ITS USE CASE

Use Case Title:	Road Works Warning for the ITS-G5 context
Project Name:	Standaardisatie Tafel (NL)
Source:	C-ITS Corridor, Amsterdam Group
Date:	2015-09-18
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Abstract:	Template for documenting use cases and scenarios. This document is derived by taking into account contributions and various online and harmonization discussions to date.
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Decision requested or recommendation:	

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1.1 Use Case Road Works Warning

1.1.1 Introduction Use-Case

1.1.1.1 Use case ID

RWW

1.1.1.2 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.

1.1.1.3 Objective

Reduce the risk of accident at the level of roadworks.

1.1.1.4 Source

ECO-AT, ETSI TC ITS, ITS Corridor, Amsterdam group

1.1.2 Description Use-Case

From [NL C-ITS Architecture]: Construction sites and temporary maintenance working areas are accident black spots, because static traffic signs are ignored or realized 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. [source: DITCM 1.0, C2C-CC]

From Amsterdam Group: the application is described in detail in a white paper with a functional specification [Message Set and Triggering Conditions for Road Works Warning Service, Amsterdam Group, version 1.1, July 2014]. 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.

1.1.3 Target System (as applicable)

This depends on the scenario. The driver is always warned via its 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 Center), Traffic Information System and SP BO is optional.

1.1.4 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 behavior 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 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."

1.1.5 Actors (as applicable)

Depends on scenario: driver, road workers contracter, pre-warner vehicle, road works safety trailer, road operator, single point of access Traffic Data platform (like 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. Possibilities are SPIN or the NDW.

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

1.1.6 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).

1.1.7 Triggers conditions (if any)

- See section 7 of [20140714 AG RWW MessageSet.pdf] 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 [ECo-AT_SWP2.1_RoadWorksWarning_v02.00.pdf]:
  - 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.

1.1.8 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.

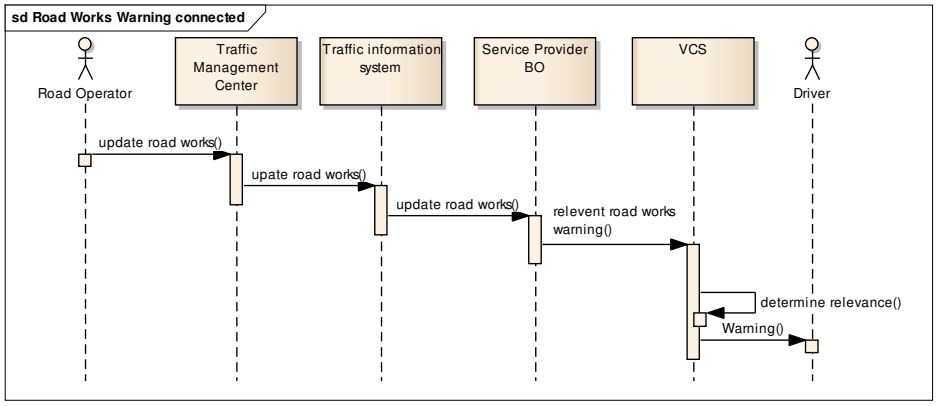
As indicated in 1.1.5, as of yet, it is unclear who will initiate such a warning (e.g. the contractor or perhaps the operator from the TCC).

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 (also see 1.1.7).

