trigger.*
- See section 5 of [i.23]:
  - Exact triggering conditions that govern the start and stop of DENM transmission in all possible scenarios will be specified in more detail in Release 3.

Use-Case Diagram (if any)

At the start of the road works a driving lane is closed to traffic. This is done with the overhead Motorway Management System. If that system is absent, a mobile version is deployed. Using such a system, a red cross is displayed above the road to indicate a certain lane is closed. At the moment the red cross appears, the road works warning message is sent.

As indicated Actors, as of yet, it is unclear who will initiate such a warning (e.g. the contractor or perhaps the operator from the TCC).

When the lane is opened up again, and the red cross disappears, a cancellation message should be sent. However, the exact triggering mechanisms have yet to be determined.

Note: The above situation is typical for the Dutch motorway. In the Amsterdam Group and ECo-AT, the Truck Mounted Attenuator is linked to the trigger moment. This Truck Mounted Attenuator is equipped with a large arrow indicating traffic whether to merge left or right. When this arrow is put in an upright position and visible to traffic, the DENM RWW is to be sent. After the roadworks, the DENM RWW is to be cancelled upon the moment that the TMA has lowered his arrow sign and thus the lane is opened to traffic again (this is regardless of what the MTM is indicating).

Normal Flow (as applicable)

In [i.17] use case diagrams are shown for 'integrated' scenarios i.e. triggered by back-end systems in TMS/TCC of the road operator. The standalone scenario is only possible with ITS-G5 and includes only a (mobile or stationary) R-ITS-S and a V-ITS-S. For now, the start, update and stop of the messages needs to be described in the procedures, and is not a technical aspect.

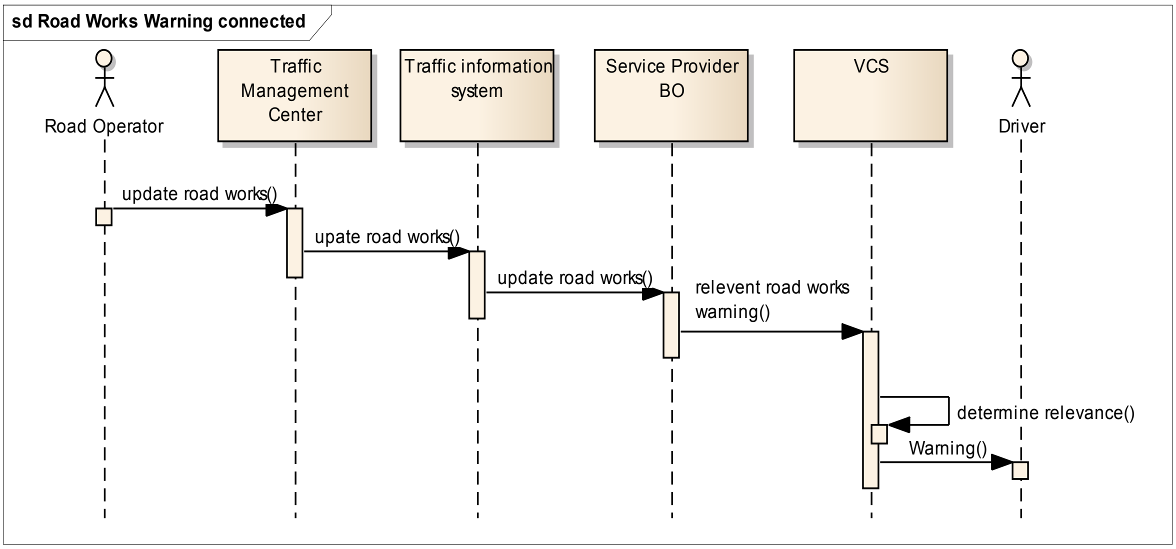

Figure 17: Sequence diagram for road works warning / information via connected communication

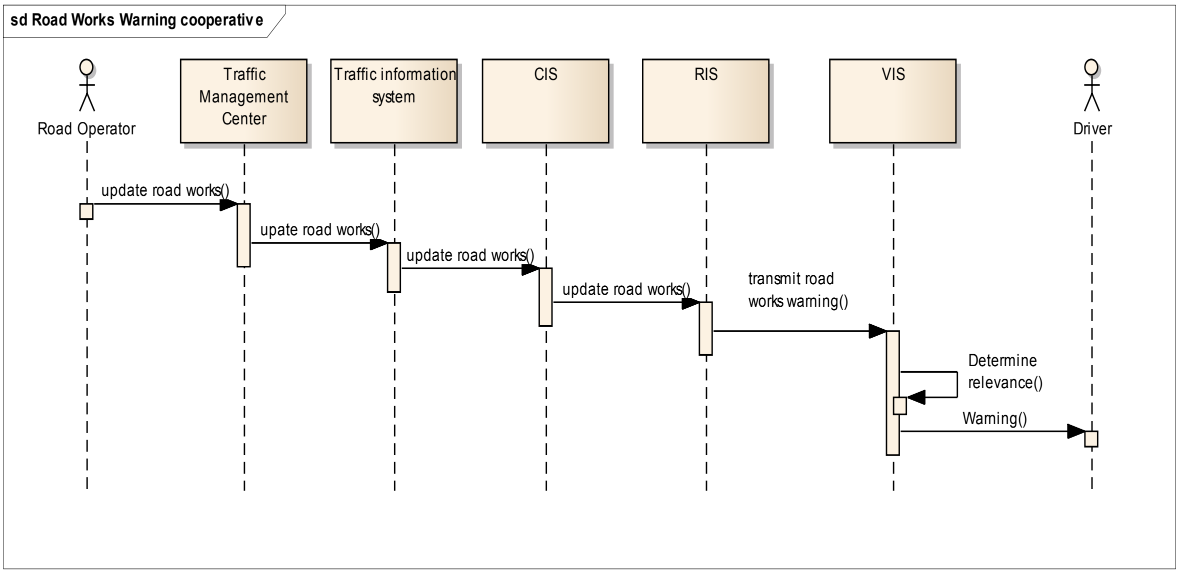

Figure 18: Sequence diagram Road works warning via cooperative communication

Alternative flow (if any)

Not applicable.

Post-conditions (if any)

The driver is informed on road works.

Termination conditions (if any)

Depends on the scenario. The start, stop and update of transmission of RWW messages should be an extension of an existing working process for RWW.

Use-Case Illustration (as applicable)

Below, two road works layouts (Figure 210 and 310) are shown: one with one lane closed off (and the hard shoulder) and one with two lanes closed off. Next to those layouts the DENM message structure is shown, which is used to hold the information about the road works.
It is important to note, that the values used in these examples are fictional. Also, the type of values used for each DE may deviate from the ETSI standards for explanatory purposes. For example, the coordinates are shown as x1, 1, 2, etc., but in the standard, the WGS84 reference system is used. Another example is the time values. Here "readable" time notation is used like 18:10:23, but in the standard the number of milliseconds since 2004-01-01T00:00:00.000Z, as specified in ISO 8601, is used.

Below the two examples Figure 19 and Figure 20 it is shown which illustrates the relation between the functional aspects and technical data fields and elements shown in the examples.

