# SWP 2.1 Use Cases
# Road Works Warning
# WP 2 - System Definition
# Version: 03.60

| | |
|---|---|
| Release Date: 2016-07-29 | |

## Overview of changes

| No. | Version | Status | Date | Type of Change |
|---|---|---|---|---|
| 1 | 01.00 | Released | 2014-11-21 | First Release |
| 2 | 02.00 | Released | 2015-03-11 | Second Release |
| 3 | 03.00 | Released | 2015-07-15 | Third Release |
| 4 | 03.10 | Released | 2016-03-01 | Update of Third Release |
| 5 | 03.50 | Released | 2016-04-29 | Third Release – Second Update |
| 6 | 03.60 | Released | 2016-07-29 | Third Release – Third Update |

*Table 1: Document History*

Reference to the status- and version administration:

**Status**:

| | |
|---|---|
| In progress | the document is currently in editing mode |
| Released | the document has been checked and released by quality assurance, it can only be modified if the version number is updated. |

**Versions**:

Takes place in two stages. Released documents receive the next higher integral version number.

| | |
|---|---|
| 00.01, 00.02 etc. | Not released versions, with the status in progress |
| 01, 02, etc. | Released version with the status released |

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# 1 Document Information

## 1.1 Purpose of this document

The ECo-AT use case is based on – and will be kept aligned with – the Amsterdam Group's *Functional Description* Paper as well as the *Message Set and Triggering Conditions* Paper for the same application [AG RWW]. Note that references to specifications have to be versioned, i.e. aligning the documents will mean updating this document to refer to any potentially updated Amsterdam Group (AG) paper. Furthermore, the essential content form the AG paper is physically copied and quoted here in order to keep the document self-contained and to avoid semantic errors in the alignment and iterative amendment process.

Further to the basic AG description, any ECo-AT specific choices / profiles and additional specifications are added in this paper in order to provide all necessary information required for a full deployment specification in ECo-AT.

## 1.2 Definitions, Terms and Abbreviations

| Abbreviation / Term | Definition |
|---|---|
| 2G/3G/4G | Different generations of cellular communication systems, offering digital communication links for data exchange – typical systems assigned to these generations in Europe are GSM/GPRS, UMTS and LTE |
| AG | Amsterdam Group – co-operation of C2C-CC, CEDR, ASECAP & POLIS for European roll-out of Cooperative ITS |
| C-ITS | Cooperative ITS – C-ITS is a *"subset of overall ITS that communicates and shares information between ITS stations to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems"* (ISO/TR 17465-1) |
| C-ITS-S | Central ITS station (as of [ETSI 302 665]) |
| CB radio | Citizens band radio – *"a system of short-distance radio communications between individuals on a selection of 40 channels within the 27-MHz (11 m) band."* (http://en.wikipedia.org/wiki/Citizens_band_radio) |
| DENM | Decentralized Environmental Notification Message – as of [ETSI 302 637-3] |
| GIS | Geographical Information System |
| GNSS | Global Navigation Satellite System |
| HMI | Human Machine Interface, e.g. a graphical user interface (GUI) |
| I2V | Infrastructure-to-Vehicle – describes the directional information flow from infrastructure communication point R-ITS-S towards passing vehicles (V-ITS-S) |

| Abbreviation / Term | Definition |
|---|---|
| ITS | Intelligent Transport Systems – systems that use information and communication technology to improve transport systems |
| MAP | Message to convey local, detailed network topology in specific areas, as specified in ISO/PDTS 19091 |
| PVIS DDS | Data Services Server, part of ASFINAG's Central Data Hub. |
| R-ITS-S | Roadside ITS station (as of [ETSI 302 665]), mobile on vehicle or fixed at roadside |
| RMS | Road Works Management System |
| RWW | Road Works Warning – Day 1 I2V use case where a R-ITS-S delivers information about downstream road works to V-ITS-S |
| TMC | Traffic Message Channel - a technology for delivering traffic and travel information to motorists using the Radio Data System on top of FM broadcasts |
| V-ITS-S | Vehicle ITS station (as of [ETSI 302 665]), i.e. on-board unit for C-ITS |
| VMS | Variable Message Sign – electronic traffic sign with dynamic content that may include textual as well as graphical elements |

*Table 2: Definitions, Terms and Abbreviations*

### 1.3 References

All references in this document can be found in the master table of references available in the "Eco-AT_SWP2.3_MasterTableOfReferences_v03.60.pdf" document.

# 2 Introduction

The following *Rationale* and *Expected Benefits* sections are quoted from [AG RWW]:

## *Rationale*

*The use case Road Works Warning informs drivers of road works, its parameters and associated obstruction (e.g. lane closed) on the route ahead on his HMI. The purpose is to alert the driver in time to increase awareness and to inform of potentially dangerous conditions. It should be noted that some aspects of a road works message overlap with information required for – or used in – other use cases, e.g. information on speed limits in road works will also be needed for the In Vehicle Signage use case.*

## *Expected Benefits*

*Warning road users via dynamic in-vehicle information about road works that potentially disrupt traffic flow, the service is expected to improve road safety. If information is available on a work site potentially disrupting traffic flow, the driver can adapt his or her speed suitable to the situation and increase his or her awareness. It is also expected that the service will improve the safety of the road workers at road work sites and prevents road work property damages.*

*The added value of a cooperative approach is increased accuracy of the road works information in time and location for the benefit of the end user. It will also be possible to explain the background of the road works and thus raise user acceptance. When conveyed upstream, it may contribute to more efficient route planning and network usage, complementing existing channels providing this type of information to navigation services.*

As we can see, the RWW use case is a typical example of a day one Infrastructure-to-Vehicle (I2V) use case, since equipped vehicles have immediate benefit from day 1 on, independent of the rate of Cooperative-ITS (C-ITS) equipped vehicles, as long as the infrastructure is equipped in the road works area. The use case is defined as a complement to existing road works information services via other channels (spoken radio, Traffic Message Channel (TMC), connected vehicles[1], etc.), focussing on localized, direct, safety-related information in the relevant vicinity of the particular road works measure. Hence, it also has a direct relevance for SP 2.6 *Convergence Strategy*.

The use case depends on Roadside ITS Stations (R-ITS-S) being available on site, upstream to the road works at a suitable distance or on vehicles to notify the driver in time. The AG paper actually provides different scenarios for the deployment of RWW – based either on equipped safety trailers and/or vehicles (mobile R-ITS-S) or on fixed and/or temporary infrastructure – for which the suitable choices for ECo-AT will be specified in this paper. In general, the use case is not depending on whether the R-ITS-S is deployed as mobile, temporary or permanent fixed infrastructure, as long as its position relative to the road works is suitable to

[1] This includes services tied to the vehicle/OEM as well as connected devices such as Personal Navigation Devices or services deployed on smartphones

provide the information to the driver sufficiently in advance. This may best be achieved by a safety trailer mounted R-ITS-S on day 1, but in future situation with more C-ITS infrastructure being available, it may be better to use existing fixed R-ITS-S. It is important to note that the driver will not recognise any difference regarding the offered service.

# 3 Functional description

## 3.1 RWW deployment scenarios

[AG RWW] specifies different deployment options for the RWW use case. The options differ in:

a) Whether the warning message is created locally in an R-ITS-S ("stand-alone mode") or centrally in the C-ITS-S ("basic service"), and

b) Whether the R-ITS-Ss used to disseminate the warning messages are part of the road works equipment or part of the infrastructure in the place where road works take place.

Stand-alone trailers / vehicles can obviously only distribute information that is derived from their own configuration – e.g. from the switches panel used to set the variable message sign (VMS) – plus the information obtained from a global navigation satellite system (GNSS) unit (time, position/direction, speed). If a link to the centre exists, the information from multiple trailers / vehicles can be combined and augmented by information from the traffic centre's database, in particular from a dedicated road works management system.

**Scenario 1: Stand-alone safety trailer**

This scenario is used for moving roadwork or as fall-back(!) for stationary short-term roadwork if an attempt of the R-ITS-S to connect to the C-ITS-S fails. In this scenario only minimal data (no geospatial extent, no speed limit, no lane info) is possible, generated from local trailer data. The scenario works everywhere (even in cellular black spots as fall-back scenario) and of course it generates no communication costs. The scenario allows for "automatic" operation (no extra handling/equipment on-site).

It must be noted that the stand-alone scenario (Figure 1) is very limited in the depth of information it can provide. Only information which is available from the safety trailer / vehicle can be provided. In this case only general RW-information like content of the VMS on the backside of the trailer, the position of the trailer and information about the approach to the trailer ("traces" recorded/collected by the trailer itself) can be distributed.

