SWP 3.1 – Central ITS Station

C-ITS-S Functional Description

WP3 - Functional specifications & development

Version: 03.60

Overview of changes

Table 1: Document History

No.	Version	Status	Date	Type of Change
1	03.00	Released	2015-07-15	Third Release
2	03.10	Released	2015-10-28	Third Release – Update
3	03.50	Released	2016-04-29	Third Release – Second Update
4	03.60	Released	2016-07-29	Third Release – Third Update

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:

Take 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

This document gives an overview about the functions and interfaces of the cooperative central system C-ITS-S of the ECo-AT project. It describes the system architecture and general basic functionality to operate the C-ITS platform. Furthermore it specifies various specific functions in the cooperative context. This document shall clarify and address the following issues

This document is the result of joint discussions between the different ECo-AT partners involved. Nevertheless there are still open issues which are currently under discussion.

Each chapter is headed by a list of requirements from [ECo-AT SWP2.3 system overview]. During the work on this document additional functions of the system have been identified. These functions result in further requirements which are collected in a separate document to be added to [ECo-AT SWP2.3 system overview] in a later version.

The following description of the proposed contents of the SWP 3.1 is taken from the ECo-AT proposal:

*„SWP 3.1 - Traffic control center urban - interurban (**SIE**, ASF, IVR, KTC, SWA)*
SWP 3.1a - Traffic control center – urban (Stadt)
Erstellen der funktionellen Spezifikationen für die innerstädtische Verkehrszentrale (Dateninterface, Operatorinterface, TCC-Applikation) und Bereitstellung des Traffic Control Centers (Hardware und Software). Die Generierung der Informationen ist mit räumlicher Relevanz versorgt und kann durch definierte Strategien aktiviert werden. Zusätzliche externe Datenanbindungen wie zu Modellen für die aktuelle Verkehrslage, ÖV-Informationen oder relevanten Messstationen werden ebenfalls berücksichtigt.
Abstimmung der funktionalen Spezifikation mit den WP2 (Systemdefinition/UseCases) für innerstädtische Anwendung und Abstimmung der Schnittstellen mit Projektpartnern
Entwicklung der zentralen Funktionen auf Grundlage der Spezifikation und Prototypische Umsetzung.
Technische Abstimmung mit den Projektpartnern bezüglich standardisierter Schnittstellen

SWP 3.1b - Traffic control center – interurban (Autobahn)
Erstellen der funktionellen Spezifikationen für die Verkehrszentrale des hochrangigen Streckennetzes (Dateninterface, Operatorinterface, TCC-Applikation) und Bereitstellung des Traffic Control Centers (Hardware und Software). Schnittstellen zu externen Systemen, welche die aktuelle Verkehrslage, die Auslastung von Parkplatz- mit Umsteigemöglichkeiten sowie die relevanten ÖV-Anbindungen beinhalten, sind für die Zentrale ebenfalls notwendig.
Abstimmung der funktionalen Spezifikation mit den WP2 (Systemdefinition/Use Cases) für außerstädtische Anwendung und Abstimmung der Schnittstellen mit Projektpartnern
Entwicklung der zentralen Funktionen des hochrangigen Streckennetzes auf Grundlage der Spezifikation und prototypische Umsetzung.
Technische Abstimmung mit den Projektpartnern bezüglich standardisierter Schnittstellen
Ergebnisse .“

- *Funktionale Spezifikation*
- *Schnittstellenspezifikation*
- *Prototypische Entwicklung der Funktionalität für Traffic Control center urban – interurban „*

Due to the fact, that there is no major difference between the urban and the interurban basic functionality and that most of the special cooperative functionality will be the same, there is no distinction made in between urban and interurban functionality. The chapters specifying special urban features are marked.

1.2 Definitions, Terms and Abbreviations

Table 2: Definitions, Terms and Abbreviations

Abbreviation / Term	Definition
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
DM	Device Management
ISS	Intersection Safety use case
ITS	Intelligent Transport Systems – systems that use information and communication technology to improve transport systems
IVI	In-Vehicle Information
IVS	In-Vehicle Signage
MAP	Message to convey local, detailed network topology in specific areas, as specified in ISO 19091
MIF	Multimodal Information
MMI	Man Machine Interface (= User Interface)
PVD	Probe Vehicle Data
R-ITS-S	Roadside ITS Station
RWW	Road Works Warning
SPAT	Signal Phase & Timing
SWP	Subworkpackage

Abbreviation / Term	Definition
TCC	Traffic Control Center
V-ITS-S	Vehicle ITS Station

2 General Description of SWP3.1

The scope of the subworkpackage SWP3.1 is the definition of the C-ITS-S functionality based on the definition of the SWP2 use cases. This includes the definition of all mandatory interfaces and the minimum system components behaviour for achieving vendor interoperability.

Within the Living Lab the ECo-AT system is embedded in an existing traffic management system and includes the components and interfaces as shown in the following figure.