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The DEs marked grey in the figures do not change from example to example and are always the same for road works of the type Short Term Static.

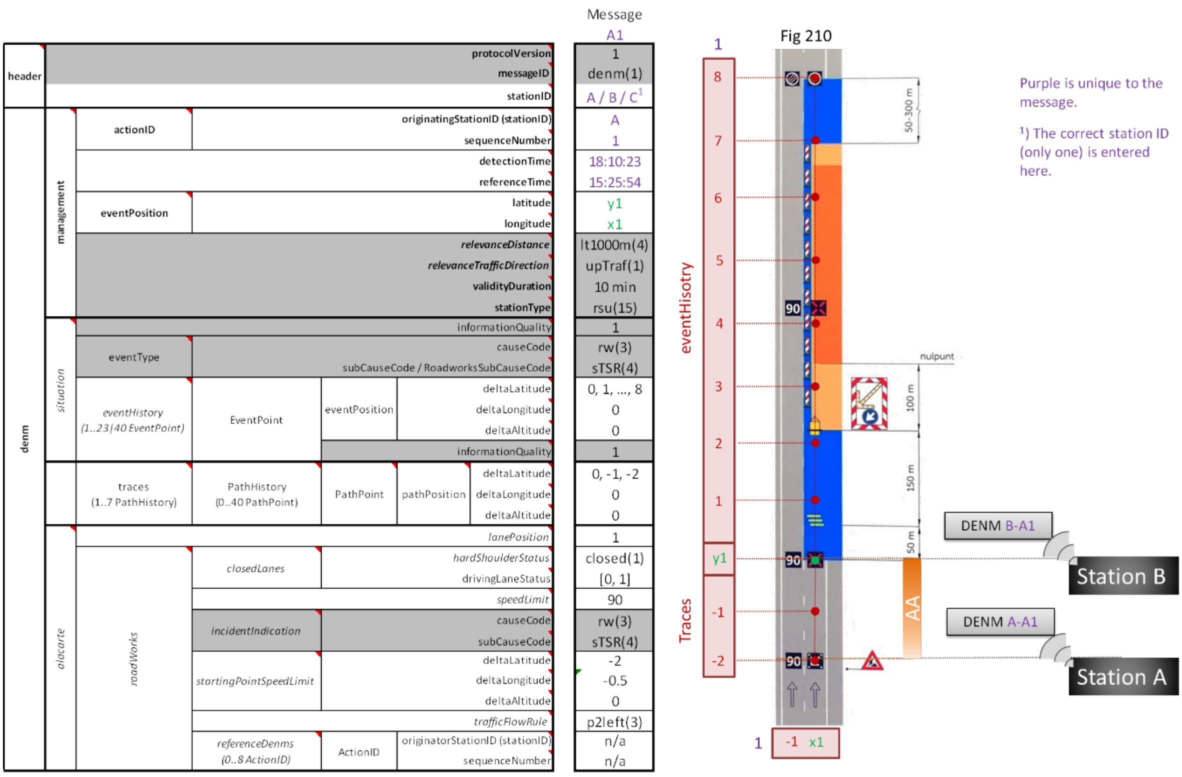

Figure 19: Road works on the hard shoulder, within 1.10m from the border line.

In Figure 19 road works are shown where a single lane is closed and there is an accompanying speed limit of 90 km/h. The red boxes with numbers in them represent an imaginary coordinates system. Using those imaginary coordinates, it is shown how a DENM would be filled for these road works.

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Location
The *eventPosition* indicates from where the lane is closed and thus corresponds to the red cross. It is positioned at (x1, y1) and is the reference position for all other location based elements (i.e. the zero point).

Road Works Area
The stretch of road for which the cross section (i.e. speed limit, closed lanes, etc.) remains the same is represented by the *eventHistory* which consists of 9 points [(x1, y1), …, (x1, 8)]. Those points are positioned on the closed lane. At least the first and last points are needed to mark the beginning and end of the said stretch of road. Those positions correspond to the *eventPosition* (gantry with the red cross) and the gantry that removes all restrictions (at x=8). In this example the length of the *eventHistory* equals the length of the road works (in the next example this is slightly different).
The fact that the right lane is closed is also shown by *drivingLaneStatus*. That DE has the values [0,1] indicating that the left lane is open and the right lane is closed in the road works area. In addition the hard shoulder is unavailable for stopping/closed in the road works area. This is indicated by the *hardShoulderStatus* which has the value 1 (closed).
Lastly, downstream of the eventPosition the TMA is located. On which lane the TMA is located, is indicated by the *lanePosition* DE. The lanes are counted from the outside of the road. As a result, in this case, the value is set to 1.

Awareness Area (AA)
Upstream of the closed lane (red cross) an area is marked as the Awareness Area. This is the area confined by the starting point of the speed limit, *startingPointSpeedLimit*, and the red cross. The red cross, as stated, is indicated by the eventPosition (x1, y1) and the *startingPointSpeedLimit* by the relative coordinates (-0.5, -2). The y-value -2 corresponds with the cross section where the gantry showing the speed limit is positioned. The value -0.5 refers to the middle of the carriageway. The speed limit itself, in this case, 90, is represented by the DE *speedLimit*.
The speed limit is accompanied by an arrow indicating vehicles should pass to the left. Although the arrow or its location is not *explicitly* communicated, its *message* is communicated using the *trafficFlowRule* element. It is set to 3 (*passToLeft*). That way drivers it is known vehicles should pass to the left to pass the closed lane.

In addition the DF *traces* is used to indicate the Awareness Area. It exists of a series of points starting at the *startingPointSpeedLimit* and ending at the *eventPosition*. For this example it is [(x1,-2), (x1,-1), (x1,y1)].

Relevance Area
Another area that is defined upstream of the *eventPosition* is the Relevance Area. The relevance area is a geographic area in which information concerning the event is identified as relevant for use or for further distribution. The length of the area is defined by the DE relevanceDistance and is set to 4 (lessThan1000m).

Another attribute used for the Relevance Area is the *relevanceTrafficDirection*. This DE indicates for which traffic, as seen from the *eventPosition*, the information is relevant. In case of road works it is upstream. The value is therefore set to 1 (*upstreamTraffic*).

Time

Above, all spatial aspects of DENM are covered. They specify where the DENM is valid. The DE *detectionTime* specifies when the DENM is valid. The DENM is valid from the time mentioned in *detectionTime* until time period mentioned in *validityDuration* has passed.
The remaining time DE is *referenceTime*. That DE is used to timestamp the broadcasted message. It is set to the time the DENM was broadcasted for the first time (i.e. the time the DENM was generated for the first time).
The exact values and the way the DE are eventually used will depend on the message handling specification (see par.Trigger Conditions).

Other

There are a few DEs, other than spatial or temporal, left. The most important are *stationID* and the DF *actionID* containing DEs *originatingStationID* and *sequenceNumber*.
The *stationID* is set to the station identity that broadcasts the message. Which/what message that is, is determined by the *actionID*. In other words, the *actionID* is the identifier for messages with the same content. The *originatingStationID* is set to the *stationID* first encountered by vehicles driving up to the road works. The *sequenceNumber* is increased with 1 for each new DENM message (having a different content and not being an update of a previous message).