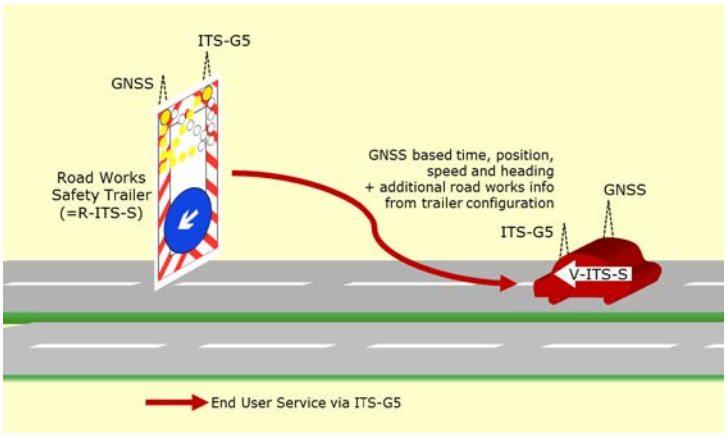


*Figure 1: Standalone trailer scenario*

Complex road works scenarios usually comprise multiple trailers / signs, and only the combination of the information of these trailers yields the details needed for a comprehensive service. Scenario 1 is thus not preferred and only valid for some very specific simple types of road works (e.g. slow moving green cutting on the hard shoulder), or as a fall-back solution in case that communication to the centre is not possible (e.g. due to 2G/3G black spots). It can nevertheless convey a minimum set of information required to issue at least a general hazard warning to the drivers.

Such trailers are currently only used for short term road works in Austria, and they are also by default not equipped with 2G/3G and GNSS. A similar approach is currently starting to be deployed based on spoken messages sent out via CB radio. Although the discussion of the different scenarios indicated that trailers equipped with 2G/3G and GNSS may provide operational benefit to the road operators that ASFINAG might also be interested in in the future, it is not clear whether and when such trailers would be available in Austria and therefore for ECo-AT it is optional to rely on safety trailer based deployment.

**Scenario 2: Safety trailer augmented**

This scenario is applicable for short term stationary RW. The scenario includes switching from initial autonomous mode to augmented mode as well as further switching between both modes, whenever the connection to the C-ITS-S is lost or recovered. The scenario requires both, C-ITS-S connection as well as equipped trailer(s), but it provides best data quality, fusing all possible types of input.

The combination of the individual trailers' GNSS and configuration information is done in the C-ITS-S based on information received from TCC (e.g. lookup in a database of typical road works layouts), but this requires the communication link between trailer and centre as in Figure 2.

The scenario in Figure 2 assumes that any equipment required to reach a suitable reliability level of the information is also deployed as standardised infrastructure. This will also require a communication channel from this equipment towards the road works management system in the traffic centre, e.g. via 2G/3G cellular radio.

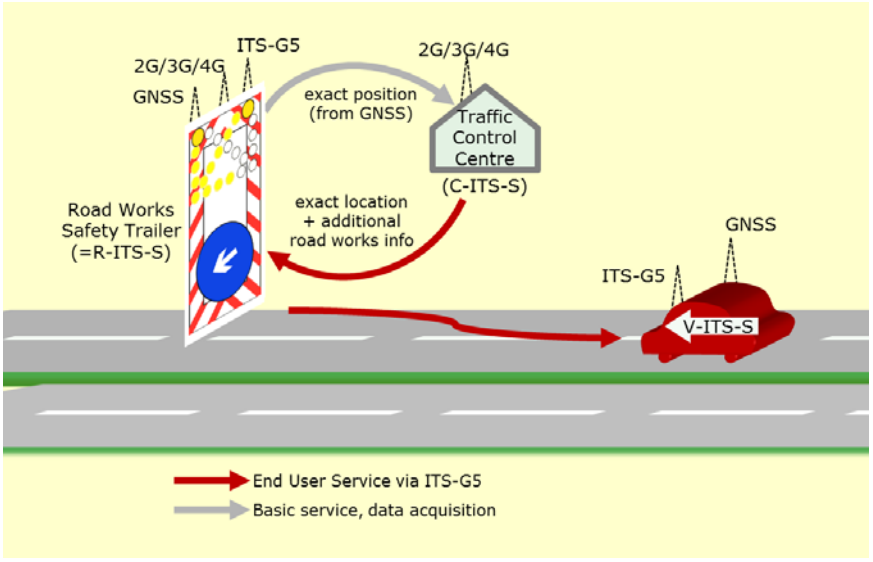


*Figure 2: Safety Trailer augmented approach of safety trailer and C-ITS-S scenario with mobile R-ITS-S*

**Scenario 3: TCC triggered (C-ITS based)**

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

The following diagram (Figure 3) depicts this third RWW-Scenario without the involvement of any mobile trailers. The road works themselves have conventional, temporary static signs here but using safety trailers is of course also possible in this scenario. Information about the exact location and further relevant parameters for the road works are collected from the centre side road works management system. How this exact location information is ensured in the centre system, e.g. whether roadside positioning equipment is integrated in this process, is still to be specified.

Scenario 3 can be used for short term stationary as well as for long term roadworks.

It is assumed that equipment required to reach a suitable reliability level of the information is deployed as standardised infrastructure. This will also require a communication channel from this equipment towards the road works management system in the traffic centre, e.g. via 2G/3G cellular radio. The scenario is thus functionally fully equivalent to the scenario 2 of the trailer-based scenarios if R-ITS-S are available at suitable locations.

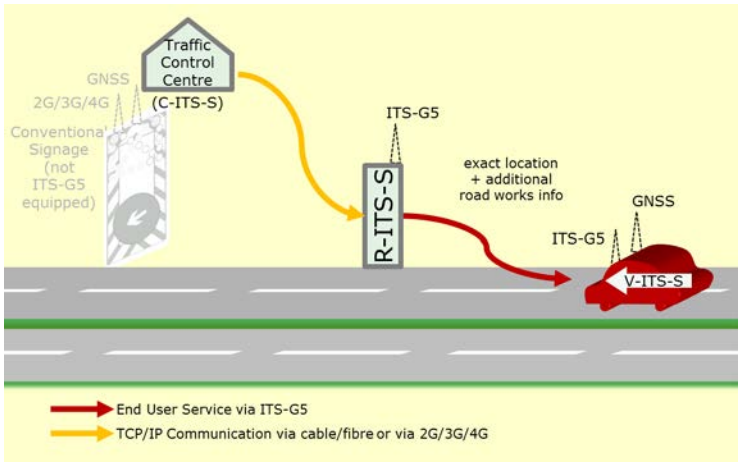


*Figure 3: TCC triggered (C-ITS-S based) scenario with fixed or mobile infrastructure*

Despite the differences in the three scenarios this implies that from the perspective of a functional description, the last two scenarios are equivalent and the interoperability interface between the R-ITS-S and the V-ITS-S – especially the message definition and triggering conditions – are not affected by the road operator's choice to prefer one or the other. Note that this is different to the stand-alone trailer scenario that is functionally limited.

For the purpose of this use case description, all centre side functionality is assigned to the C-ITS-S. It is already clear that in the later specification steps in ECo-AT this will be further refined as the centre side functionality will be split into functions that are specific to the C-ITS domain (e.g. mapping content to data elements and structures from the C-ITS Common Data Dictionary or the selection of suitable R-ITS-S for dissemination) and those that are generic for all content provision from ASFINAG to ITS service providers. The latter functionality will be allocated to the existing VISP / DDS, ASFINAG's central traffic data hub system, which is currently functionally extended. The former functionality will be fully specified in the ECo-AT system specification and will become part of the ECo-AT phase one final deliverable.

For all scenarios with the involvement of VISP / DDS, ASFINAG will develop an action plan to ensure the required quality of the following road works parameters in their road works management system, based on standardised infrastructure:

- TRIGGER to active/deactivate the RWW
- Road works start time and end time
- Type of RWW/event
- Road works exact start and end position (these points will also need to be supported by traces), also with due update cycles in case of moving road works

- Road works lane layout, i.e. closed / available lanes and use of hard shoulder, segmented if the values change inside the road works' area
- Speed limits including their exact start and end locations

[AG RWW] provides the following functional description of this scenario from different stakeholders' perspective:

***User's Perspective***

*When passing a Roadside ITS Station (R-ITS-S,) the vehicle receives relevant current road works information. The vehicle HMI informs the driver when approaching road works. The recommended route may be adapted based on the received information.*

***Road Operator's Perspective***

*The road operator collects all road works information in the traffic control centre. All road works information is provided to the Roadside ITS Stations, filtered according to geographic relevance for passing vehicles.*

*The Roadside ITS Stations transmits the road works information. The messages selected for transmission by a particular R-ITS-S are repeatedly transmitted in order to ensure that all passing vehicles have a sufficiently high probability of receiving all messages.*

*In case of updates on the road works information, the traffic control centre distributes an updated version of the network wide road works information to all R-ITS-S affected.*

The R-ITS-S itself is either already available at a suitable location or can be deployed in such a spot on demand with short notice and acceptable effort (e.g. due to standardised access to power supply and communication media, etc. or because it is mounted on a vehicle/trailer that is put at a suitable location) – we call this concept "standardised infrastructure". The concept implies appropriate organisational and/or contractual (with contractors on site) efforts that ensure not only the correctness of the data in the traffic centre, but also the proper deployment and/or configuration of suitable R-ITS-S. The advantage of this scheme is that with the appropriate technical, organisational and contractual framework in place, a rich set of information can be sent into the vehicles, including detailed information of the oncoming set of road works but also potentially including further downstream information, e.g. regarding further segments subject to road works up to the next motorway intersection.