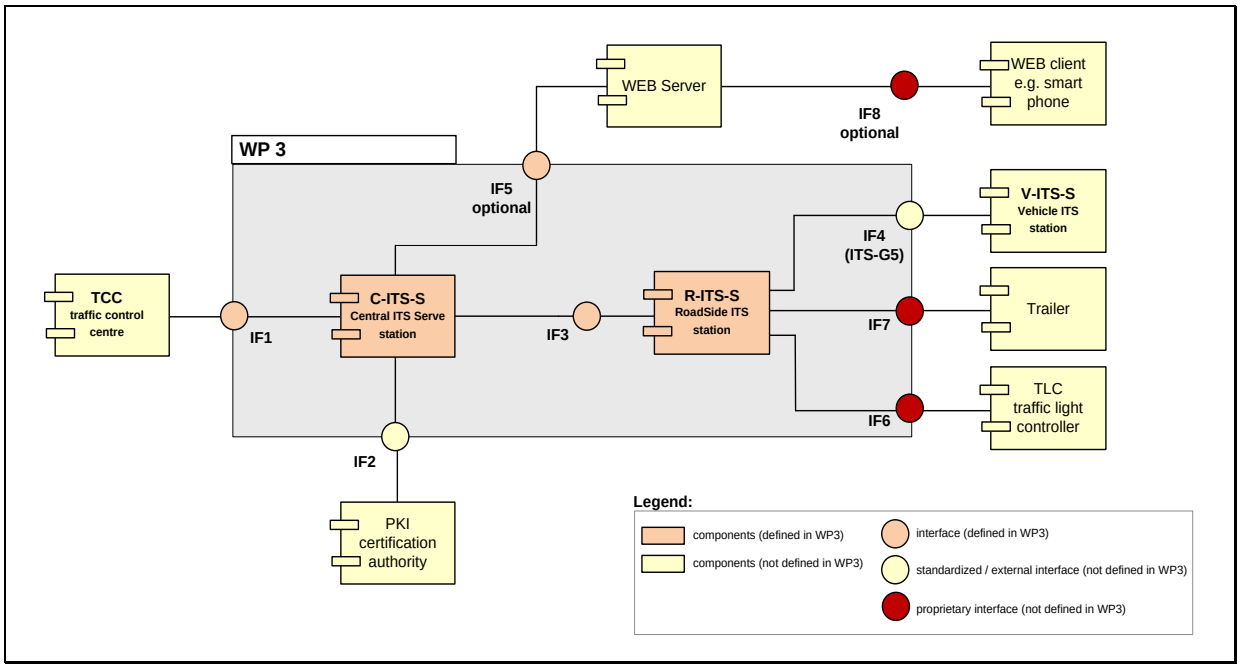

Figure 1 ECo-AT system overview

3 Requirements and normative references

The system behaviour and interface description of the ECo-AT project is based on the system architecture and the use case description from subworkpackage SWP2.

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.

4 Detailed Specification C-ITS-S System Platform

The general concept of the C-ITS-S system is designed in that way, that new modules can be easily connected without changing the general architectural concept of the system. Besides the cooperative functions the C-ITS-S platform provides the basic functions for visualization, map, user management, error handling, archive and further more.

The C-ITS-S server is the central component in the C-ITS system. It is connected to the interurban traffic control centre (TCC), to one or more roadside ITS stations (R-ITS-S) a to a public key infrastructure server (PKI) and to a Web-server for the provision of 3G/4G-messages.

The functionality of the system component PKI (certification authority) is not yet standardized. There is a propriatary PKI-server implementation existing within the the C2C-CC consortium. The usage of the C2C-CC PKI server is reserved for C2C-CC members and needs special agreement if the manufacturer is not member of the the C2C-CC. The C2C-CC pilot PKI will be just used for the Living Lab, not for the final specification.

Within SWP3 the basic functional behavior and interfaces of the C-ITS-S will be described:

- C-ITS-S functional descriptions
- IF1 (C-ITS-S <> TCC) interface
- IF3 (C-ITS-S <> R-ITS-S) interface
- IF5 Web-Server is described in [ECo-AT SWP3.6 convergence]

In SWP 2 the requirements of the C-ITS have been defined. Based on the requirements the C-ITS-S shall implement various functions which are specified in this document. The following table gives an overview on the functionality blocks of the C-ITS.

Table 3: Overview of C-ITS-S functionality blocks

#	Functionality block	Definition, Example
001	Basic System Functionality	e.g. architecture, modules like user interface, graphical representation of map, archive, user management, persistence, Device management / maintenance, firmware download
002	Logging, archive	e.g. Logging of sent and received messages (interfaces: TCC, R-ITS-S)

#	Functionality block	Definition, Example
003	Interfaces	Interfaces to TCC, PKI-Server, R-ITS-S and Web-Server
004	Data Processing	Message processing and management e.g. DENM generation/reception, message generation/reception, location based message preparation, e.g. Processing of traffic information and traffic data (aggregated CAM data), Generation of the IVI message on the basis of TCC-signage etc.
005	Performace, Hardware	Hardware infrastructure and system architecture to ensure a proper function of the system even during peak periods.
006	Security, PKI management	e.g. Retrieval of PKI certificates on behalf of using the interface IF2., R-ITS-S PKI certificates management on behalf of R-ITS-S, internal security
007	Data dissemination	e.g. Selection of the appropriate RSU to send specific message

4.1 Basic System Functionality

This description is based on the following requirements [ECo-AT SWP2.3 system overview]:

R_C_069 C-ITS-S time shall be synchronized to a common time reference which originates from the TCC.

The C-ITS-S system is based on a software platform which serves as the distributor of the data, which provides either cooperative functionality and basic functionality for a proper operation of the system[1]. Several modules containing the specific functionality of the system are connected to that software platform. The data exchange in between the different modules is organized by that software platform. New modules can be added to the system[2].

Besides the specific cooperative functions defined in this document, the software platform provides the general functionality to design, configure and manage the system (user management), to visualize data, objects, errors and alarms and to archive the data. This type of functionality is called basic system functionality.

[1] NReq 1: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

[2] NReq 2: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

4.1.1 Data Model

One basic module of the system platform handles the data model. All modules of the system will have access to the data model to write and retrieve data.

Generally the system is able to add individual data models for use by individual applications connected to the middleware. The data model is accessible by all applications after being started.

Data read and write access functions are available to be used in local applications

A diagnostic tool[1] enables read and write access to the data. It enables service and development a look into data available in the data model. The data can also be modified with the tool. The tool is accessable within the service menue at server side.

4.1.2 User Management

Basis for this chapter are the definitions and requirements specified in [Eco-AT SWP3.4 security]. This document includes references to controls which could be interpreted as requirements for the management of system users and for the access to the system. Especially the following controls will have a direct influence.

- SC-04 Information Remnance
- AC-05 Separation Of Duties
- AC-06 Least Privilege
- AC-07 Unsuccessful Login Attempts
- AC-08 System Use Notification
- IA-04 Identifier Management

The user management[2] offers functions to handle the different users of the system and the rights of those users. In detail the following functions are provided which allows:

- the administrator to create and delete a user
- the user to modify his password
- the user to modify his user attributes
- to add a UI-language to user
- the admin to assign a user to user group (=user role)

[1] NReq 4: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

[2] NReq 5: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

- the admin to assign a user to a customer (to allow multi tenancy)
- the admin to create, modify and delete a user group
- the admin to assign permissions to usergroup
- the admin to create, delete and modify user permissions
- to add individual user permissions for local applications
- to name and describe user permissions for further usage
- The user management is used to restrict the rights for different users:
- to get access to data
- to change parameters
- to add and delete new devices

4.1.3 Persistence of data

Once data is entered to the system, it might be required that this data gets stored to survive subsequent server restarts. Data which should be defined to be persistent[1] is configured (flagged) within the datamodell accordingly. No special coding is required within applications, using individual data models. Persistency does not store the history path of configuration data, just the last value is stored.

4.1.4 User Interface (MMI)

This description is based on the following requirements [ECo-AT SWP2.3 system overview]:

R_C_076 The parameters that control the aggregation of CAM data in all R-ITS-Ss shall be adjustable at the C-ITS-S.

R_C_049 The visualization of the R-ITS-S shall be via an icon of the R-ITS-Ss on the C-ITS-S GUI. The rough position and the name shall be indicated on the display. An operator shall be able to call for additional, detailed status information.