It is important to note that each DENM (with the same *actionID*) can be transmitted from any ITS station. Only the value of the stationID would change in such a scenario. In the ether, there can be two DENMs, broadcasted by different stations (*stationID*), but with the same content (*actionID*). To illustrate this, the attributes in the example figures related to these IDs are shown in purple.

In this example just one DENM is needed. If, however, multiple DENMs are needed, they will refer to each other's *actionIDs* within the *referenceDenms* DF. This is explained in the next example (Fig. 3).

Three DEs remain: *informationQuality*, *causeCode* and *subCauseCode*. The *informationQuality* is used to indicate the accuracy/quality of the information. It can be set to one of eight values (0-7). What each value represents is, however, not defined by ETSI. A proposal is done by the Amsterdam Group, but it is not finalized yet.
The *causeCode* and *subCauseCode* indicate the type of event the DENM refers to. In this case that is 3 (*roadworks*) and 4 (*shortTermStationaryRoadworks*).

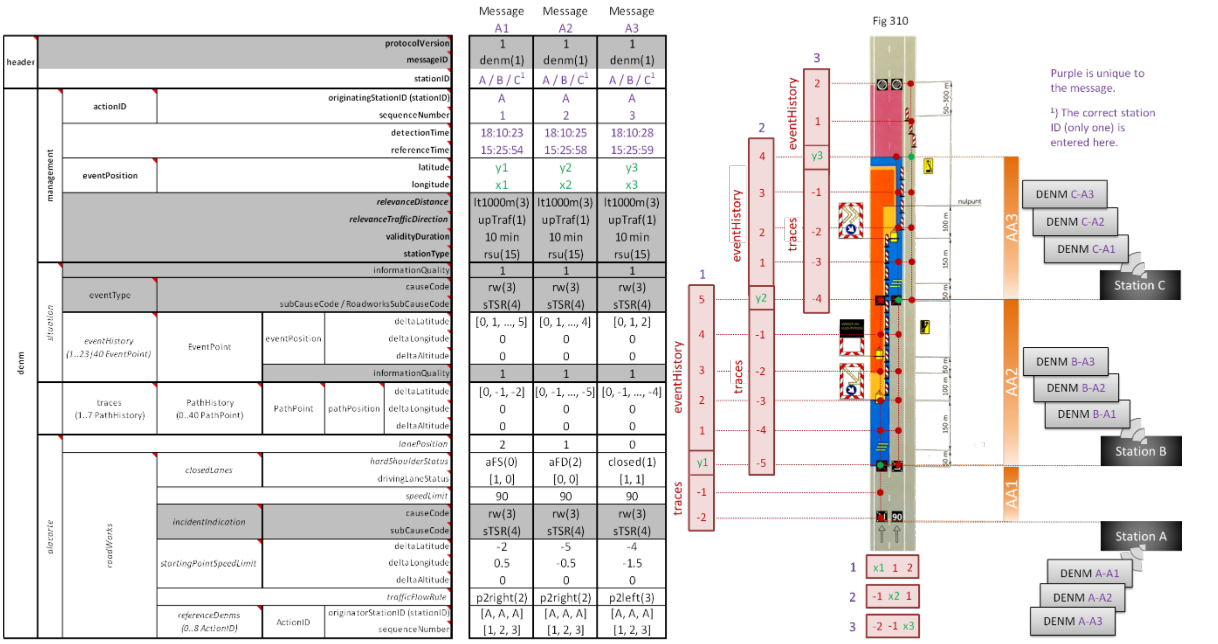


Figure 20:Road works on multiple bordering lanes.

In Figure 20 road works are shown where two lanes are consecutively closed off with an accompanying speed limit of 90 km/h. It differs from the previous example in that three DENMs are now needed to describe the road works. Below, only deviations from the first example are described.

Location

Instead of one *eventPosition*, there are now three (shown in green): one for each “closed lane” / ”red cross” / ”closed hard shoulder”. That also means there are now three coordinate systems and thus reference positions (zero points) for all other location based elements. However, the principle on how to refer to those locations, remains the same.

Road Works Area

In the previous example the *eventHistory* represented the length of the road works area. However, only one DENM was needed. In this example, the *eventHistory* of all DENMs need to be summed up to determine the length of the road works area. The *eventHistory* for each DENM is confined by its *eventPosition* and the *eventPosition* of the next DENM. As a result each DENM describes a stretch of road within which the traffic rules do not change (i.e. speed limit, closed lanes, status of the hard shoulder, etc.).

The *drivingLaneStatus* for the three DENMs is respectively [1,0], [0,0] and [1,1], meaning first the left lane is closed, than the right lane is closed and after that, both lanes are available again.

The *hardShoulderStatus* is 0 (*availableForStopping*), 2 (*availableForDriving*) and 1 (*closed*), meaning the first part is the normal situation, the second part makes the hard shoulder available for driving and, lastly, the hard shoulder is shortly unavailable because of the markers forcing the road users back onto the road.

Finally, the *lanePosition* DE is used to indicate which lane is has a red cross, TMA or is otherwise closed. The values for the three DENMs (counting from the outside of the road) are respectively, 2, 1 and 0.

Awareness Area (AA)
The traces DF translates the same way to this example as the *eventHistory* DF does. It is interesting to note that for the first two DENMs the *trafficFlowRule* is set to 2 (*passToRight*) and for the third DENM to 3 (*passToLeft*). This corresponds with the required flow of traffic around the road works.

Relevance Area
This is the same as in the first example, except the area is shifted with each eventPosition.

Time
Each DENM has its own timestamps, but other than that, there is no further difference with the first example.

Other
Since there are now three DENMs, the *sequenceNumber* has to be updated. For the purpose of the example, these are set to 1, 2 and 3 for the three DENMs respectively. The *originatingStationID* is A for all DENMs, since A is the first station encountered by traffic driving up to the road works.

Most interesting about this example is, however, the use of the DF *referenceDenms*. That container now holds the *actionIDs* of all DENMS: [(A,1), (A,2), (A,3)]. That way, the recipient of the broadcasted DENMs “knows” that these messages belong together and as a whole describe the road works.

Other DFs and DEs are used similarly as in the first example.