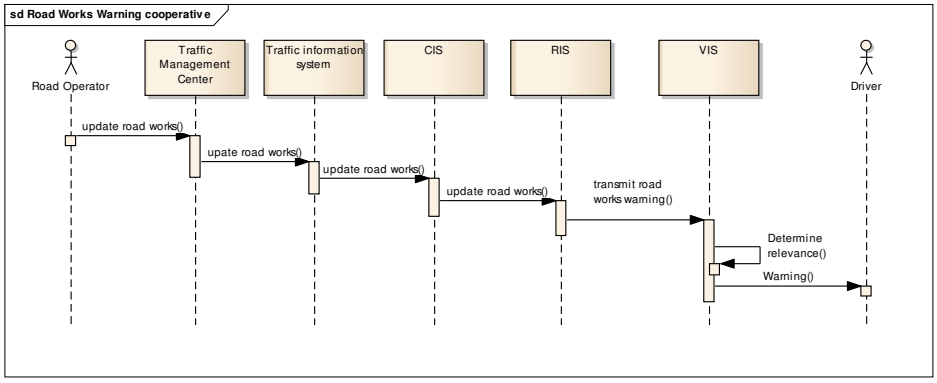
Note: The above situation is typical for the Dutch motorway. In the Amsterdam Group and ECo-AT, the Truck Mounted Attenuator is linked to the trigger moment.
This Truck Mounted Attenuator is equipped with a large arrow indicating traffic whether to merge left of right. When this arrow is put in an upright 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).

1.1.9 Normal Flow (as applicable)

In DITCM 1.0 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 VIS. For now, the start, update and stop of the messages needs to be described in the procedures, and is not a technical aspect.



Sequence diagram for road works warning / information via connected communication



Sequence diagram Road works warning via cooperative communication

1.1.9.1 Alternative flow (if any)

1.1.10 Post-conditions (if any)

The driver is informed on road works.

1.1.11 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.

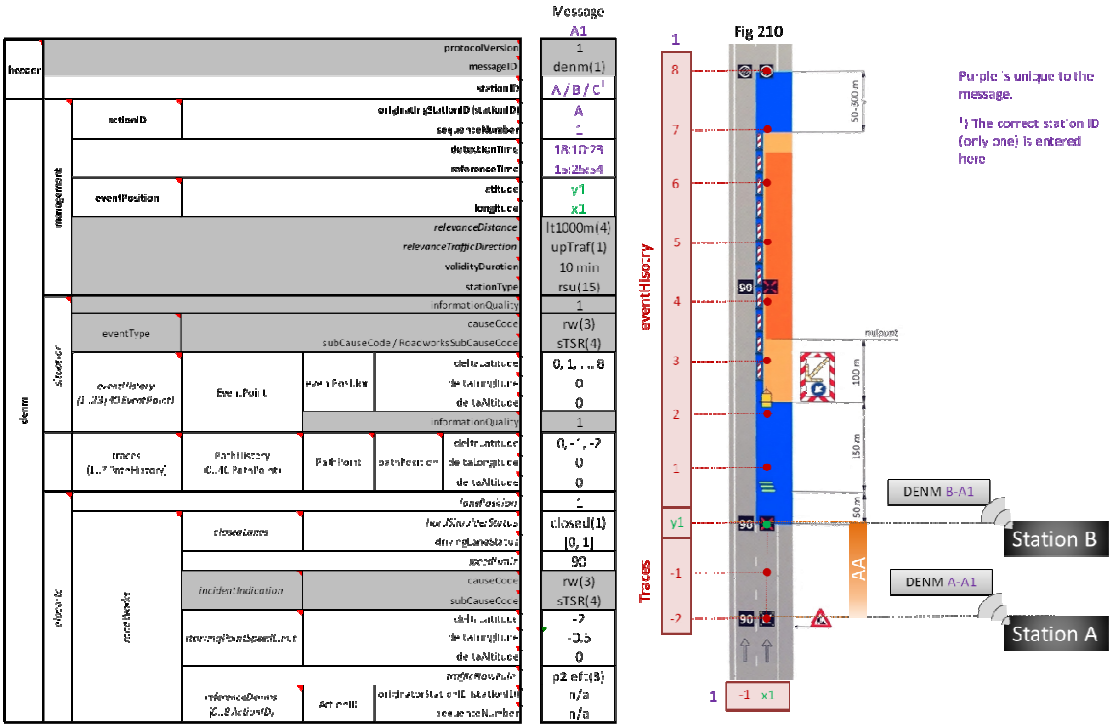
1.1.12 Use-Case Illustration (as applicable)

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 a figure (Figure $$$) is shown which illustrates the relation between the functional aspects and technical data fields and elements shown in the examples.