R_C_050 Position of road works trailer. A road works trailer connected to the C-ITS-S shall be indicated by an icon on the C-ITS-S GUI.

R_C_088 The C-ITS-S shall present status of currently deployed messages.

R_C_096 The C-ITS-S shall group CEN-DSRC protected zones, received by the TCC, for each relevant R-ITS-S (max. 16).

[1] NReq 6: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

The following information is visualized on a graphical representation of a map, according to the available coordinates.

- Road network with major towns
- Location of the R-ITS-S
- Position of the road works trailer (the position is reportet by the R-ITS-S located on the trailer)
- Location of an event (road works, accidents….) reported by vehicles

There is no referencing or map matching of devices or events.
Other information is provided in lists and tables, which can be sorted. This relates to:

- Error messages
- R-ITS-S
- Parameter

4.1.4.1 Graphical Representation of MAP

Network related static information like the position of R-ITS-S and other dynamic information is visualized in a map.

- The visible map section can be moved using dragging
- Zoom in/out
- Graphical representation – with the possibility to use UTM coordinates to place an object or an event
- An object (e.g. R-ITS-S) can be positioned in the graphical representation

4.1.4.2 User Input

There will be the possibility for a user to input data for different purposes:

- Setting of the parameters, e.g. CAM aggregation (collection interval, detection zone)
- Generation of statistics
- Selection of R-ITS-S
- Activation and deactivation of R-ITS-S

To fulfill the requirements of device management the following functions and main services are provided.

- Listing installed RSUs

- Monitoring and Alarm/Event display
- Access to configuration parameters (list parameters, set parameters)
- Pre Configuration of RSU for quick and simple deployment
- Default parameter profiles[1] for R-ITS-S to ease rollout / replacement
- Display of RSUs in the graphical representation of the map
- Alarm and Event UI

4.1.5 Device Management

This description is based on the following requirements [ECo-AT SWP2.3 system overview]:

R_C_030 The C-ITS-S shall provide the necessary functionality (windows, parameter sets) for the configuration of the R-ITS-S (system parameter sets, firmware update).

R_C_120 The basic initialization of an R-ITS-S (deployment of a new R-ITS-S) shall be supported by the C-ITS-S. This REQ has to be more detailed in the next release.R_C_121 The C-ITS-S is responsible for the device management of the R-ITS-Ss.

The modul Device Management is responsible for the administrative management of the R-ITS-S. It contains the following functionality:

- Remote access to R-ITS-S from C-ITS-S
- Remote configuration of the R-ITS-S (e.g. parameters, certificates) from C-ITS-S
- SW-updates of the R-ITS-S, firmware download
- Monitoring (errors, status) with automatic alerts and reporting of error messages e.g. list of alarms
- Activation / deactivation (status) of R-ITS-S on the basis of subscribing (registering) and unsubscribing (check out) of R-ITS-S[2]
- Plug &Play[3] functionality (automatic configuration, load of default parameter set)
- The DM service will provide a well-defined database table with infrastructure information for all other services (e.g. station position, station type, station network address, ...)[1]

[1] NReq 7: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

[2] NReq 8: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

[3] NReq 9: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

The module device management enables the user to derive information about the status of an R-ITS-S and to setup all actions to run an R-ITS-S.
A load of the default setting will be not required if the R-ITS-S is mounted on a RW-trailer. In this case a specific parameter set for this type of R-ITS-S can be loaded or is already loaded and can be used.
The process of connecting an R-ITS-S to the C-ITS-S has to be further specified in the nect release.

The C-ITS-S will automatically remove an R-ITS-S from all following operations (e.g. message dissemination) if it is disconnected.

The following list provides additional functionality of the Device Management Service:

- Performance monitoring[2]
- Configurable alarm and event notifications[3]
- Configuration of parameters

The parameters for the aggregation and analysis carried out in the R-ITS-S are defined and changed at the C-ITS-S.

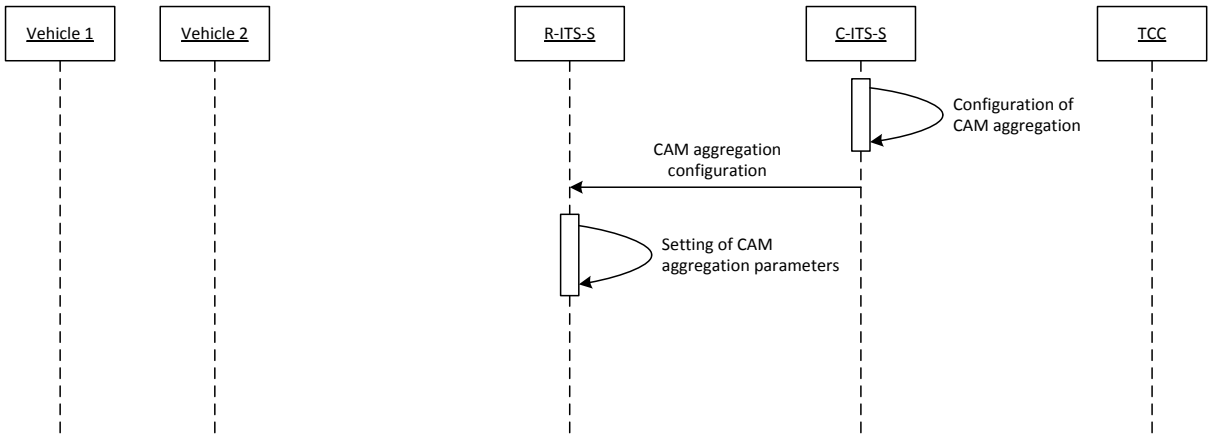

Figure 2 Configuration process for CAM aggregation

[1] NReq 10 This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

[2] NReq 11: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

[3] NReq 12: This requirement needs to be discussed. An update of [ECo-AT SWP2.3 system overview] is required.

The CAM aggregation parameter configuration (roadside ID, short term collection interval, long term collection interval, detection zones, short term station type group) is done at the C-ITS-S. This configuration is send to the R-ITS-S with the specific roadside ID that sets this configuration parameters.

4.1.6 Alarms, Error Handling

The C-ITS-S is responsible for the operation of the connected R-ITS-S. In this context it will ensure, that it will get notice of all alarms and errors of a device. All events and alarms are presented to the user in a list showing the time the alarm occurred, the device name and the type of error.

4.1.7 Management and Processiong of Events from DENM

This description is based on the following requirements:

R_G_003 The integrity of the message content shall be checked in the system component.