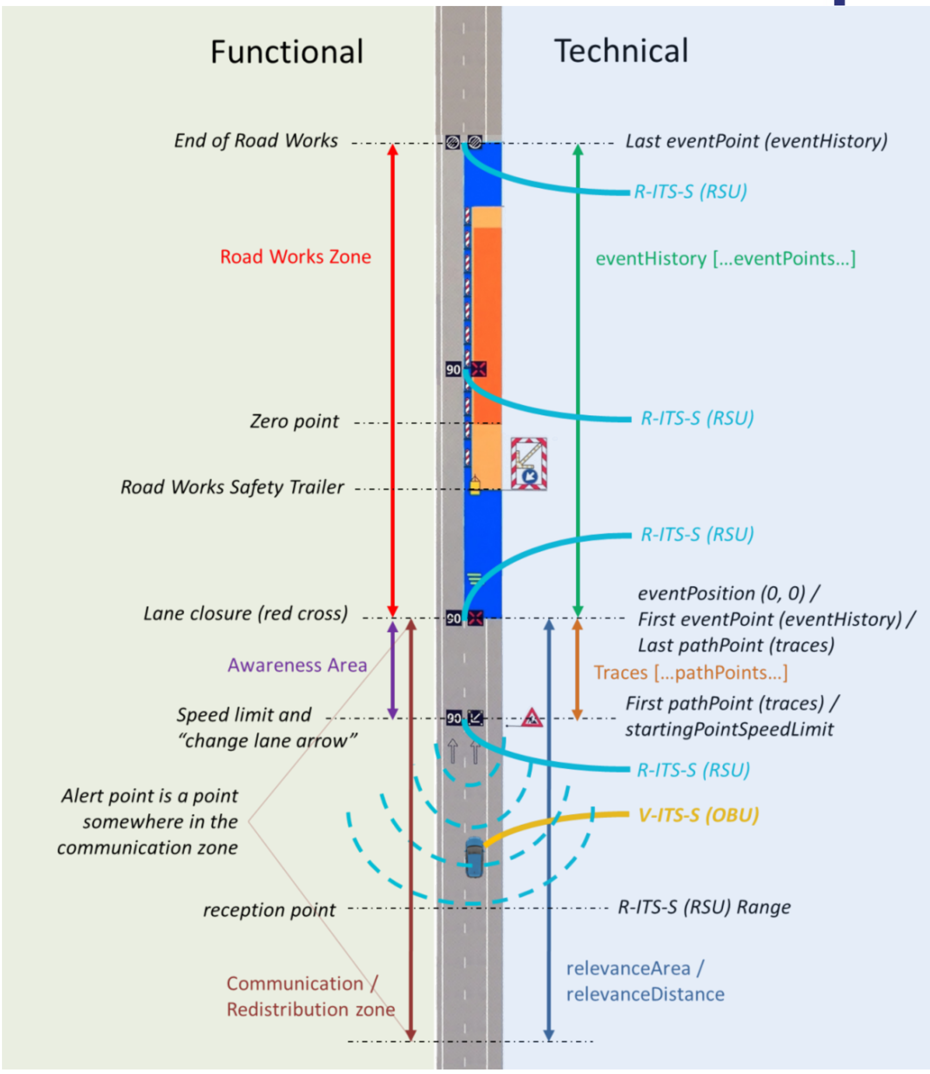
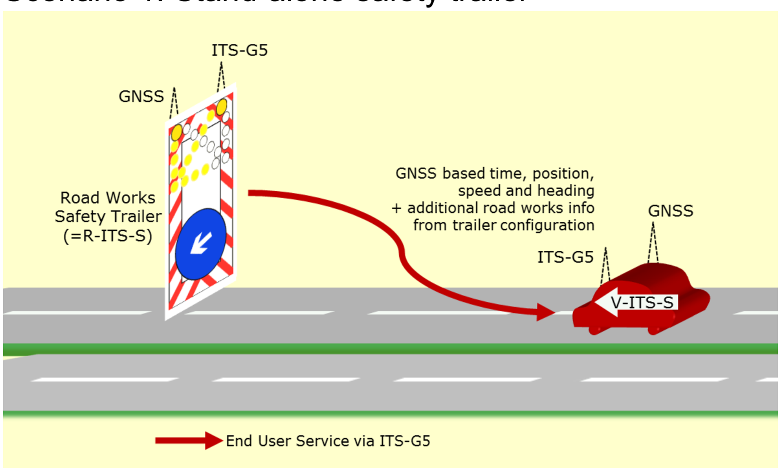


Figure 21: Functional versus technical view

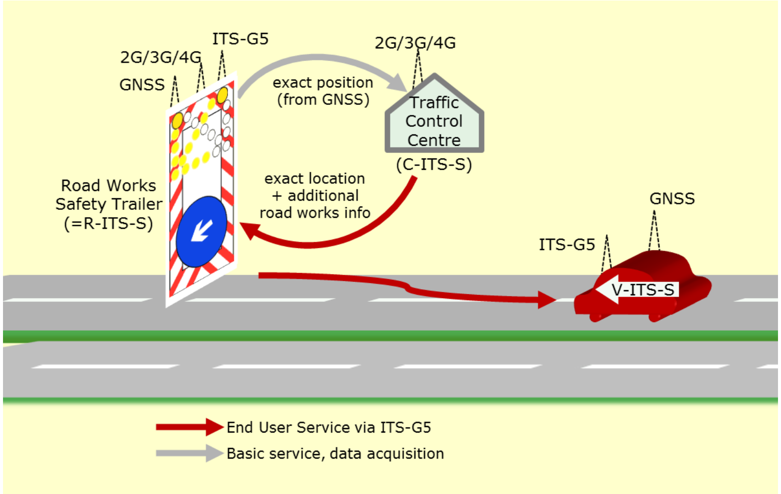
ECo-AT

In the ECo-AT project the use cases are illustrated for the 3 scenarios:

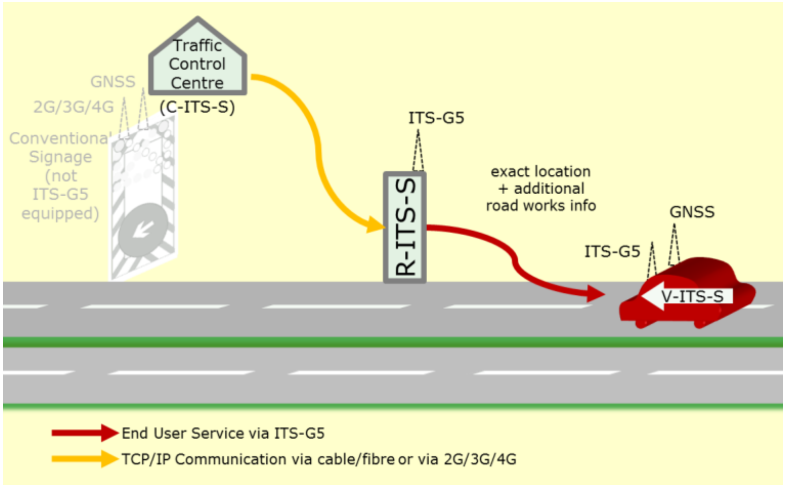
Scenario 1: Stand-alone safety trailer



Scenario 2: Integrated approach



Scenario 3: C-ITS-S based scenario



Potential requirements (as applicable)

The scenarios all depend on providing accurate information.

Main requirements based on [i.20]:

- Capability for a road side unit to broadcast I2V decentralized environmental notification messages providing the status of local roadwork.
- Capabilities for vehicle to receive and process I2V decentralized environmental notification messages and inform drivers accordingly.
- Capabilities for concerned vehicles to store and forward according to geocasting messages cancel rules, I2V decentralized environmental notification messages.
- Minimum frequency of the periodic message: 2 Hz.
- Maximum latency time: 100 ms.

From ECo-AT: the HLA is described in the [i.24] and shown below. The requirements for the overall system and the system components can be found here in section 5. For RWW all components and interfaces are needed, except {TLC} and {IF6}.