The trailer-based scenarios have advantages where the trailer as a physical, mobile platform is needed and useful to actually deploy the R-ITS-S. In the Austrian situation, these requirements in the long run may be better met by additional requirements and potentially improved procedures regarding road works management and by using the standardised infrastructure along the ASFINAG roads, where available. In essence, the scenario with trailers connected to a centre and the scenario with standardised infrastructure are equivalent

for stationary roadworks, just that they use different infrastructure mechanisms to deploy the R-ITS-S and that they use different means to generate and ensure the quality of the parameters provided for the road works.

It is important to note that passing vehicles will not be able to determine whether the information provided to them is conveyed via safety trailers / road works vehicles or via standardised infrastructure[2]. This is a design decision of the road operator that is entirely transparent to the in-vehicle application, as long as the geographic requirements (awareness area, relevance area) are met.

### 3.2 Use of Road Works Warning / Information by other services

[AG RWW] provides a fourth scenario described as follows:

*The Road Works Warning / Information might serve as input for other Cooperative ITS services. Examples might be the road works information leading to a change in the recommended itinerary. The recommended itinerary service takes the Road Works Warning / Information as input and considers it when calculating the recommended itinerary.*

*For more details see specification of Recommended Itinerary Service. (TBD)*

The interpretation of this scenario in ECo-AT is that all road works information is based on the same source of information, i.e. the road works management system in the ASFINAG traffic centre, which will be distributed via VISP / DDS. This information is fed into multiple channels for end user information, including Websites, spoken radio, TMC, etc. The RWW service is a new element in this portfolio, which will have to ensure consistent information with the other elements. This aspect – especially the consistence and complementary design of services based on ITS-G5 local area and 2G/3G/4G cellular communications – will be elaborated in detail in SWP 3.6.

[2] This statement refers to functional equivalence. The different type of stations may still be distinguishable due to markup data, e.g. dedicated attributes indicating the type of R-ITS-S in a ITS G5 message

# 4 Data and message content

In order to specify the possible content of messages sent out to the ITS G5 radio channel, a structured analysis of road works parameters has been carried out by analysing the relevant Austrian guideline RVS 05.05.42 [RVS] and mapping the content derived from the specified road works layout to data elements and data frames from the DENM message set [ETSI 302 637-3]. The mapping was visualised in form of schematic diagrams.

## 4.1 Basic mapping – connected scenario

During the work it became apparent that indeed most possible layouts could be mapped by a basic message structure that only had slight deviations for the different road works layouts. This basic mapping is depicted in the following diagram.

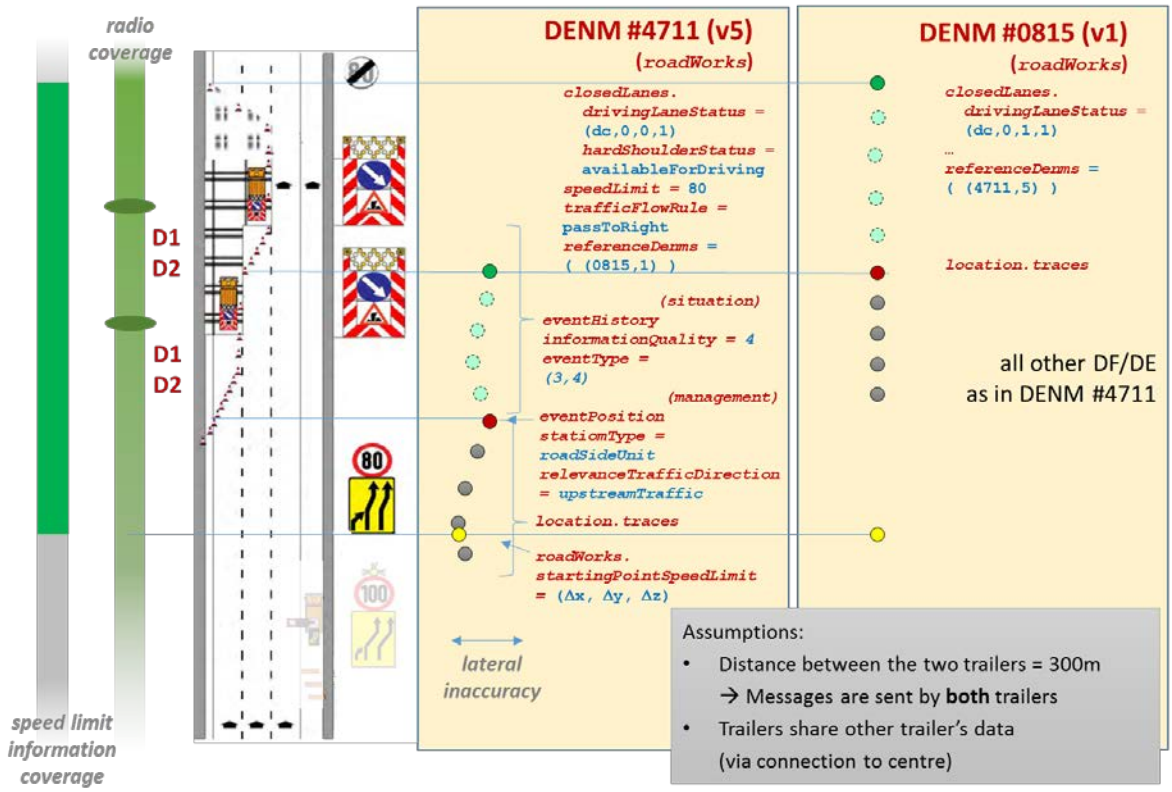


*Figure 4: KIII/2.4 road works layout mapped to DENM*

As the "radio coverage" bar on the left indicates, both trailers send the same messages. This redundant message transmission improves reliability. The messages to be sent out by both trailers have to come from the centre anyway, based on RMS data and upstream communication from both safety trailers.

Note the first bit of *drivingLaneStatus* which is a don't care bit. The value of this bit is meaningless. There is currently a change request at ETSI to re-specify the definition of the indexing in *drivingLaneStatus.*

Note the cross-reference in the *referenceDenms* data element. This cross-reference uses the *actionID* element of DENM. Since this value is produced in the facilities layer of an ITS station, the message content has to be produced in the C-ITS-S and then transferred to the R-ITS-S. The actual transmission via the ITS G5 channel is then handled by the R-ITS-S as a single hop broadcast transmission of the message.

Traces may come either from the trailer's GNSS box or the centre, but both event positions as well as the end point of DENM #0815 and the starting point of the speed limit must be either determined by dedicated equipment (e.g. signs and special traffic cones equipped with GNSS and 3G mobile radio), measured manually on site (e.g. with hand-held equipment) or calculated in the centre from a GIS database. The value of *positionConfidenceEllipse*[3] in the latter case is set to "unavailable(4095)" for data elements *semiMajorConfidence* and *semiMinorConfidence* and to "unknown(3600)" for *semiMajorOrientation*. Note that the example shown has *informationQuality* set to "4", which indicates a validated position for *eventPosition* and *traces*. Depending on the exact conditions, other values are also possible.

Note that only the last speed limit prior to the road works zone is transferred in this mapping (more details will be conveyed by IVS – depending on the deployment progress of IVS it needs to be decided when this information should be deprecated).

It should be noted that the complete geospatial extent of the road work can be provided in the DENM via *eventHistory*, but this information is only available if confirmed with on-site equipment. If that is not the case, *eventHistory* will not be present in the message. *eventHistory* in ECo-AT is a full history of the event (using equidistant points) from the *eventPosition* to the end of event. Default point distance is 50m but can increase if events are longer than 1150m due to the restriction of 23 points in the *eventHistory.* The geospatial semantics of ITS G5 messages are based on indicating relevant points plus traces (= sequences of points) that allow approaching ITS-Ss to determine the relevance of the information for their path. Hence, the *traces* vector is used here to code traces approaching the *eventPosition* of the road work section.

### 4.2 Amendments for other layouts

Release 3.6 has been specified to cover the layouts for

- Short term road works (K-type layouts from RVS 05.05.42)
- Moving road works (A-type layout layouts from RVS 05.05.42)
- Stationary road works (D, E and U-type layouts from RVS 05.05.42)
  Stationary road works will be addressed by using the same mapping as for K-type layouts, only addressing the initial entry point into the road work area. See chapter 4.3.

A fourth type of road works specified in RVS are Ad-hoc road works. Ad-hoc road works are in RVS specified by S-type layouts (SII/1 & SII/2). They can be coded exactly like the stand-alone example, except that because

[3] Horizontal position accuracy in a shape of ellipse with a predefined confidence level (e.g. 95 %), expressed as the length of two semi-axes and a heading value (see [ETSI 102 894-2])

of the missing traffic cones, the *eventPosition* can directly be taken from the trailer's GNSS box. Securing road works according to ad-hoc road works layouts is typically replaced immediately by full protection according to short-term layouts (K-types).