R_T_014 The TCC shall receive DENM information (UC other DENM applications) from the C-ITS-S. The DENM UC, DENM triggered by the V-ITS-S will be described in the Ref. [ECo-AT UC other DENM] in a later release.

R_C_083 The C-ITS-S shall forward DENM information (DENM data / UC other DENM applications) to the TCC.

R_C_012 The C-ITS-S shall be able to receive “basic RWW from R-ITS-S” DENM as well as operational data from the RW trailer via IF3.

R_C_013 The C-ITS-S shall be able to receive DENM information (based on DENM from the vehicle / UC other DENM applications) from R-ITS-S.

In case of an event DENM are sent from the different vehicles approaching the location and encountering the situation. Futhermore the message can be sent from the detecting vehicle to any other vehicle, which sends the DENM to the R-ITS-S. On the level of the C-ITS-S messages are used to initiate further actions.

4.2 Logging, Archive

This description is based on the following requirements:

R_G_002 Messages in the C-ITS system shall be unique and traceable to the source.

R_G_008 All log entries produced on the C-ITS-S and R-ITS-S shall have a UTC based time stamp.

R_G_009 All log entries shall be available in a human readable format (except binary message information possibly contained) and in a way no vendor specific tooling is needed for reading.

R_C_073 All logs created by and stored within the C-ITS-S shall be available to a C-ITS-S operator.

R_C_116 C-ITS-S shall be able to log type and time of received and sent messages over IF1 and IF3.

R_C_117 The C-ITS-S shall be able to log the list of all R-ITS-Ss, which were selected for message dissemination. Further the C-ITS-S shall be able to log the list of R-ITS-Ss, which successfully received the messages generated by the C-ITS-S.

R_C_118 The C-ITS-S shall be able to log all occurrences of R-ITS-S reboots.

R_C_119 The C-ITS-S should be able to log full message content for messages received and sent on IF1 and IF3.

The security document [Eco-AT SWP3.4 security] states that data has to be logged. The archiving of data has therefore to be carried out in the C-ITS-S. The following data is archived.

- all messages sent and received
- error messages
- system and operational messages (failures, alarms)

When archiving messages for later retrieval the time the message was received and the sender or originator of the message have to be stored with the message.

4.3 Interfaces

4.3.1 IF1 (C-ITS-S <> TCC) interface

This description is based on the following requirements

R_T_014 The TCC shall receive DENM information (UC other DENM applications) from the C-ITS-S. The DENM UC, DENM triggered by the V-ITS-S will be described in the Ref. [ECo-AT UC other DENM] in a later release.

R_T_016 The TCC shall receive aggregated CAM data (aggregated by the R-ITS-S) from the C-ITS-S.

R_T_023 The TCC shall receive single vehicle data from the C-ITS-S via IF1.

R_T_024 For travel time estimation the TCC shall take single vehicle data (received from the C-ITS-S) from different R-ITS-S where the vehicleID is the same.

R_T_003 The TCC shall send IVI information to the C-ITS-S, as described in Ref. [ECo-AT SWP2.1 UC IVI]. The information is sent to the C-ITS-S for a new IVI and for an update to an existing IVI.

R_T_026 The TCC shall send CEN-DSRC protected zone data for the tolling stations on the operator's road network to the C-ITS-S. This list is continually updated when new tolling stations / protected zones become available

R_C_001 The C-ITS-S shall receive IVI data from the TCC, as described in Ref. [ECo-AT SWP2.1 UC IVI].

R_C_004 The C-ITS-S shall forward aggregated CAM data received from the R-ITS-S to the TCC considering requirements R_C_011, R_C_089.

R_C_094 The C-ITS-S shall forward single vehicle data received from the R-ITS-S to the TCC considering requirements R_C_090, R_C_091, R_C_092, R_C_093.

R_C_095 The C-ITS-S shall be able to receive CEN-DSRC protected zone data from the TCC.

Definition of the interface between the C-ITS-S and the TCC compliant to the requirements defined in the SWP2 system specification [ECo-AT SWP2.3 system overview].

Details of the interface between the C-ITS-S Server and the TCC are specified in the document [ECo-AT SWP3.1 IF1 data].

The data of this interface is sent in containers and data elements specified in DATEX II. To further process the input, data will be transformed into the relevant G5-structure (DENM, IVI, RWW). The mapping tables for the mapping of the DATEX II-elements into the G5-messages can be found in document [ECo-AT SWP3.1 DATEX II mapping].

4.3.2 IF2 (C-ITS-S <> PKI Server) interface

R_C_086 There shall be an interface from the C-ITS-S to the PKI server.

For details on this interface please refer to [ECo-AT SWP3.4 security].

4.3.3 IF3 (C-ITS-S <> R-ITS-S) interface

This description is based on the following requirements related to data sent from from R-ITS-S

R_C_011 The C-ITS-S shall receive aggregated CAM data from the R-ITS-Ss.

R_C_012 The C-ITS-S shall be able to receive “basic RWW from R-ITS-S” DENM as well as operational data from the RW trailer via IF3.

R_C_084 The C-ITS-S shall send DENM data to the R-ITS-S, as described in Ref. [ECo-AT SWP2.1 UC RWW] and Ref. [ECo-AT SWP2.1 UC other DENM] (UC RWW and UC other DENM applications). The information is sent to the R-ITS-S for a new DENM and for an update to an existing DENM.

R_C_013 The C-ITS-S shall be able to receive DENM information (based on DENM from the vehicle / UC other DENM applications) from R-ITS-S.

R_C_090 The C-ITS-S shall receive single vehicle data from the R-ITS-S.

R_C_085 The C-ITS-S shall send IVI data to the R-ITS-S, as described in Ref. [ECo-AT SWP2.1 UC IVI]. The information is sent to the R-ITS-S for a new IVI and for an update to an existing IVI.

R_C_098 The C-ITS-S shall provide CEN-DSRC protected zone data individually (max. 16) to R-ITS-Ss.

Details of this interface are specified in the documents [ECo-AT SWP3.1 IF3 management] and [ECo-AT SWP3.1 IF3 comm].

4.3.4 Traceability IF1 -> IF3 interface

For the traceability between Interface IF1 and Interface IF3 a message identifier shall be used.

Roadworks Warning, Other DENM:

The DATEX II identifier "id" of the "situationRecord" is used for this purpose. The "id" includes a prefix of 3 digits and following 5 digits. These final 5 digits are used in the interface IF3 data element "ItsCommDENMtype.mgmt.ItsCommValidity.key" for identification of the message.