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



In Figure 210 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.

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*).

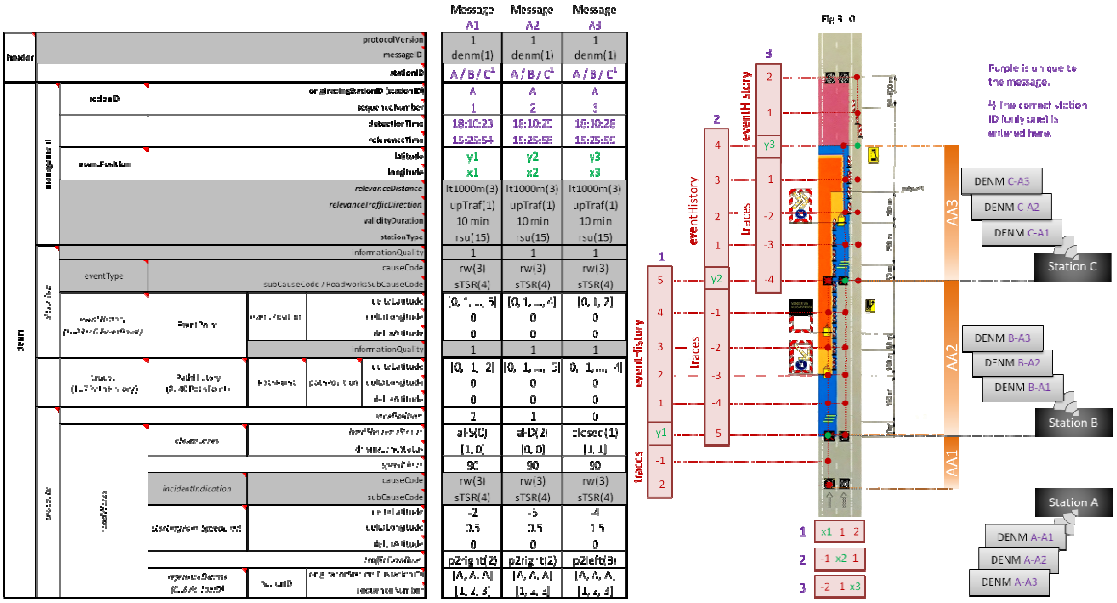
Time
Above, all spatial aspects of DENM are covered. They specify where the DENM is valid. The DE *detectionTime* specifies when the DENM is valid. The DENM is valid from the time mentioned in *detectionTime* until time period mentioned in *validityDuration* has passed.
The remaining time DE is *referenceTime*. 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. 1.1.7).

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. 310).

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 310 Road works on multiple bordering lanes.



In Figure 310 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.