### 4.2.1 Amendments for other K-type layouts

- RVS 05.05.42
  - **KIII/2.3** – two outer lanes closed/pre-warning vehicle
    - `drivingLaneStatus` = `(dc,1,0,0)` resp. `(dc,1,1,0)`
    - `hardShoulderStatus` = `closed`
    - `trafficFlowRule` = `passToLeft`
  - **KIII/2.2** – inner lane closed/pre-warning vehicle
    - Only one DENM
    - `drivingLaneStatus` = `(dc,0,0,1)`
  - **KIII/2.1** - outer lane closed/pre-warning vehicle
    - Only one DENM
    - `drivingLaneStatus` = `(dc,1,0,0)`
    - `hardShoulderStatus` = `closed`
    - `trafficFlowRule` = `passToLeft`
  - **KII/2.1 – KII/2.3**
    same coding except for one lane less: `drivingLaneStatus` = `(dc,1,0)` or `(dc,0,1)`
  - **KII/1.1** same coding except for all lanes available
  - **KII/3.1 – KII/3.3 & KIII/3.1 & KIII/3.2** same coding (only difference: fixed sign pre-warner)
  - **SII/1 & SII/2** – immediate action
    equivalent to fall-back KII/2.1 & KII/2.2 without pre-warner

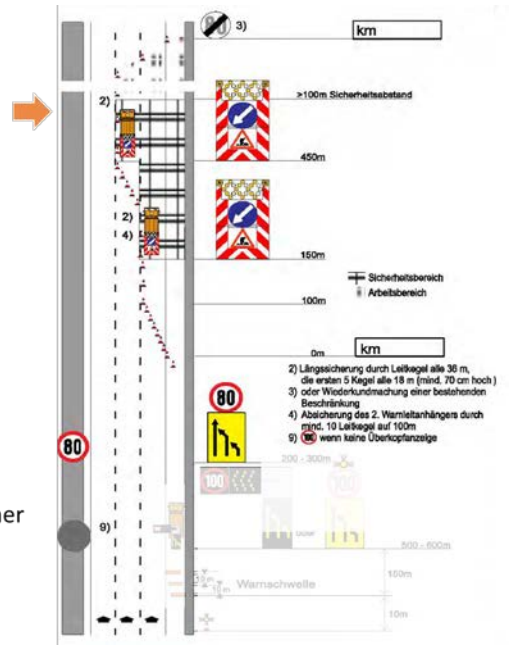


*Figure 5: Mapping other K-type layouts*

As Figure 5 depicts, the other K-type road works layouts can be mapped with a similar data structure, with the minor differences listed in the figure.

The only really problematic case for short term fixed road works seems to be the **KII/3.4** layout, where the whole carriageway is closed and vehicles are forced to leave the motorway at the next exit. We could use in principle the same coding as before, just that a third DENM with event position at the point of the full closure (eventPosition and traces have to come from the centre database) indicates all lanes closed and hard shoulder closed. Nevertheless, this coding would NOT explicitly convey that the traffic is forced to leave at the respective exit – the applications would have to deduce that themselves from the fact, that all lanes plus the hard shoulder are closed.

- RVS 05.05.42
  - KII/3.4
    - *drivingLaneStatus* = (dc,1,1)
    - *hardShoulderStatus* = closed
  - We could use in principle the same coding as before, just that a third DENM with event position at the point of the full closure (*eventPosition* and traces have to come from the centre database) indicates all lanes closed and hard shoulder is closed as well.
  - This coding would NOT explicitly convey that the traffic is forced to leave at the respective exit – the applications would have to deduce that themselves from the fact that all lanes plus the hard shoulder are closed.

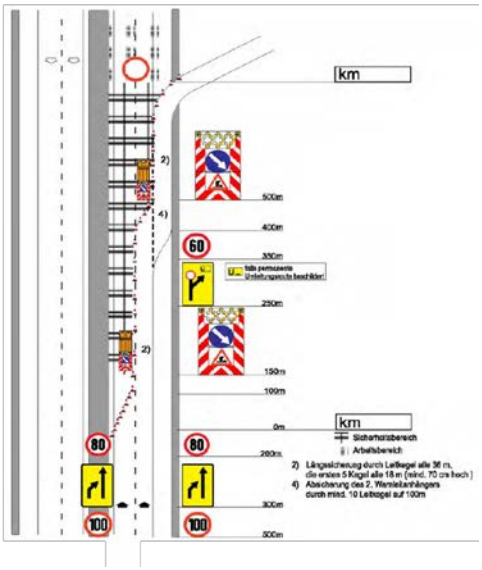


*Figure 6: KII/3.4 mapping with full closure of a carriageway*

### 4.2.2 Equipped Pre-warner

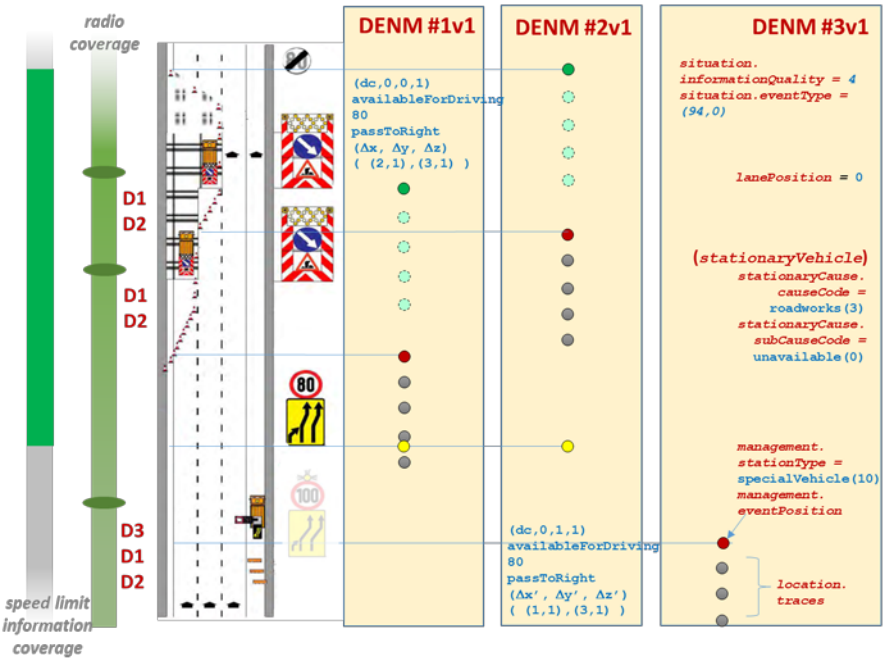


*Figure 7: Equipped Pre-warner*

Figure 7 shows a richer road works data set that could be produced if a pre-warning vehicle is also equipped with GNSS, 3G and ITS G5. The combined use of *alacarte* elements *lanePosition* and *stationaryVehicle* containers would allow to warn drivers about the safety risk generated by the pre-warning vehicle itself. The

pre-warner with an R-ITS-S could further send out all three DENMs ensuring that information can be received earlier by the approaching vehicles.

### 4.2.3 Stand-alone mode

If the trailers cannot connect to the centre, the fusion of trailer data and the augmentation of messages is not possible. Each trailer can only produce a simplified message based on its own ego data, which is the last positions from the GNSS and the position of the arrow.

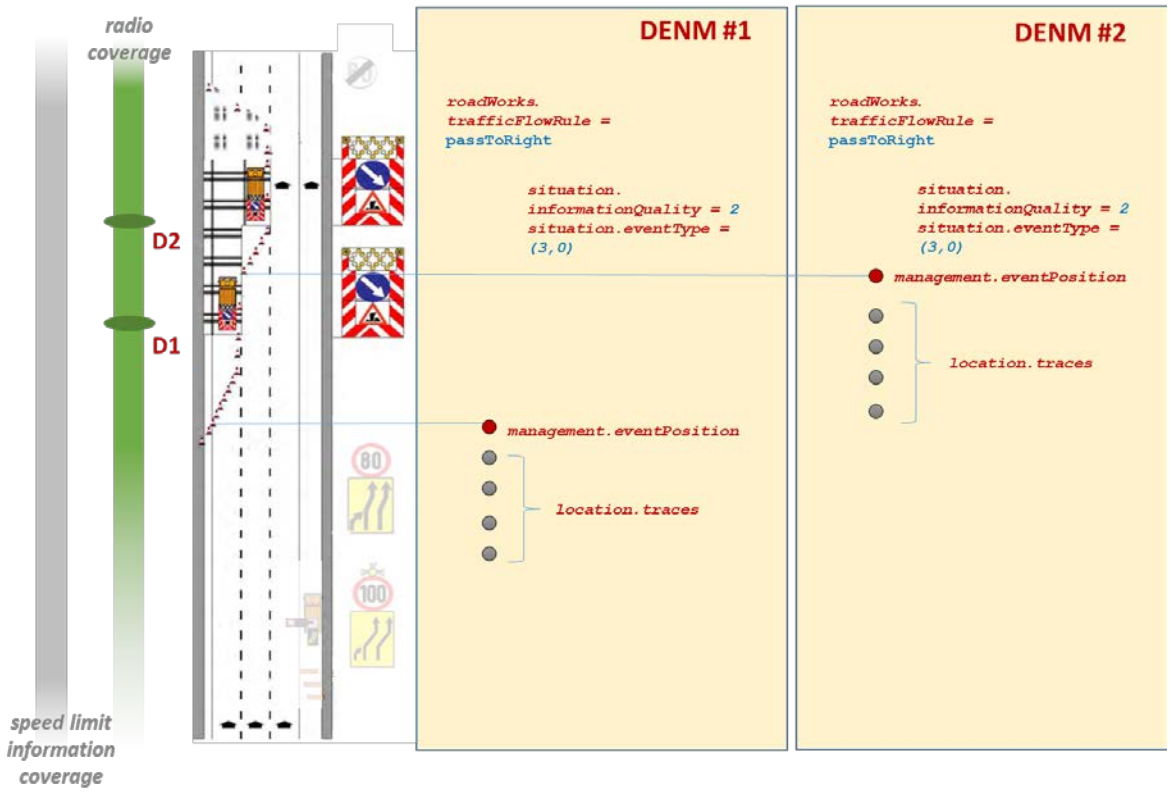


*Figure 8: KIII/2.4 in stand-alone mode*

Each R-ITS-S can only transmit ego information. It is not clear yet how accurately the actual event position can be derived locally from the trailer's GNSS position data, since this position is determined by a traffic cone rather than the trailer position. Fixed offsets (150m) cannot be used, since local conditions can lead to significant deviations from this rule. There is no information on longitudinal extent in this scenario.