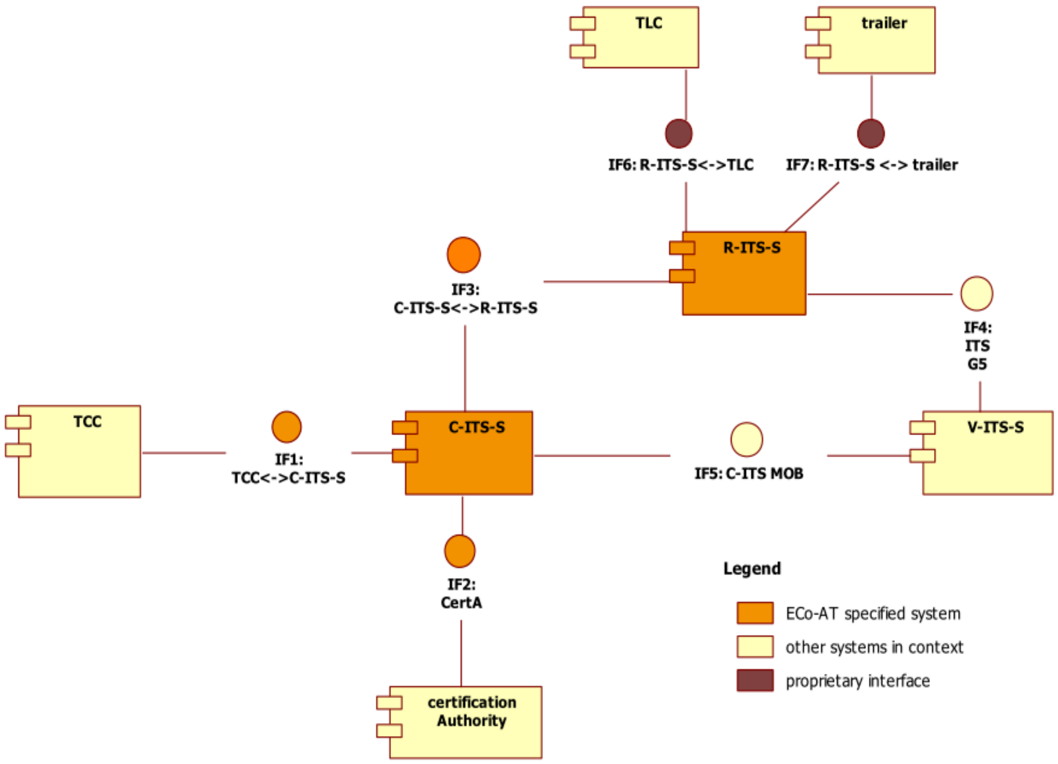


Figure 22: High level system architecture

Linked use cases (as applicable)

In Vehicle Signage: the use case RWW is closely related to In Vehicle Signage since in some scenarios information on traffic signs are communicated. The RWW implementation in ECo-AT uses DENM messages to ‘indirectly’ communicate traffic signs on closed lanes, and speed limits. IVI messages seem better suited to send this information.

Annex D:
Use Case Probe Vehicle Data

Introduction Use-Case

Use case ID

PVD

Background

This Probe Vehicle Data use-case focuses specifically on road user floating data recovery. It enables road operators to improve road safety and efficiency and limit CO_2 emission based on awareness and warning messages provided by C-ITS solution.

Road Users such as cars, trucks, motorcycles, mopeds, bicycles, impaired road users, pedestrians, prioritised traffic and others, send awareness and warning messages to each other and others. Road operators can collect the information via ITS-G5 equipped R-ITS-S along urban roads and highways.

From the implementation point of view there can be 2 sub-Use-Cases. Both result in collecting similar information types about traffic, but possibly differ slightly in coverage / the amount of data gathered.

1. The locations of R-ITS-S do not fully cover the road network. Standard messages from initiating V-ITS-S are only received when in range of a R-ITS-S.
2. The locations of R-ITS-S's do not fully cover the road network, but in addition to option 1 above, the R-ITS-S can send requests to V-ITS-S's in the vicinity. V-ITS-S's receiving this request need to have stored the requested information. When V- ITS-S's are equipped with this function, they can send this requested information when requested. Via this mechanism the road infrastructure can receive information, which was not possible to receive earlier by the/other V-ITS-S's.

This use-case description only specifies the mandatory functional requirements. It does not cover privacy and security related requirements although these are essential for the realisation of this use-case.

Beside data recovery being realized based on ITS-G5 awareness and warning services, data recovery can also be done through other communication techniques (e.g. 3G/4G). This use case description handles solely the ITS-G5 implementation and only indicates others when relevant.

At present time 2 sub Use-Cases can be identified. Sub Use-Case 1, based on information derived from the reception of CAM, DENM and event messages and Sub Use-Case 2, similar to Sub Use-Case 1, but with the possibility to request (buffered / collected) information from other stations. When implementing Sub Use-Case 2, a limited R-ITS-S coverage enables a much larger coverage for collecting awareness and warning messages.

Sub Use-Case 1, based on information derived from received CAM and DENM messages

Objective

To recover the relevant information from road users to support road operators in increasing road efficiency and safety, while taking into account privacy and security issues, by placing Infrastructural ITS-G5 stations such that relevant data can be received.

Source

Amsterdam Group; Eco-AT; Dutch Corridor project; Scoop@F; C2C-CC Trigger conditions

ETSI EN 302 637-2/3 [2], [3], Cooperative Awareness Message (CAM) and Decentralized Environmental Notification Message (DENM) services:

- Provide the normative and optional data elements to be provided at Day-1 deployment by the Car manufacturing community.

ETSI TS 102 894-2 [6], Common Data Directory (CDD)

- Required describing the elements required for EN 302 637-2/3.x
-

Description

The intention of this Use-Case is that all, for traffic controller relevant information, can be received from road users by road operators with the purpose to improve road efficiency, to improve road safety and lower CO2 emissions.

In this Sub-Use-Case this is realized by placing RSU at critical locations in the road network, thereby ensuring that most relevant information can be captured by the road infrastructure system.

The only thing to agree on, is that V-ITS-S's provide the relevant information/parameters. Within the section requirements a description of the current known required parameters are included as well as expected message transmission behaviour.

This initial use-case description is followed by ECco-AT, Scoop@F and expected to be followed by the Dutch Corridor project and is supported by the Amsterdam Group. The related Infrastructural implementation may differ based on the existing infrastructure. The message exchange will be harmonized on a European level and specified at ETSI in cooperation with CEN/ISO.

Target Systems (as applicable)

The targeted system is composed of V-ITS-S's, R-ITS-S's and road infrastructure data systems enabled to collect and combine information as received my more than 1 R-ITS-S.

Target system includes: any V-ITS-S, R-ITS-S, C-ITS-S and traffic management system (TMC).

Implementation environment (as applicable)

None.

Actors (as applicable)

- Road user
- V-ITS-S
  - Road user equipment provider
  - Road user service provider
- R-ITS-S
  - Road Infrastructure supplier
  - Road Infrastructure service provider (such as NDW)
- Road Operator (such as RWS)
-

Pre-conditions (if any)

- For this Use-Case it is required that R-ITS-S's are placed such that most relevant V-ITS-S's information can technically be received without any request from the R-ITS-S being sent to any V-ITS-S.
- TMC is connected to the ITS-G5 equipped R-ITS-S's which can provide information on current (T=0) and the TMC can process the information within T=0+t, where t needs to be defined but is in line with maximum CAM rate.
- The R-ITS-S's can receive CAM and DEMN information from V-ITS-S's.
- The V-ITS-S provides CAM and DEMN as standardized.