IVI:

The DATEX II identifier "id" of the "vmsUnitReference" is used for this purpose. The "id" includes a prefix of variable digits and following 5 digits. These final 5 digits are used in the interface IF3 data element "ItsCommDENMtype.mgmt.ItsCommValidity.key" for identification of the message.

4.4 Data Processing

4.4.1 Message Handling and Generation

This description is based on the following requirements:

R_T_016	The TCC shall receive aggregated CAM data (aggregated by the R-ITS-S) from the C-ITS-S.
R_C_011	The C-ITS-S shall receive aggregated CAM data from the R-ITS-Ss.
R_C_099	The C-ITS-S shall map the DATEX II event data received from the TCC via IF1 to appropriate DENM events sent on interface IF3.
R_C_108	The C-ITS-S shall map the DATEX II event data received from the TCC via IF1 to appropriate DENM events sent on interface IF5 (convergence).
R_C_100	The C-ITS-S shall perform message management of DENM content based on the DATEX II data on IF1 before sending it on IF3.
R_C_109	The C-ITS-S shall perform message management of DENM content based on the DATEX II data on IF1 before sending it on IF5 (web server for convergence).
R_C_101	The C-ITS-S shall be able to generate DENM messages for transmission to the R-ITS-S. The C-ITS-S shall support encoding of DENM: UPER, XER, and XERC
R_C_112	The C-ITS-S shall be able to generate DENM messages for transmission to the web server via IF5. The C-ITS-S shall support encoding of DENM: UPER, XER, and XERC
R_C_102	The C-ITS-S shall map the event data received from the R-ITS-S via IF3 to appropriate DATEX II events sent on interface IF1.

R_C_106	The C-ITS-S shall augment the “basic RWW from R-ITS-S” DENM(s) received from R-ITS-S(s) mounted on RW trailers with “augmentation RWW from TCC”. The resulting “augmented RWW” DENM(s) shall be sent to relevant R-ITS-Ss. The C-ITS-S shall set the “augmentation FLAG” for the DENMs send to involved R-ITS-S(s) (R-ITS-S(s) that sent an “basic RWW from R-ITS-S” to the C-ITS-S which information is included in the “augmented RWW” DENM). For all other R-ITS-Ss the “augmentation FLAG” shall not be set.
R_C_110	The C-ITS-S is responsible for message management (e.g. cancel DENM, run out DENM, store DENM info) when it is transmitting an “augmented RWW” DENM to the R-ITS-S and loses or resumes the IF3 connection.
R_C_111	The C-ITS-S is responsible for updating the “augmented RWW” DENM sent to the R-ITS-S in case an update of “augmentation RWW from TCC” is received via IF1 or an update of “basic RWW from R-ITS-S” is received on IF3.
R_C_089	The C-ITS-S shall map the CAM aggregated data received from the R-ITS-S in IF3 format to DATEX II format for interface IF1.
R_C_091	The C-ITS-S shall map the single vehicle data received from the R-ITS-S in IF3 format to DATEX II format for interface IF1.
R_C_092	The C-ITS-S shall map the stationID received in the single vehicle data from the R-ITS-S to a vehicleID for transmission to the TCC.
R_C_093	Each mapping of stationID to vehicleID in the mapping table (stationID/vehicleID) in the C-ITS-S for single vehicle data shall be kept 120min after receiving the specific stationID. After 120min counted from the first single vehicle data with this stationID, the stationID vs. vehicleID shall be deleted.
R_C_103	The C-ITS-S shall map the DATEX II IVI data received from the TCC via IF1 to appropriate IVI sent on interface IF3.
R_C_104	The C-ITS-S shall perform message management of IVI content based on the DATEX II data on IF1 before sending it on IF3.
R_C_105	The C-ITS-S shall be able to generate IVI messages for transmission to the R-ITS-S. The C-ITS-S shall support encoding of IVI: UPER, XER, and XERC
R_C_113	The C-ITS-S shall map the DATEX II IVI information received from the TCC via IF1 to appropriate IVI messages sent on interface IF5 (convergence).
R_C_114	The C-ITS-S shall perform message management of IVI content based on the DATEX II data on IF1 before sending it on IF5 (web server for convergence).
R_C_115	The C-ITS-S shall be able to generate IVI messages for transmission to the web server via IF5. The C-ITS-S shall support encoding of IVI: UPER, XER, and XERC
R_C_107	The C-ITS system shall provide convergence functionality (possibility of C-ITS messages distribution via another communication technology beside ITS-G5), as described in Ref.

[ECo-AT SWP3.6 convergence]. The C-ITS-S shall provide IVI and DENM downstream information via IF5 to a webserver.

This module is responsible for generation of the cooperative messages to be sent and the handling of the received messages and their data content like DENM, CAM and IVI. Furthermore it is responsible for the processing of all data.

4.4.2 Traffic Data and CAM Processing

The R-ITS-S has already processed and aggregated the CAMs into traffic data so that this data can be sent to the TCC without further processing in the C-ITS-S (Figure 3).