The arrow position can be conveyed by the *passingRule* attribute. The ego data does not contain any information about speed limits. The IVS information of the arrow sign is to be replaced by proper IVS messages as soon as possible.

Each trailer sends its own DENM (different action IDs, no common reference).

If the pre-warner is also equipped, the pre-warner shall create a stationary vehicle warning as depicted in Figure 9.

Note that the indication of messages sent out only refers to the station as *originator ITS station* of a message. Messages received from other stations (e.g. D1 and D2 received by the pre-warner) can still be forwarded using geo networking.

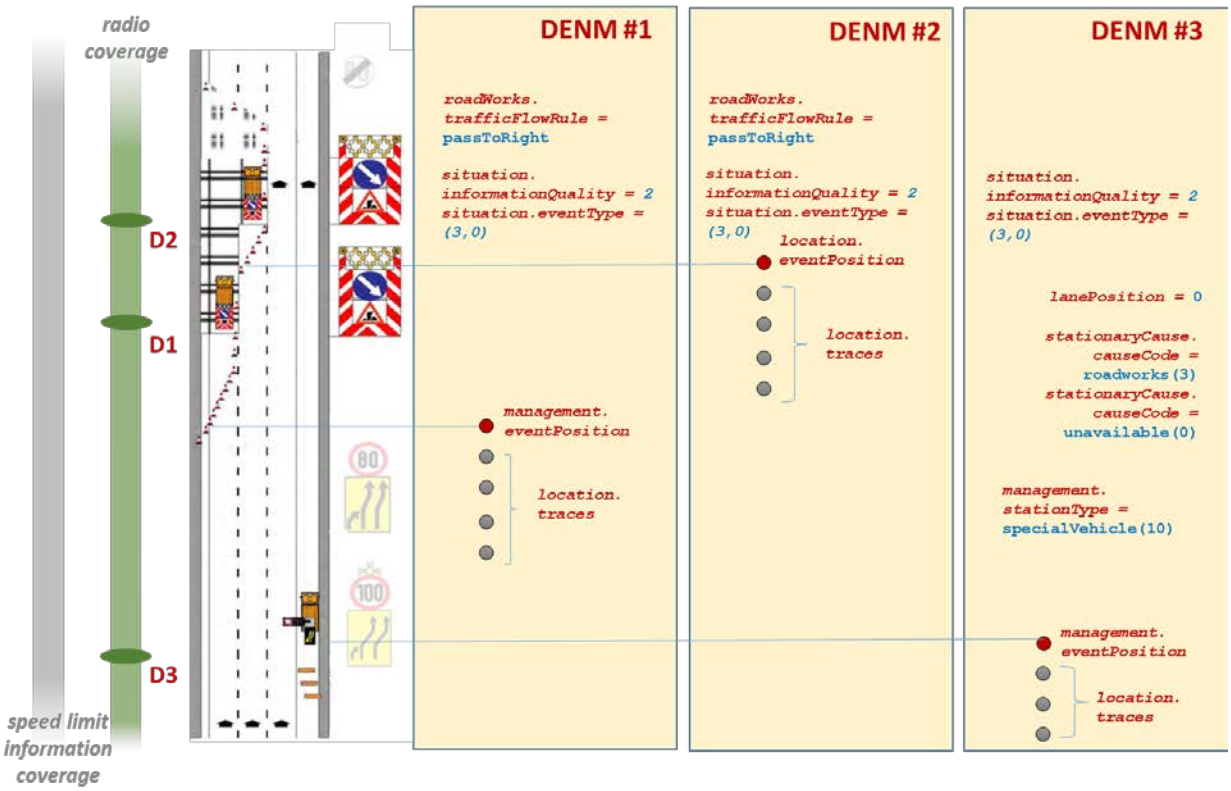


*Figure 9: Stand-alone mode with equipped pre-warner*

### 4.2.4 Moving road works

The road works layouts for moving road works are similar to those for stationary road works in stand-alone mode; just that due to the moving nature there are no cones ahead of the safety trailers. This means that basically the content mapping is

AII/2.1 ≈ KII/2.1
AII/2.2 ≈ KII/2.2
AIII/2.1 ≈ KIII/2.4

With five notable deviations:

a) The *eventPosition* is now the position of the safety trailer itself

b) All position dependent data element values change over time; this implies that the corresponding DENMs are frequently updated. Details about update strategy and frequency will be specified in downstream documents of subsequent work packages in ECo-AT.

c) There will be no information about the spatial extent (*eventHistory*).

d) *eventSpeed* and *eventPositionHeading* may be available

The value for *informationQuality* will in these cases always be “2” (simple GNSS).

No *startingPointSpeedLimit* value can be provided.

#### 4.2.5 Stationary R-ITS-S [4]

The current mapping is not dependent on bundling the dissemination (R-ITS-S as transmitter) with the required infrastructure to generate the message, as long as the C-ITS-S is in contact with the R-ITS-S and the R-ITS-S’ location is known. In case of road segments covered with fixed R-ITS-S, these can be used to transmit the DENM messages. Exact specification for required conditions and further details will be added in downstream documents of subsequent work packages in ECo-AT.

The Scenario TCC triggered with stationary R-ITS-S is used to publish long-term roadworks information (see next chapter).

### 4.3 Long-Term roadworks

Long-Term roadworks are operated according to scenario 3 “TCC triggered”, but without the use of Road Works Safety trailers. Thus, long term roadworks do not provide a mobile R-ITS-S and no global navigation satellite system (GNSS) information in the “native” way short term road works can do. To support R-ITS data transfer, other elements of (stationary) infrastructure have to take the role of R-ITS-stations.

[4] Sub-scenario of “TCC triggered”, see scenario 3 (chapter 3)

The following diagram depicts the long term RWW scenario. The road works themselves have conventional signs via temporary static signs. Information about the location and further relevant parameters for the road works are received from the centre side (either TCC or road work management centre).

To ensure exact information in the TCC, time and location information should be validated using on-site positioning equipment (see figure below).

It is assumed that equipment required to reach a suitable reliability level of the information is deployed as standardised infrastructure. This will also require a communication channel from this equipment towards the road works management system in the traffic centre, e.g. via 2G/3G/4G or (in future) 5G cellular radio.

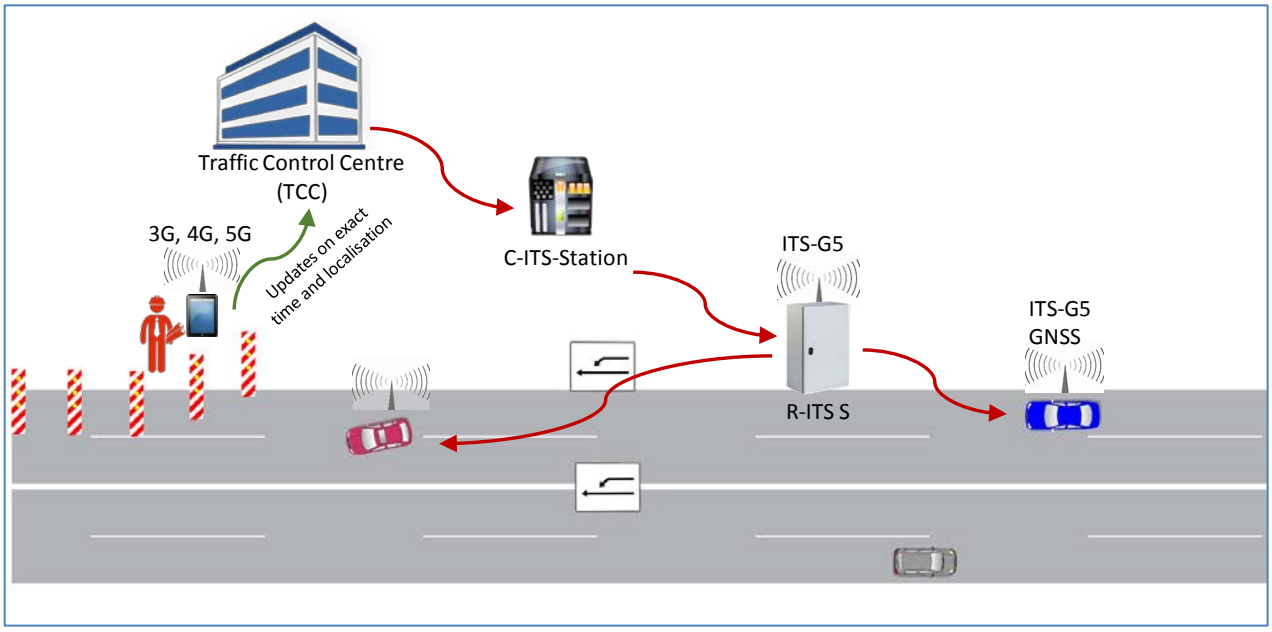


*Figure 10: Long-term roadworks*

Long-term road work warning is different from short-term road work scenarios in a sense that there is no trailer or pre-warner on the road. Thus, only one single DENM with essential information is broadcasted. Through this information, drivers will be warned of the general risk of a long road work section regardless of the complexity of road works' layout, which means in principal mainly information about the location of the entry to road work and basic parameters valid at this entry point. Mapping of one E-type layout (EIII/8) from RVS 05.05.42 is depicted in the following diagram for the sake of illustration.