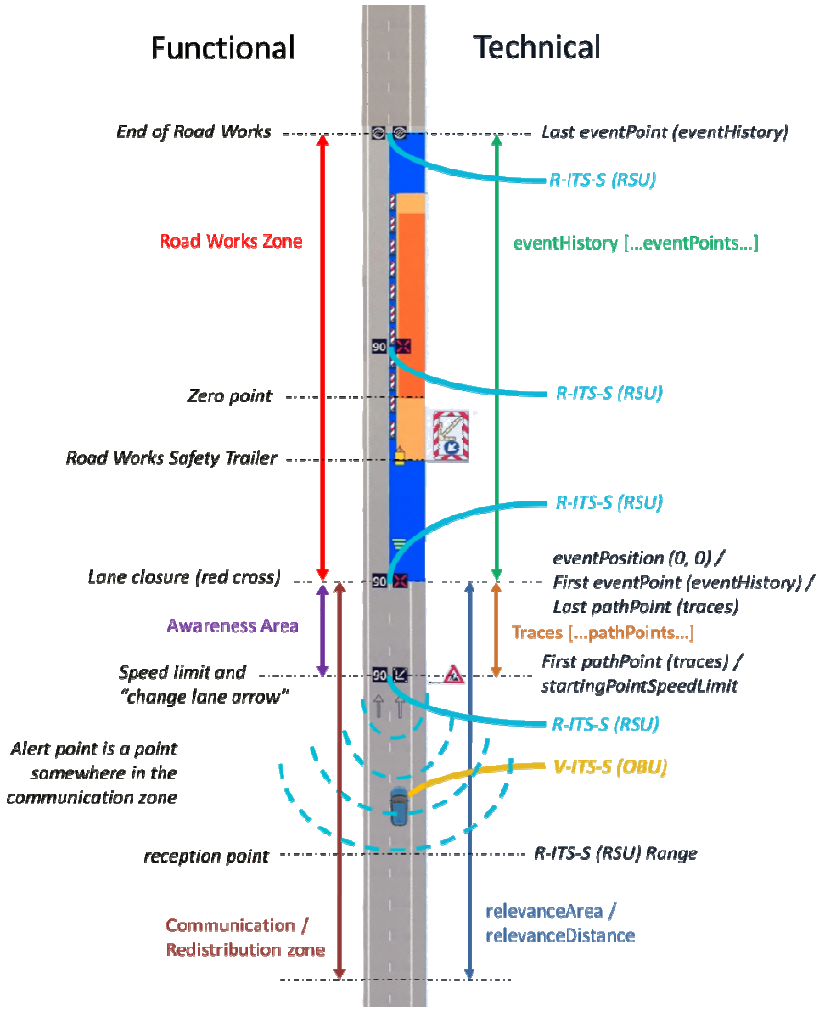
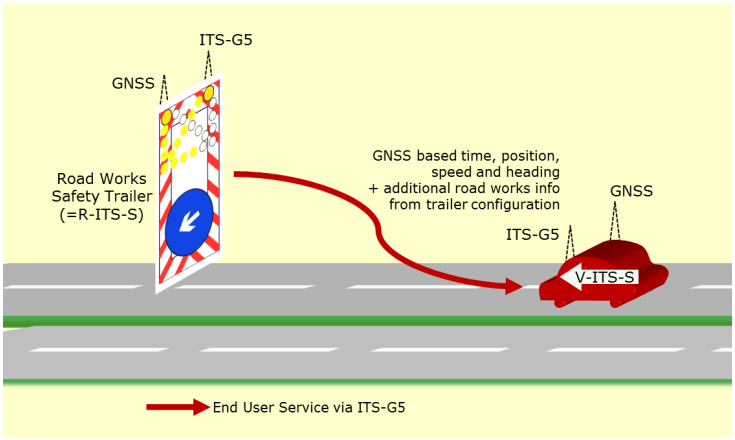