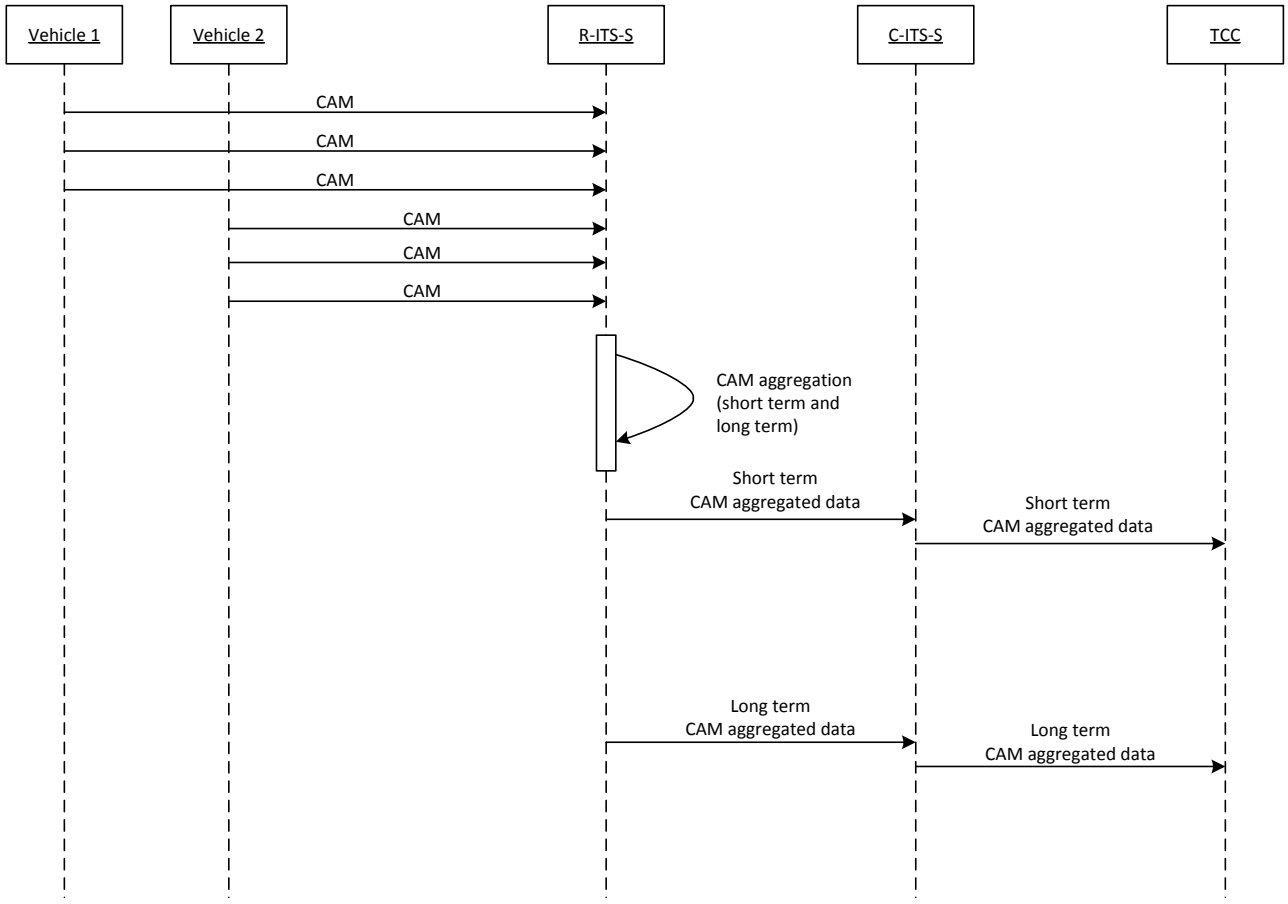

Figure 3 Process for CAM-aggregation in R-ITS-S and CAM-processing in C-ITS-S

The R-ITS-S receives all the CAMs from the vehicles in its coverage area. Based on the CAM aggregation configuration, the R-ITS-S is aggregating the short term data and the long term data. These aggregated data

is sent with an interval (short term data with default interval of 1min, long term data with default interval 1h) to the C-ITS-S. The C-ITS-S forwards these data to the TCC.
If the connection between the R-ITS-S and the C-ITS-S is lost the R-ITS-S will buffer the long term aggregated data (up to 3 days) and send the buffered data to the C-ITS-S when the connection is reestablished. Short term aggregated data will be not buffered at the R-ITS-S.

- **R-ITS-S <-> C-ITS-S connection interrupted:** R-ITS-S starts to buffer long term aggregation data (one set of data for each hour)
- **R-ITS-S <-> C-ITS-S connection still interrupted after 3 days:** the buffer shall follow the first-in first-out concept (FIFO). The oldest data set shall be deleted and the latest data set after 3 days shall be stored.
- **R-ITS-S <-> C-ITS-S connection reestablished:** all the buffered long term data is sent to the C-ITS-S
    - Interruption < 3 days: all data sets until the reestablishment are sent to the C-ITS-S
    - Interruption > 3 days: data sets of the last 3 days are sent to the C-ITS-S

A further process is handling the position data of vehicles at consecutive R-ITS-S to calculate travel time. At each R-ITS-S the CAM messages of the vehicles contain several positions (coordinates) are collected and sent via the C-ITS-S to the TCC.

4.4.3 DENM from Road Works-Trailers (RWW)

One major task of the C-ITS-S is to support the process of road works by handling RWW messages from the trailers and processing this information. Basis of the concept are R-ITS-S mounted on the trailer and connected to the control unit of the trailer.

This chapter describes the processes of generating, updating, augmenting and stopping RWW-messages. The processes are based on the inter-operation of two road works trailers each equipped with an R-ITS-S, one C-ITS-S and the TCC.

Before a road works is established on the motorway the securing vehicles (RW-trailers) are towed to their final positions where they are stopped to block one lane. The R-ITS-S is continuously recording the trace of the previous positions.

Road works trailers which are equipped with an R-ITS-S will start to send DENMs once the trailer is towed to the position on the road where the trailer is stopped (phase I). It is still open whether this DENM will contain information of a slow moving vehicle or about a moving road works. Either of these DENMs will be read by the vehicles and it will be transferred to the C-ITS-S.

In case of an established connection to the C-ITS-S, the DEN-messages are also received by the C-ITS-S. In the C-ITS-S a process is started to augment the roadside information from the trailer with information available from the TCC.

Two different types of information are available in the level of the TCC. On the one hand static information from the road works planning process will be available. On the other hand it is planned to establish a system

with hand-held devices, which enables the roadside personnel to provide actual information, positions and traces about the placed cones, the extent of the road works and the start of speed limit (on-site data1). Both types of information are combined in the TCC and a data set with the information is sent to the C-ITS-S.

The C-ITS-S will start the fusion of the data sent from the R-ITS-S on the trailer with the road works information provided by the TCC. This process contains several steps.

- Location based mapping of the positions reported by the trailers with the positions available from the on-site data of the TCC.
- In case that on-site data is not available or a matching does not lead to a result the process will be stopped and the R-ITS-S continoues to send the “stand-alone RWW at R-ITS-S” DENM.
- A logical check of all message contents is carried out to proof that the information is consistent, e.g. the position of the trailers and position of the arrows on the trailers are to be compared with the information about closed lanes from the TCC.
- If this check is positive one or two (depending on the number of trailers) augmented DENM will be generated.

The R-ITS-S positioned on the road works trailer will stop sending its own generated message ("stand-alone RWW at R-ITS-S" DENM) and continue sending the message of the C-ITS-S. Other R-ITS-S which are selected to distribute the DENM will start to send the message accordingly.

RWW augmentation and fusion

The C-ITS-S carries out a fusion of information in between the data sent by the RW-trailer and data which is available on the level of the TCC. Figure 4 and Table 4 vizualize and describe the sources and the type of data.

Information from trailer R-ITS	Information from TCC	Source
Position	Position of start	Planning
Trace	Planned start (time)	Planning
Passing information	Planned end (time)	Planning
	Extension of road works	Planning
	Speed limit	Planning
	Closed lanes	Planning
	Starting point lane 1 (cone)	On-site
	Trace of starting pont lane 1	On-site
	Starting point lane 2 (cone)	On-site

[1] The provision of on-site data by a hand-held device or an App is currently under discussion at the ASFINAG.