Triggers conditions (if any)

None.

Use-Case Diagram (if any)

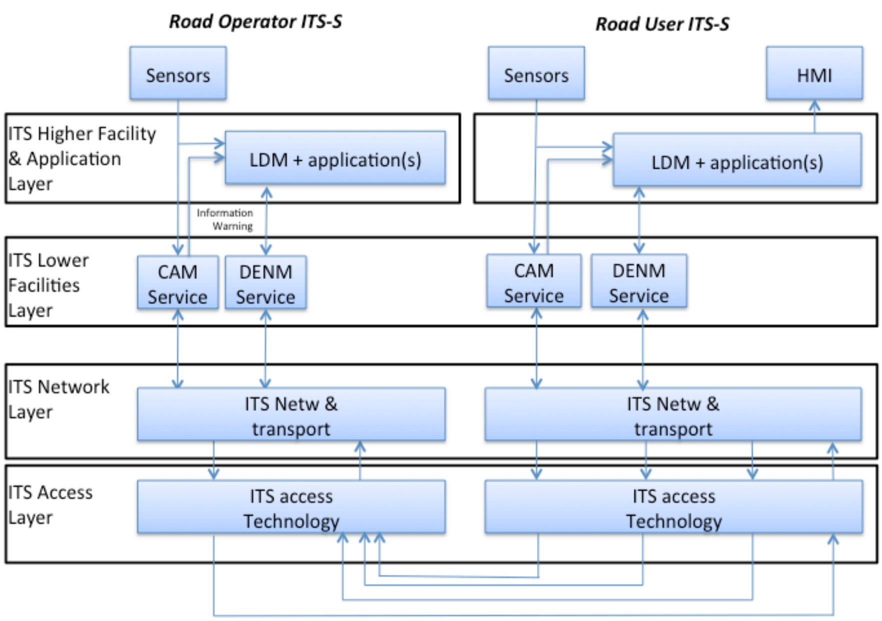


Figure 23: use case diagram

Normal Flow (as applicable)

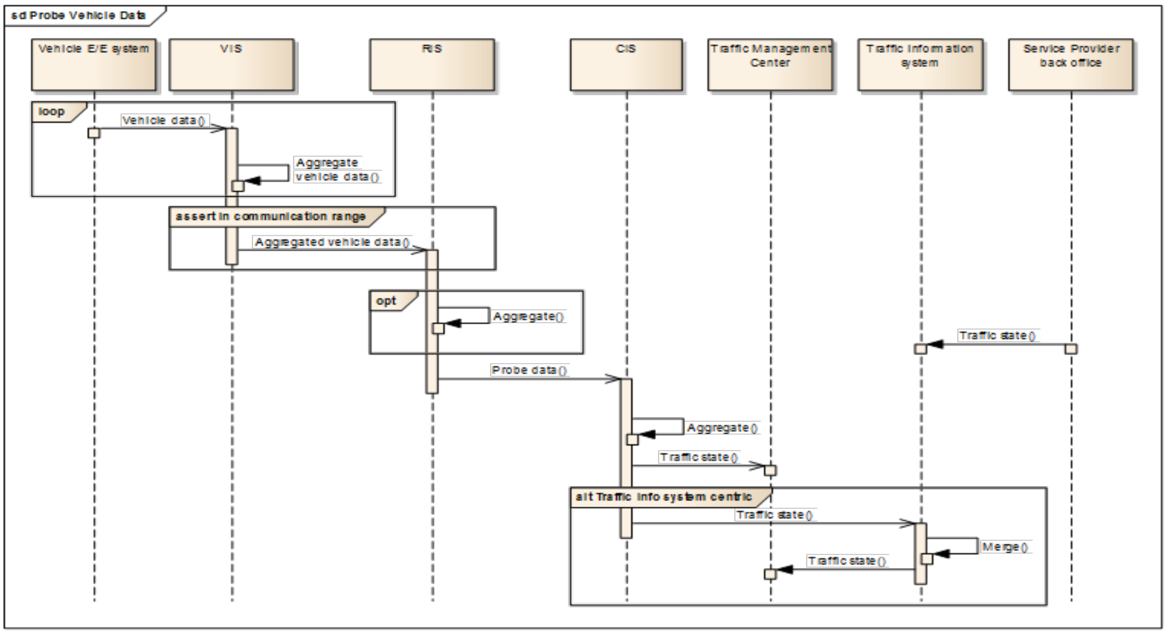


Figure 24: Normal flow

Alternative flow (if any)

None.

Post-conditions (if any)

At this moment none.

Termination conditions (if any)

At this moment none.

Use-Case Illustration (as applicable)

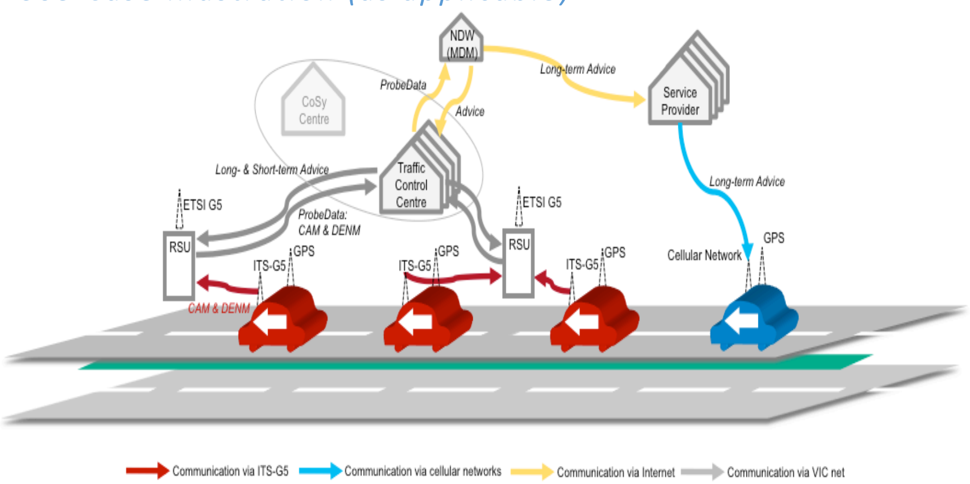


Figure 25: Use case illustration

Figure 3: use case illustration

Potential requirements (as applicable)

- Awareness Data parameters (CAM related)
  - Minimum required Parameters
    - Road User Type
    - Vehicle length (wish)/ width (optional)
    - Time/Position
  - Lane accuracy (not in CAM today)
    - Speed
    - Longitudinal Acceleration
    - Drive direction (forward / backward)
    - Heading
  - Optional Parameters
    - Wiper status (not in CAM today)
    - Headlight status
    - Road temperature (not in CAM today)
    - Road condition (slippery, bumps,….) (not in CAM today)
    - Warning light blinking (not in CAM today)
  - Detected Data parameters (DENM related)
    - Optional warning Messages
    - Slow vehicle warning
    - Wrong way driving warning
    - Road condition warnings
    - E-call warning
  - Behavioral
    - No requirement other than specified in current CAM and DENM specifications.
  - Security
    - No requirement other than specified in current CAM and DENM specifications.
  - Privacy
    - No requirement other than specified in current CAM and DENM specifications.