Figure $$$

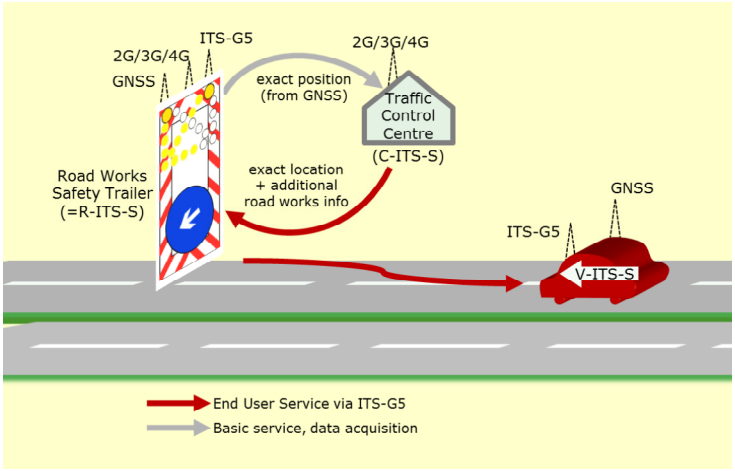
1.1.12.1 ECo-AT

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

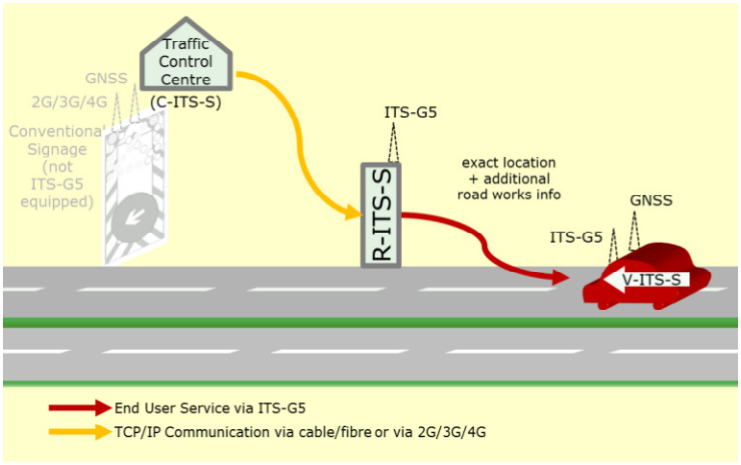
Scenario 1: Stand-alone safety trailer



Scenario 2: Integrated approach



Scenario 3: C-ITS-S based scenario



1.1.13 Potential requirements (as applicable)

The scenarios all depend on providing accurate information.

From ETSI TR 102 638:

Main requirements:

- 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 [ECo-AT_SWP2.3_SystemOverview_v02.00.pdf] 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}.

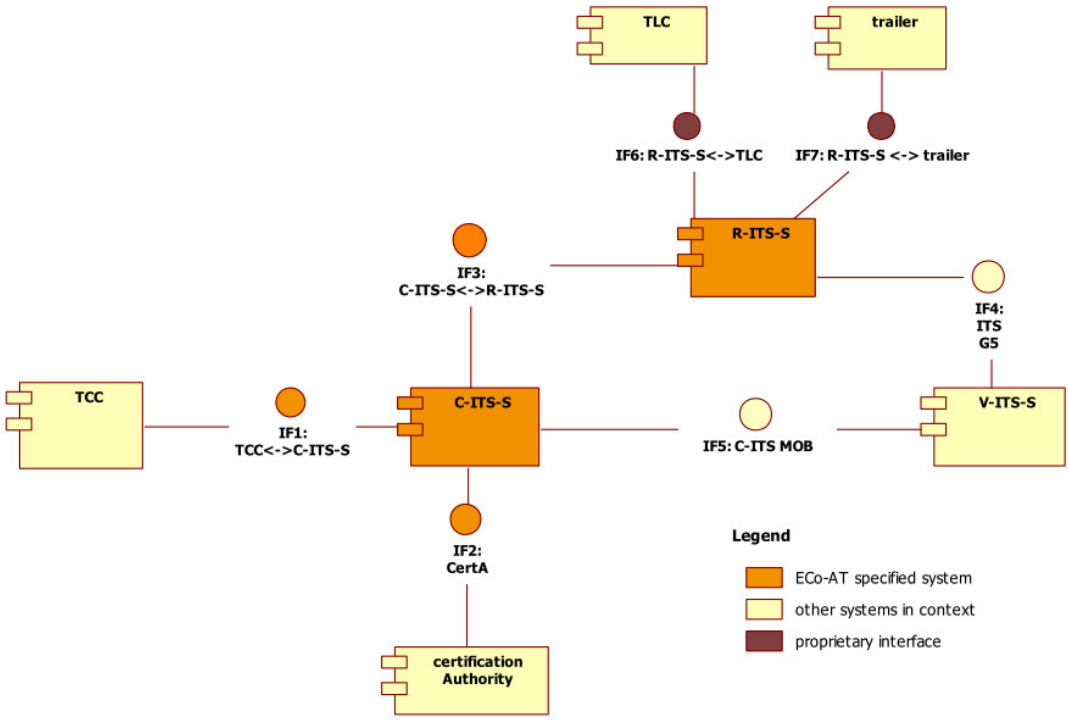


Figure 2: High level system architecture

1.1.14 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.