	Trace of starting point lane 2	On-site
	End of RW	On-site
	Trace of end of RW	On-site
	Start of speed limit	On-site
	Trace of start of speed limit	On-site

Table 4: Comparison of information provided by a RW-trailer and information provided by the TCC

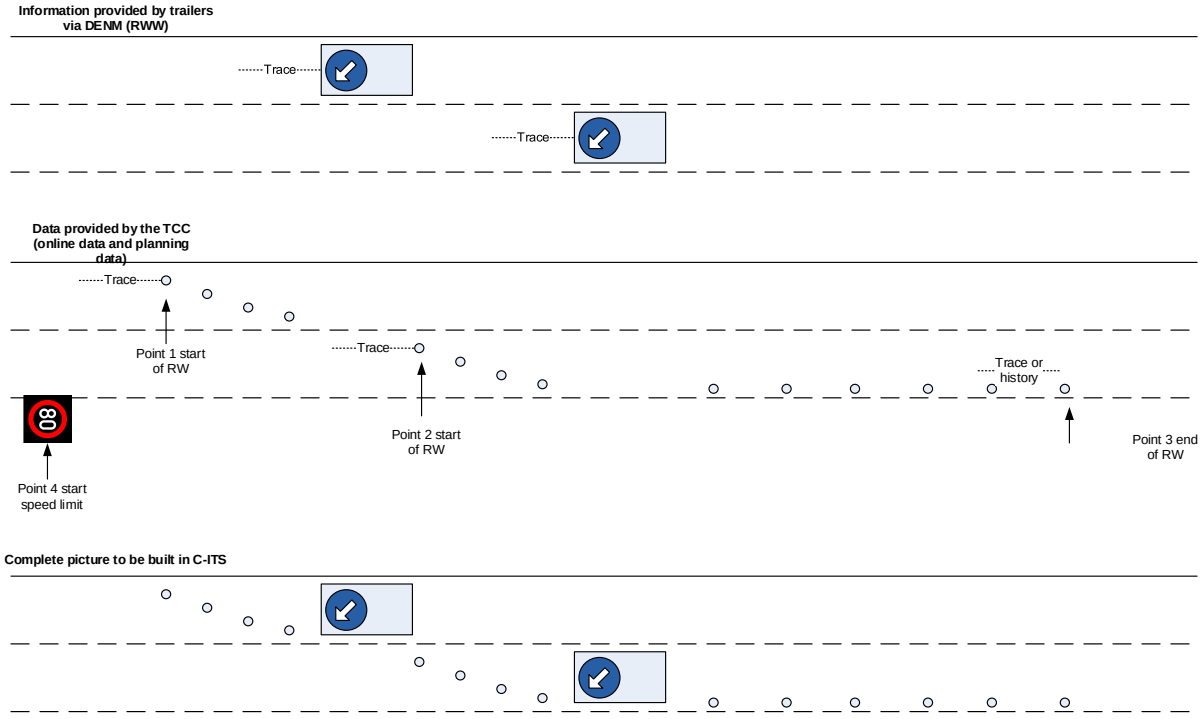

Figure 4 Description of the two types of information from trailers and from the TCC

If two lanes have to be closed, two RW-trailers will be positioned on the motorway according to the local regulations. The process in that case will be carried out in the same way except that two trailer-positions have to be merged with the on-site information from the TCC.

Interim trailer movement

During operation in connected mode it might be possible that the trailer is moved (towed to any other position upstream or downstream or to another lane). In the case that this movement is preceeded by a shutdown of the trailer operation, the trailer automatically stops sending DENM.

In the case that this movement is carried out with an unfolded backside of the trailer which is in full operation,the sending of the augmented DENM has to be stopped by the trailer. The trailer has to start sending stand-alone DENM. The trigger for this process is the change of the position. After the trailer has

reached its new position, the C-ITS-S can generate a new augmented DENM for distribution by the trailer R-ITS-S.

Two trailer scenario

A closure of one or more lanes requires the installation of more than one trailer [ECo-AT SWP2.1 RWW]. According to the description in [ECo-AT SWP 2.1 UC RWW] at least one warning trailer for each closed lane and one pre-warning trailer is required. All of them are initially providing DENM in the "stand-alone mode". Once the C-ITS-S has received the different DENM of the trailers related to one roadworks, it can generate three different augmented DENMs for distribution by the trailer R-ITS-S.

4.4.3.1 Definitions

For the full understanding of the process of sending RWW-messages, a few topics and steps of the process have to be defined.

R-ITS-S modes:

In both of the modes, the R-ITS-S is located and connected to a RW trailer. The RW trailer is activated.

stand-alone mode	The R-ITS-S can have a connection to the C-ITS-S or not. Without a connection to the C-ITS-S the R-ITS-S is broadcasting „stand-alone RWW at R-ITS-S“ DENMs on IF4. With connection to the C-ITS-S the R-ITS-S is broadcasting „stand-alone RWW at R-ITS-S“ DENMs on IF4 and sending „basic RWW from R-ITS-S“ on IF3 to the C-ITS-S. If the connection to the C-ITS-S is available a possible scenario for the „stand-alone mode“ is that the „augmentation RWW from TCC“ or „basic RWW from R-ITS-S“ (from a second RW trailer) are missing at the C-ITS-S.
augmented mode	The R-ITS-S has a connection to the C-ITS-S. It received an „augmented RWW“ from C-ITS-S and the trailer it is mounted on is part of the RW of this „augmented RWW“. The R-ITS-S is not broadcasting „stand-alone RWW at R-ITS-S“ DENMs on IF4.

Table 5: Definitions for RWW: R-ITS-S modes

Indication of R-ITS-S mode: The C-ITS-S sets an „augmentation FLAG“ in the „augmented RWW“ sent to the involved R-ITS-S (an involved R-ITS-S is an R-ITS-S mounted on a RW trailer that is part of the RW described in the „augmented RWW“). If an „augmented RWW“ is sent to a stationary R-ITS-S (mounted on a gantry) or to a trailer R-ITS-S that is not part of the RW described in the „augmented RWW“ the „augmentation FLAG“ has to be set to false.

If the R-ITS-S receives an „augmented RWW“ from C-ITS-S with the „augmentation FLAG“ it shall switch to the „augmented mode“.