header	
protocolVersion	Version of the protocol. Current version is 1, thus field is set to 1.
messageID	Indicates the type of message. Examples are denm(1), cam(2), ivi(6), etc. Here 2 is used.
stationID	This is the ID of the station (vehicle) broadcasting the message.
cam	
generationDeltaTime	Timestamp belonging to the referencePosition.
basicContainer	
stationType	This DE can be 0 or 4 – 10. Other values indicate vehicles that are not allowed on the motorway.
referencePosition	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).
highFrequencyContainer	
heading	The (compass) direction of the vehicle, in 1/10th of a degree.
speed	Speed of the vehicle in cm/s.
driveDirection	The direction the vehicle is travelling in: forward(0), backward(1) or unavailable(2).
vehicleLength	Length of the vehicle in steps of 10 cm. 1 == 10cm.
vehicleWidth	*The vehicle width in 10 cm steps. 1 == 10cm. Required by the standard but not part of the wish list.*
longitudinalAcceleration	The longitudinal (forward / backward) acceleration of the vehicle in steps of 0.1 m/s^2.
curvature	*The curvature of the vehicle trajectory. Required by the standard but not part of the wish list.*
curvatureCalculationMode	*The calculation mode for the curvature. Required by the standard but not part of the wish list.*
yawRate	*The rate the vehicle is spinning around its centre of mass. Required by the standard but not part of the wish list.*
lowFrequencyContainer	
vehicleRole	*The role of the vehicle (e.g. public transport). This is set in accordance with ETSI TS 102 894-2 (usually 0-default). Required because of the use of the lowFrequencyContainer but not part of the wish list.*
exteriorLights	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.).
pathHistory	*This DF can hold up to 40 points (PathPoint) of where the vehicle has been, optionally with an accompanying timestamp (pathDeltaTime). The timestamp would allow for speed calculation between the points. Required because of the use of the lowFrequencyContainer but not part of the wish*

	list.

Legend	
bold	required by standard
cursive	optional by standard
normal	required when parent container is used

Linked use cases (as applicable)

At this moment none.

Sub Use-Case 2, Extended Sub Use-Case 1 with requests sent by RSU's and earlier transmitted data response by V-ITS-S's.

Objective

To recover the relevant information from road users to support road operators in increasing road efficiency and safety, while taking into account privacy and security issues, by placing Infrastructural ITS-G5 stations such that most relevant data can be received and no relevant information gets lost.

Source

Amsterdam Group; Eco-AT; Dutch Corridor project; Scoop@F; C2C-CC Trigger conditions

ETSI EN 302 637-2/3 [2], [3], Cooperative Awareness Message (CAM) and Decentralized Environmental Notification Message (DENM) services

- Provide the normative and optional data elements to be provided at Day-1 deployment by the Car manufacturing community.

ETSI TS 102 894-2 [6], Common Data Directory (CDD)

- Required describing the elements required for EN 302 637-2/3.

Description

The intention of this Use-Case is that all, for traffic controller relevant information, can be received form road users by road operators with the purpose to improve road efficiency and predictable travel time, to improve road safety and, lower CO2 emissions and improve road safety.

In this Sub-Use-Case this is realized by a handshake between road infrastructure RSU's and Road User ITS stations such that RSU's can be intermittently placed along urban roads and highways but still get most relevant information while not being present at all locations to receive the data without a request.

This method will allow the deployment with a much lower amount of RSU's especially in rural areas. The functionally as described in Sub-Use-Case 1 is also applicable here and for those aspects we refer to this Sub-Use-Case 1.

This initial use-case description is followed by ECo-AT, and expected to be followed by the Dutch Corridor project and is supported by the Amsterdam Group. The related Infrastructural implementation may differ based on the existing infrastructure. The message exchange will be European wide harmonized and specified at ETSI in cooperation with CEN/ISO.

Target Systems (as applicable)

The targeted system is composed of road user ITS's, RSU ITS's and road infrastructure data systems enabled to collect and combine information as received my more than 1 RSU.

Target system includes: any user ITS-S (such as V-ITS-S), R-ITS-S, C-ITS-S and traffic management system (TMC).

Implementation environment (as applicable)

None.

Actors (as applicable)

- Road user
- Road user ITS-S
    - Road user equipment provider
    - Road user service provider
- Road Infrastructure ITS-S
    - Road Infrastructure supplier
    - Road Infrastructure service provider (such like NDW)
- Road Operator (such like NDW)

Pre-conditions (if any)

- For this Use-Case it is required that RSU's are placed such that most relevant road user ITS-S's information can technically be received without any request from the RSU being sent to any user ITS-S.
- TMC is connected to the ITS-G5 equipped R-ITS-S's which can provide information on current (T=0) and the TMC can process the information within T=0+t, where t needs to be defined but is in line with maximum CAM rate.
- The R-ITS-S's can receive CAM, DEMN and PVD information from other ITS-S's and provides PDM to those others.
- The V-ITS-S can receive CAM, DENM and PDM from other ITS-S's and provides CAM, DEMN and PVD.
- That PDM and PVD are standardized which they are not at the moment of release of this document.

Triggers conditions (if any)

None.

Use-Case Diagram (if any)

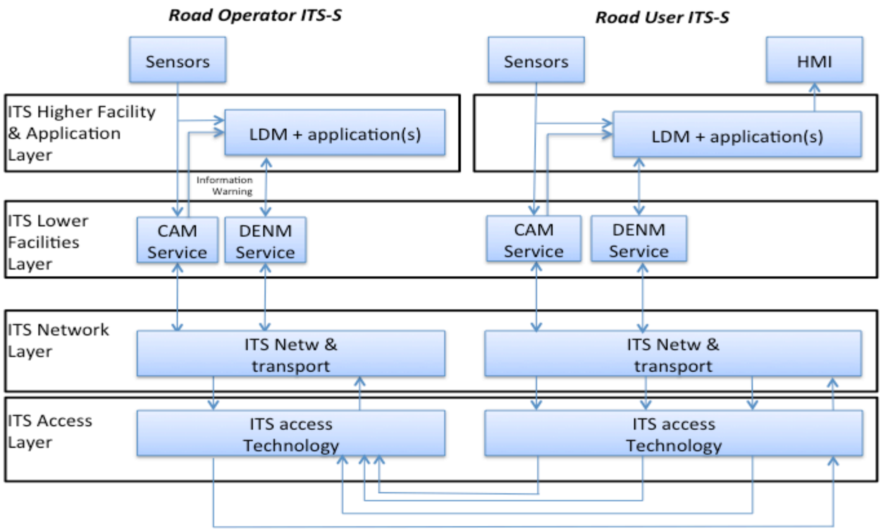


Figure 26: use case diagram

Normal Flow (as applicable)