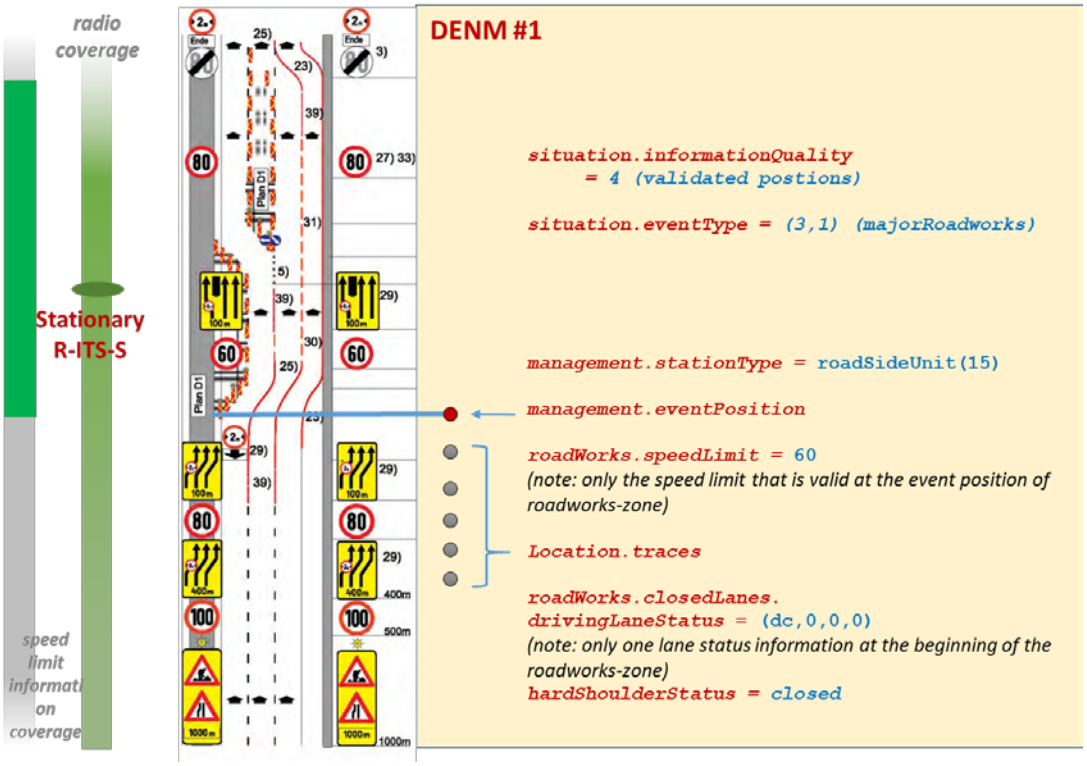


*Figure 11: Mapping of long-term road works (EIII/8)*

As the “radio coverage” bar on the left indicates, the stationary R-ITS-S broadcasts one DENM message that must have been transferred by the C-ITS-S to the stationary R-ITS-S. This means that the master will be explicitly the C-ITS-S and it requires a permanent communication with the R-ITS-S. This connection must be ensured during the life time of the road works, as there is no stand-alone fall back mode for long-term roadworks.

As shown in the diagram, there will be a single DENM #1 that warns upcoming traffic of long-term road works at its starting point. This implies that the road works are not segmented (for example different lane deviations or other changes within the roadworks layout).

For reason of simplicity, only the *eventPosition* is given as the starting point of the road works (i.e. there is no *EventHistory* and hence no *releasePoint*). The starting point for the speed limit can optionally be specified separately (if omitted, the *eventPosition* is considered to be the reference point for the speed limit). The speed limit is specified as the speed limit at the *eventPostion*.

Traces are generated by TCC, but the *eventPosition* must be validated on site. Note that the example shown has *informationQuality* set to “4”, which indicates a validated position for *eventPosition* and *traces*. Depending on the exact conditions, other values are also possible.

It should be noted that the complete geospatial extent of the road work – or the segments that constitute the road work in case that attributes change like in the case depicted above – is not provided in the DENM.

# 5 Operational specifications (including trigger conditions)

For ECo-AT, we propose the following system setup:

1. The Central ITS station (C-ITS-S) conveys the RWW messages to a roadside R-ITS-S via IP-based communication. Standard IP technologies (including security) are used on this link.

2. In case of fixed R-ITS-S, the R-ITS-Ss used for sending are selected by the C-ITS-S according to the geographical position of the R-ITS-S as the best match for the area covered by ***eventPosition*** and ***traces*** (i.e. dissemination area)***.***

3. The management of DENM transmission by the roadside controller can be switched to an augmented mode by the C-ITS-S if the R-ITS-S is connected to the centre. The R-ITS-S will then stop to send their own information created for stand-alone operation and transmit the messages provided by the C-ITS-S.

4. The R-ITS-S uses the relevant components of the ETSI ITS station architecture to transmit the corresponding, currently active RWW messages with the frequency and priority values that will be specified in downstream documents of subsequent work packages in ECo-AT.

R-ITS-S which are deployed on vehicles / trailers and that are connected to the traffic centre use the IP based link to the centre to announce their availability and current status (including position/direction/speed and information that can be derived from local configuration information, e.g. the VMS, lamp and sign settings of a safety trailer). If an R-ITS-S connects successfully to the centre, the centre may become the master for this R-ITS-S' transmission of RWW messages. The R-ITS-S will in this mode not transmit DENMs generated autonomously, but receive DENMs to be transmitted from the traffic centre.

The DENMs sent to an R-ITS-S from the traffic centre may contain information from other vehicles / trailers, from other pieces of equipped infrastructure, from the traffic centre's GIS database or from the Road Works Management System (augmented information).

R-ITS-Ss which are deployed on vehicles / trailers and that are (temporary) not connected to the traffic centre will work in a stand-alone mode with a limited set of information, which will be derived from the vehicle / trailer trajectory (to calculate traces), the current position/direction/speed values of the vehicle / trailer and the information that can be derived from local configuration information (e.g. the VMS, lamp and sign settings of a safety trailer). The transmission of DENM will in this scenario be based on a manual trigger, e.g. when the VMS function of the trailer is switched on.

R-ITS-Ss that operate in augmented mode constantly monitor the communication link to the centre. Should a link failure be detected, the R-ITS-S will switch immediately to stand-alone mode and will keep operating in this mode as long as no link to the centre can be established.

The ECo-AT will not use the *termination* data element in the *ManagementContainer*, i.e. when a roadwork has reached its end, the originating ITS stations will simply stop sending the DENM. The DENM still may exist and seen as valid in receiving ITS stations that have received the DENM prior to this moment until the end of the

DENM validity (*detectionTime* + *validityDuration*) is reached. Therefore, appropriate values are chosen for *validityDuration* later in this document, depending on the volatility for the information in the respective scenario. When the time to the end of validity has reached half of the *validityDuration*, the DENM will be updated with an appropriately increased *detectionTime*.

Note that this approach addresses a DENM update and is different from the repetition of DENMs.

More exact triggering conditions that govern the start and stop of DENM transmission in all possible scenarios – based on the specifications from the Amsterdam Group – will be specified in more detail in downstream documents of subsequent work packages in ECo-AT.

# 6 Annex A: Description of Data Elements

Decentralized Environmental Notification Messages (DENMs) are mainly used by the Cooperative Road Hazard Warning (RHW) application in order to alert road users of the detected events. The RHW application is an event-based application composed of multiple use cases, one of them being Roadworks Warning (RWW) as used in ECo-AT. The general processing procedure of a RHW use case like RWW is as follows:

- Upon detection of an event, the ITS station immediately broadcasts a DENM to other ITS stations located inside a geographical area and which are concerned by the event.
- The transmission of a DENM is repeated with a certain frequency.
- This DENM broadcasting persists as long as the event is present.
- The termination of the DENM broadcasting is either automatically achieved once the event disappears after a predefined expiry time, or by an ITS station that generates a special DENM to inform that the event has disappeared.
- ITS stations, which receive the DENMs, process the information and decide to present appropriate warnings or information to users, as long as the information in the DENM is relevant for the ITS station.

Scenarios considered:

- **Scenario 1 (SC1): : TCC originated RWWs**
- **Scenario 2 (SC2): standalone trailer without TCC connection (warning trailer / pre-warning vehicle)**
  (mind: safety trailer and pre-warner are not distinguished and just referred to as “trailer”).

## 6.1 Management Container

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *actionID* | Management | M | **SC1:**<br>C-ITS-S on behalf of TCC<br><br>**SC2:**<br>R-ITS-S | **Def**: station that implements the DEN message;<br>Station ID + sequence number = action ID;<br>Each ITS station needs a unique station ID<br><br>C-ITS-S creates the *actionID* based on its own stationID (as originating station) and a sequence number based on the DATEX II identification of the event from the TCC.<br><br>When C-ITS-S creates an *actionID* as originator, update and cancellation with a single source as well as identification of the same content is much easier. | [ETSI 302 637-3] |

| | | | | | |
|---|---|---|---|---|---|
| *detectionTime* | Management | M | **SC1**: C-ITS-S<br><br>**SC2**: R-ITS-S | **Scenario1: TCC originated RWKs**<br>Def: According ETSI EN 302 637-3, this is when the information was “detected”.<br><br>**SC1:**<br>*detectionTime* shall be set based on C-ITS-S system time when it receives the event information from the TCC. Will be updated using the DENM update mechanism whenever the event changes according to the TCC or after half of *validityDuration* has passed if the event duration indicated by the TCC is longer than the maximum value for validityDuration for this use case (720s).<br>**SC2:**<br>*detectionTime* shall come from local time source of R-ITS-S. It shall be set upon the system activation. Trailer is acting as a trigger.<br><br>**Note:** *detectionTime* must be updated every time the DENM content is updated by the application | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *referenceTime* | Management | M | **SC1:**<br>C-ITS-S<br>**SC2:**<br>R-ITS-S | **Def**: timestamp when message is generated / updated<br><br>**SC1:**<br>*referenceTime* shall be the time the DENM is encoded or updated in the C-ITS-S. Will be updated in the same manner as *detectionTime*.<br><br>**SC2:**<br>*referenceTime* shall be the time the DENM is encoded in R-ITS-S. | [ETSI 302 637-3] |
| *isNegation* | Management | M | **SC1:**<br>n.a.<br>**SC2:**<br>n.a. | **Def:** indicates that in another (not the originating) ITS-S' "opinion" the information should not be valid any more.<br>**SC1 & SC2:**<br>Not applicable for this use case. Not used. ECo-AT will work with validity durations, indicating the time when the event will end. | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *isCancellation* | Management | M | **SC1:** TCC **SC2:** trailer | **SC1 & SC2:** Not applicable for this use case. Not used. ECo-AT will work with validity durations, indicating the time when the event will end. | [ETSI 302 637-3] |
| *transmissionInterval* | Management | O | **SC1:** Not used for Road Works Warning on Day 1 (for later usage C-ITS-S) **SC2:** Not used for Road Works Warning on Day1 | **SC1 + SC2:** Option not used in SC1 + SC2. | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *eventPosition* | Management | M | **SC1:**<br>TCC<br><br>**SC2:**<br>R-ITS-S or trailer | **SC1:**<br>We assume: TCC will deliver WGS84 Lat/Long information, which can directly be used on the information processing chain downwards. TCC will however not deliver altitude information, as there is no data source of sufficient quality. In case of TCC triggered RWW, this information must be validated by on-site personal using mobile handhelds (2G/3G/4G/5G) and sent to TCC. In case of augmented information, it may come from uplink information from safety trailers.<br><br>**SC2:**<br>Vendor specific; requires a position source (see also below element “traces”) | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *relevanceDistance* | Management | O | **SC1:**<br>TCC<br><br>**SC2:**<br>R-ITS-S | **Def:** enumeration (0-7) indicating in which distance the event information is relevant for the receiver<br>**SC1:**<br>If TCC furnished the *relevanceDistance*, the follow up processing systems forward this information. If TCC does not provide this data, a default value of lessThan5km(5) is used which corresponds to the average length of events provided by the TCC.<br><br>**SC2:**<br>Configurable default value (for RWW standalone trailer).Proposal: lessThan5km(5) | [ETSI 302 637-3] |
| *relevanceTrafficDirection* | Management | O | **SC1:**<br>TCC<br>**SC2:**<br>R-ITS-S | **SC1:**<br>*upstreamTraffic*(1)<br>**SC2:**<br>*upstreamTraffic*(1) | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *validityDuration* | Management | M | **SC1:**<br>C-ITS-S based on TCC<br>**SC2:**<br>R-ITS-S | **Def:** time (seconds since detectionTime) set by the originator ITS-S, at which DENM should be deleted by the DEN basic service of the receiver. If not set defaultValidity=600 [s] is applied<br><br>*validityDuration* is related to *detectionTime* and must be set accordingly!<br>**SC1:**<br>720s is used for TCC triggered and augmented mode (originated by C-ITS-S)<br>**SC2:**<br>20s is used for Moving Roadworks and Stand Alone Mode (originated by R-ITS-S) | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *stationType* | Management | M | **SC1:**<br>C-ITS-S or<br>R-ITS-S<br>**SC2:**<br>R-ITS-S | **Def:** from [ETSI 102 894-2]:<br>StationType ::= INTEGER { unknown(0), pedestrian(1), cyclist(2), moped(3), motorcycle(4), passengerCar(5), bus(6), lightTruck(7), heavyTruck(8), trailer(9), specialVehicles(10), tram(11), roadSideUnit(15) } (0..255)<br>**SC1:**<br>The station composing the DENM (C-ITS-S or R-ITS-S) shall set this to *roadSideUnit*(15)<br>**SC2:**<br>*roadSideUnit*(15)<br>comment: the role the unit acts is such as a road side unit while in fact it is a trailer (9) physically located where it is (and in which vehicles could potentially run into). | [ETSI 302 637-3] |

*Table 3: DEN message data elements - management container*

### 6.2 Situation Container

The Situation Container is an optional container in the DEN message. It is needed for the pre-warner trailer scenario, but also in other cases to provide the *EventHistory.*

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *informationQuality* | Situation | M | **SC1:** TCC<br>**SC2:** R-ITS-S | **Def:** InformationQuality ::= INTEGER { unavailable(0), lowest(1), highest(7) } – Amsterdam Group: Planned by operator (1). Simple GNSS(2), Differential GNSS(3), Validated position(4)<br>The ITS-S, acting as the information originator shall set this attribute related to the positioning information.<br>**SC1:** If the position information has been validated on-site, it is set to Validated position (4), higher values are in principle possible in the future but not foreseen in ECo-AT.<br>**SC2:** If the position information is coming from a simple GNSS, simple GNSS(2), if the information is coming from a differential GNSS, differential GNSS(3). | [ETSI 302 637-3] |

| | | | | | |
|---|---|---|---|---|---|
| *eventType* | Situation | M | **SC1:**<br>TCC<br><br>**SC2:**<br>R-ITS-S | **Def:** [ETSI 102 894-2]:<br>Cause code 3 = Roadworks<br>RoadworksSubCauseCode ::= INTEGER {unavailable(0), majorRoadworks(1), roadMarkingWork(2), slowMovingRoadMaintenance(3), shortTermStationaryRoadworks(4), streetCleaning(5), winterService(6)}<br>(0..255))<br>**SC1:**<br>(C ITS S will have to execute a mapping based on an agreed ASFINAG system specific mapping)<br>**SC2:**<br>*causeCode* 3 = Roadworks<br>*Reasonable values for RoadworksSubCauseCode:*<br>*Unavailable(0)*<br>*slowMovingRoadMaintenance(3)*<br>*shortTermStationaryRoadworks(4)*<br>"0" will be used since trailers cannot distinguish "3" and "4" in standalone<br><br>*causeCode* = 94 (stationary vehicle) for pre-warning trailer | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *linkedCause* | Situation | O | **SC1:**<br>n.a<br>**SC2:**<br>n.a. | **Def:** same as eventType: possibility to provide a further information using Cause/subCause.<br>**SC1:**<br>Not used by RWW<br>**SC2:**<br>Not used by RWW | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *eventHistory* | Situation | O | **SC1:**<br>TCC<br>**SC2:**<br>n.a. | The DF consists of a list of event points which represents the dimension of a plain event in a predefined order. In case that the plain event is detected by a vehicle ITS-S, the DF consists of a list of event detection points along the path that the detecting ITS-S has travelled over some past time and/or distance. Each event point corresponds to a point at which the same event was detected along the path.<br>**SC1:**<br>Provided by the TCC (if the originating event is not a point event only), it describes the history of the event up until the final release point of the road works.<br><br>*EventHistory will not be considered by the LT-RWW scenario.*<br>**SC2:**<br>Not use by RWW | [ETSI 302 637-3] |