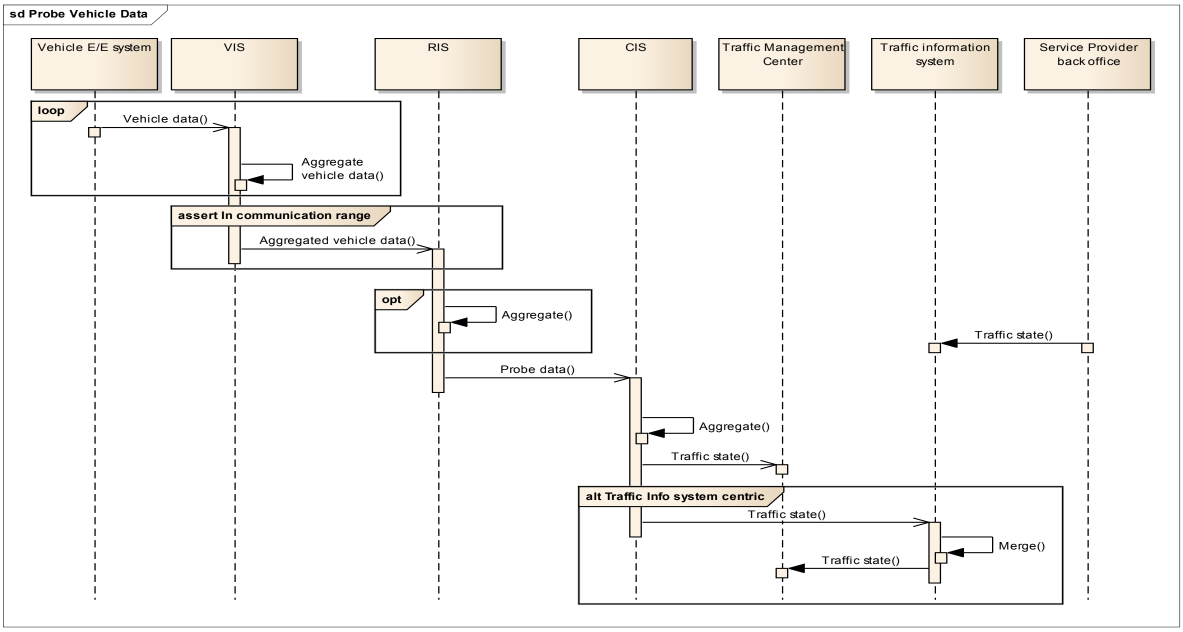


Figure 27: Normal flow

Alternative flow (if any)

Not applicable.

Post-conditions (if any)

At this moment none.

Termination conditions (if any)

At this moment none.

Use-Case Illustration (as applicable)

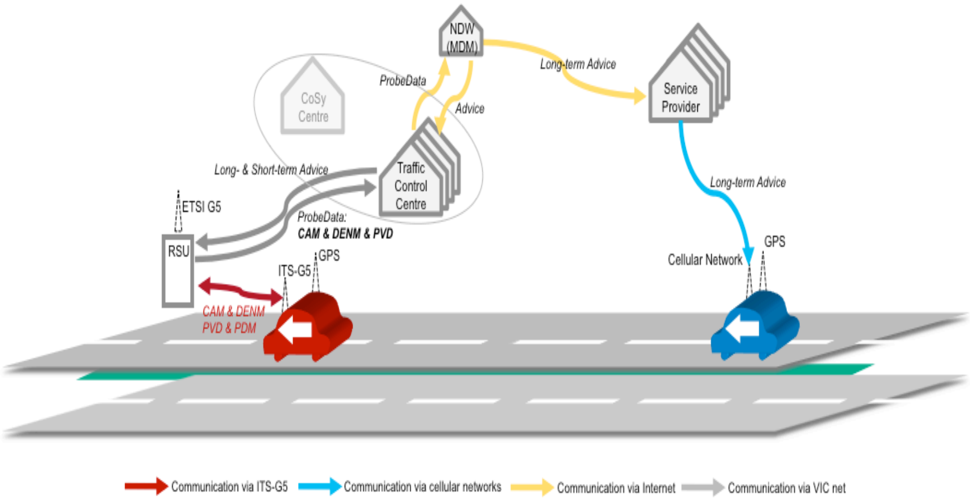


Figure 28: Use case illustration

Potential requirements (as applicable)

- Awareness Data parameters (CAM related)
  - Minimum required Parameters
    - Road User Type
    - Vehicle length (wish)/ width (optional)
    - Time/Position
      - Lane accuracy (not in CAM today)
    - Speed
    - Longitudinal Acceleration
    - Drive direction (forward / backward)
    - Heading
  - Optional Parameters
    - Wiper status (not in CAM today)
    - Headlight status
    - Road temperature (not in CAM today)
    - Road condition (slippery, bumps,….) (not in CAM today)
    - Warning light blinking (not in CAM today)
  - Detected Data parameters (DENM related)
    - Optional warning Messages
      - Slow vehicle warning
      - Wrong way driving warning
      - Road condition warnings
      - E-call warning
  - Behavioural
    - No requirement other than specified in current CAM and DENM specifications.
  - Security

- No requirement other than specified in current CAM and DENM specifications.
- Privacy
  - No requirement other than specified in current CAM and DENM specifications.

header	
protocolVersion	Version of the protocol. Current version is 1, thus field is set to 1.
messageID	Indicates the type of message. Examples are denm(1), cam(2), ivi(6), etc. Here 2 is used.
stationID	This is the ID of the station (vehicle) broadcasting the message.
cam	
generationDeltaTime	Timestamp belonging to the referencePosition.
basicContainer	
stationType	This DE can be 0 or 4 – 10. Other values indicate vehicles that are not allowed on the motorway.
referencePosition	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).
highFrequencyContainer	
heading	The (compass) direction of the vehicle, in 1/10th of a degree.
speed	Speed of the vehicle in cm/s.
driveDirection	The direction the vehicle is travelling in: forward(0), backward(1) or unavailable(2).
vehicleLength	Length of the vehicle in steps of 10 cm. 1 == 10cm.
vehicleWidth	*The vehicle width in 10 cm steps. 1 == 10cm. Required by the standard but not part of the wish list.*
longitudinalAcceleration	The longitudinal (forward / backward) acceleration of the vehicle in steps of 0.1 m/s^2.
curvature	*The curvature of the vehicle trajectory. Required by the standard but not part of the wish list.*
curvatureCalculationMode	*The calculation mode for the curvature. Required by the standard but not part of the wish list.*
yawRate	*The rate the vehicle is spinning around its centre of mass. Required by the standard but not part of the wish list.*
lowFrequencyContainer	
vehicleRole	*The role of the vehicle (e.g. public transport). This is set in accordance with ETSI TS 102 894-2 (usually 0-default). Required because of the use of the*

	lowFrequencyContainer but not part of the wish list.
exteriorLights	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.).
pathHistory	*This DF can hold up to 40 points (PathPoint) of where the vehicle has been, optionally with an accompanying timestamp (pathDeltaTime). The timestamp would allow for speed calculation between the points. Required because of the use of the lowFrequencyContainer but not part of the wish list.*

Legend	
bold	required by standard
cursive	optional by standard
normal	required when parent container is used

Linked use cases (as applicable)

Sub use-case 1.