*Table 4: DEN message data elements - situation container*

## 6.3 Location Container

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *eventSpeed* | Location | O | **SC1:**<br>n.a.<br>**SC2:**<br>R-ITS-S or trailer | **Def:** moving speed of detected event<br>**SC1:**<br>Moving roadworks remain in stand-alone mode, hence no event speed is used for TCC triggered road works<br>Not applicable to LT-RWW scenario since roadwork is stationary<br>**SC2:**<br>Only applicable to short term moving road works<br>Vendor specific; requires a speed sensor | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *eventPositionHeading* | Location | O | **SC1:**<br>n.a.<br>**SC2:**<br>R-ITS-S or trailer | **Def:** heading direction of the event<br>**SC1:**<br>Moving roadworks remain in stand-alone mode, hence no event heading is used for TCC triggered road works<br>**SC2:**<br>Only applicable to short term moving road works<br>Vendor specific; requires a heading sensor | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *traces* | Location | M | **SC1:**<br>TCC or uplink information from R-ITS-S<br>**SC2:**<br>R-ITS-S or trailer | **Def:** up to 7 *pathHistory traces* composed of geocoordinates<br>**SC1:**<br>Created in the TCC/GIP from known event location information (potentially originating from a trailer) and provided to C-ITS-S. In augmented mode based on uplink information from R-ITS-S.<br><br>**SC2:**<br>Traces are recorded in R-ITS-S or trailer (without any manual interaction); GNSS required; | [ETSI 302 637-3] |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *roadType* | Location | O | | **Def:**<br>[ETSI 102 894-2] RoadType ::= ENUMERATED {<br>urban-NoStructuralSeparationToOppositeLanes(0),<br>urban-WithStructuralSeparationToOppositeLanes(1),<br>nonUrban-NoStructuralSeparationToOppositeLanes(2),<br>nonUrban-WithStructuralSeparationToOppositeLanes(3) }<br>**SC1:**<br>Not used for Road Works Warning.<br>**SC2:**<br>Not used for Road Works Warning. | [ETSI 302 637-3] |

*Table 5: DEN message data elements - location container*

### 6.4 ImpactReduction alacarteContainer

Not used

### 6.5 Roadworks Alacarte Container

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| | Alacarte Container | O | | | |
| *lightBarSirenInUse* | RoadWorks | O | **SC1:** n.a.<br>**SC2:** n.a. | **Def:** Indicate when the lightbar or audible alarm is active<br>**SC1:** Not used for Road Works Warning.<br>**SC2:** Not used for Road Works Warning. | |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *closedLanes* | RoadWorks | O | **SC1:**<br>TCC<br>**SC2:**<br>not available | **Def:** indicate if hard shoulder or driving lanes are closed<br>ClosedLanes ::= SEQUENCE {<br>hardShoulderStatus HardShoulderStatus OPTIONAL,<br>drivingLaneStatus DrivingLaneStatus,... }<br>HardShoulderStatus ::= ENUMERATED { availableForStopping(0), closed(1), availableForDriving(2) }<br>DrivingLaneStatus ::= BIT STRING { outermostLaneClosed(1), secondLaneFromOutsideClosed(2) } (SIZE (1..14)) -- numbering matches LaneNumber numbering<br>**SC1:**<br>Will be included, if TCC provides the information about closed lanes.<br><br>**SC2:**<br>Not used in the standalone trailer case, since not enough information is available at a trailer. | |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *restriction* | RoadWorks | O | n.a. | **Def:** List of ITS-S types to which a certain traffic restriction, e.g. the speed limit, applies.<br>RestrictedTypes ::= SEQUENCE (SIZE(1..3, ...)) OF StationType<br>**SC1:**<br>n.a.<br>**SC2:**<br>n.a. | |
| *speedLimit* | RoadWorks | O | **SC1:**<br>TCC<br>**SC2:**<br>n.a. | **Def:** Speed Limit applied to the roadworks zone<br>SpeedLimit ::= INTEGER { oneKmPerHour(1) } (0..255)<br>**SC1:**<br>TCC provides this information<br>**SC2:**<br>Not available at trailer | |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *incidentIndication* | RoadWorks | O | **SC1:**<br>n.a.<br>**SC2:**<br>n.a. | **Def:** provide additional information of the roadworks zone<br>(another *causeCode* element)<br>**SC1:**<br>n.a.<br>**SC2:**<br>n.a | |
| *recommendedPath* | RoadWorks | O | n.a. | **Def:** a sequence of *referencePosition*<br>**SC1:**<br>n.a.<br>**SC2:**<br>n.a | |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *startingPointSpeedLimit* | RoadWorks | O | **SC1:** TCC **SC2:** n.a. | **Def:** The DF indicates the effective starting position of a speed limit being applied to the roadwork zone. Generally speaking, the speed limit applies a certain distance prior to the roadwork zone starting position. It is described as a delta position with regards to the eventPosition for a DENM. **SC1:** Can/shall be set, if Information is available. **SC2:** n.a. | |
| *trafficFlowRule* | RoadWorks | O | **SC1:** trailer **SC2:** trailer | **Def:** TrafficRule ::= ENUMERATED {noPassing(0), noPassingForTrucks(1), passToRight(2), passToLeft(3), ... } **SC1:** The C-ITS-S shall set that information, if available from uplink information from R-ITS-S **SC2:** *passToRight*(2), *passToLeft*(3) | |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *referenceDenms* | RoadWorks | O | TCC | **Def:** The DF indicates is a sequence of *actionID*s for different DENMs that describe the same event. If it is available it is part of all DENMs describing this event.<br>**SC1:**<br>to be applied according to the RWW UseCase description. TCC provides the entire data set. Not used in LT-RWW scenario with only one basic warning DENM.<br>**SC2:**<br>Not used | |

*Table 6: DEN message data elements - roadworks alacarte container*

### 6.6 StationaryVehicle Alacarte Container

In the RWW use case, the StationaryVehicleContainer can be used for equipped pre-warners to send a warning DENM that informs the drivers about the obstacle (the pre-warner itself is a stationary vehicle) on the hard shoulder. To do so, the following DEs are set in the respective containers:

- situation.eventType = (94,0) [stationaryVehicle, unavailable]
- lanePosition = 0 [hardShoulder]
- management.stationType = 10 [specialVehicles]

In this case, the StationaryVehicleContainer will be used and the following DEs will be set:

- stationaryCause.causeCode = 3 [roadworks]
- stationaryCause.subCauseCode = 0 [unavailable]

### 6.7 DE in Alacarte container

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *lanePosition* | á la carte | O | **SC1**<br><br>trailer or R-ITS-S<br>**SC2**<br><br>trailer or R-ITS-S | **Def:** indicates the transversal position information on the road in resolution of lanes, counted from the outside border of the road for a given traffic direction<br>LanePosition ::= INTEGER {offTheRoad(-1), hardShoulder(0), outermostDrivingLane(1), secondLaneFromOutside(2)} (-1..14)<br>**SC1:**<br>only used if upstream information from R-ITS-S is available in augmented mode<br>**SC2:**<br>Use for optional inclusion of pre-warner; o be set 0 to indicate, that the pre-warner is located on the hard shoulder (default value in Day 1) | |
| *impactReduction* | á la carte | O | C-ITS-S | **Not used** | |
| *externalTemperature* | á la carte | O | C-ITS-S | **Not used** | |

| Data element | DENM Container | | Source | Comment | Ref. |
|---|---|---|---|---|---|
| *roadWorks* | á la carte | M | C-ITS-S | **See 6.5** | |
| *positioningSolution* | á la carte | O | C-ITS-S | **Not used** | |
| *stationaryVehicle* | á la carte | O | C-ITS-S | **See 6.6** | |

*Table 7: DEN message data elements - data elements in alacarte container*

# 7 Annex B: Scenarios for test cases

The use case has been broken down into so called “scenarios” in this document, which relate but differ slightly from the scenarios presented in the Amsterdam Group document in order to reflect the specifics in the Austrian situation. A scenario is s a sequence of events within the C-ITS system that forms a mode of operation for the use case. Each use case contains at least one scenario, but can of course also consist of multiple scenarios, covering different ways of operation possible for the underlying C-ITS system.

With respect to deriving technical requirements and defining test cases, it seems useful to recall – and potentially refine – the scenarios of the “Road Works Warning” use case, with a focus on requirements/testing aspects:

## 7.1 Stand-alone safety trailer

This test scenario is used for moving roadworks or as fall-back (!) for stationary short term roadwork if an attempt of the R-ITS-S to connect to the C-ITS-S fails. In this scenario only minimal data (no geospatial extent, no speed limit, no lane info) is possible, generated from local trailer data. The scenario works everywhere (even in cellular black spots as fall-back scenario) and of course it generates no communication cost for If3. The scenario allows for “automatic” operation (no extra handling/equipment on-site).

## 7.2 TCC triggered

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

## 7.3 Safety trailer augmented

This scenario is applicable for short term stationary road works. The scenario includes switching from initial autonomous mode to augmented mode as well as switching between modes if connection to the C-ITS-S is lost/recovered. The scenario requires both, If3 connection as well as equipped trailer(s), but it provides best data quality, fusing all possible types of input.