RWW message types:

triggerable RWW from TCC	The TCC sends triggerable RWW to the C-ITS-S. This message is the trigger for the system to generate DENMs.
stand-alone RWW at R-ITS-S	The R-ITS-S mounted on a RW trailer generates RWW DENM just with information from the trailer and the R-ITS-S itself.
augmented RWW	This RWW is generated on the basis of two RWW messages from TCC and R-ITS-S available at the C-ITS-S: 1) **„augmentation RWW from TCC“** is sent from the TCC to the C-ITS-S. 2) **„basic RWW from R-ITS-S“** is sent from the R-ITS-S to the C-ITS-S (this „basic RWW from R-ITS-S“ is similar to the „stand-alone RWW at R-ITS-S“). The C-ITS-S augments the „augmentation RWW from TCC“ and „basic RWW from R-ITS-S“ to an “augmented RWW“

Table 6: Definitions for RWW: RWW message types

Distinction between „triggerable RWW from TCC“ and „augmentation RWW from TCC“ at the C-ITS-S:

- „triggerable RWW from TCC“: IF1 DATEX II: groupOfLocations contains three containers (eventPosition (0), trace (1), eventHistory (2)).
    - o IF1 DATEX II: q1:groupOfLocations xsi:type="q1:ItineraryByIndexedLocations"> → „triggerable RWW from TCC“
- „augmentation RWW from TCC“: groupOfLocations contains just one container (startpoint and endpoint of RW)
    - o IF1 DATEX II: <q1:groupOfLocations xsi:type="q1:Linear"> → „augmentation RWW from TCC“

RWW trailer trigger conditions:

Start trigger from trailer	Trailer is activated (IF3: ItsCommTrailerStatus.arrowBoardPosition = up)
Stop trigger from trailer:	Trailer is deactivated (IF3: ItsCommTrailerStatus.arrowBoardPosition = down)

Table 7: Definitions for RWW: RWW trailer trigger conditions

4.4.3.2 States of operation

For the R-ITS-S and the C-ITS-S several states of operation can be defined. These states are referenced in the later process diagrams and flow charts.

R-ITS-S	1R	Trigger from trailer No connection to C-ITS-S available
R-ITS-S	2R	Trigger from trailer connection to C-ITS-S available
R-ITS-S	3R	Transmission of „augmented RWW“ Looses connection to C-ITS-S
R-ITS-S	4R	Transmission of „triggerable RWW from TCC“ Looses connection to C-ITS-S
R-ITS-S	5R	Transmission of „stand-alone RWW at R-ITS-S“ (no connection to C-ITS-S) Connection to C-ITS-S will get established

Table 8: R-ITS-S States of Operation

C-ITS-S	1C	Trigger from TCC („triggerable RWW from TCC“)
C-ITS-S	2C	„basic RWW from R-ITS-S“
C-ITS-S	3C	C-ITS-S generated „augmented RWW“ and sent to relevant R-ITS-Ss receives updated „basic RWW from R-ITS-S“
C-ITS-S	4C	C-ITS-S generated „augmented RWW“ and sent to relevant R-ITS-Ss receives updated „augmentation RWW from TCC“

Table 9: C-ITS-S States of Operation

4.4.3.3 Process Flow Charts and Sequence Diagrams for Start - Processes

This chapter describes the processes related to the generation of RWW in between the involved system components (R-ITS-S, C-ITS-S,....). Besides the communication and the data exchanged the first graphs define the timeline in between the different processes. The first graph (Figure 5) shows the general process and timeline for the generation of DENM.

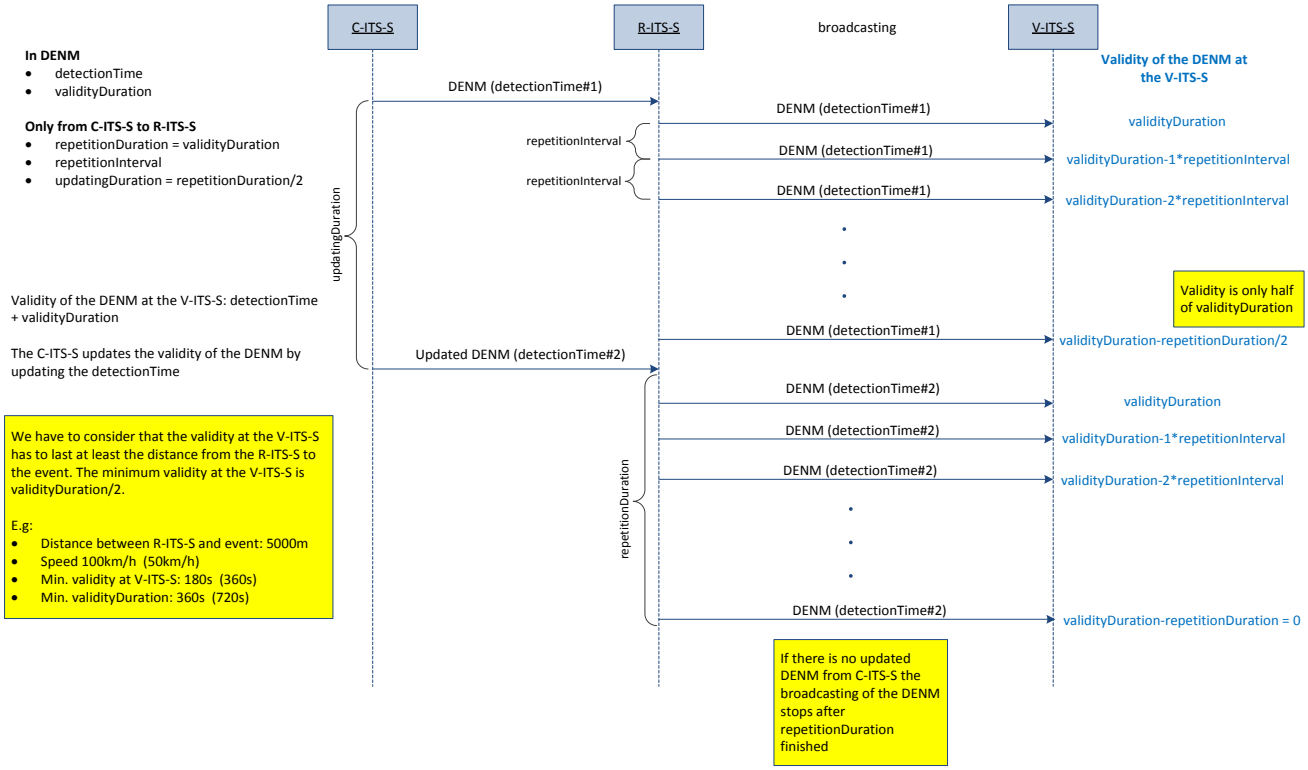

Figure 5: Update of DENM at R-ITS-S regarding validityDuration

The next graph (Figure 6) shows the process and update of stand-alone RWW at R-ITS-S.

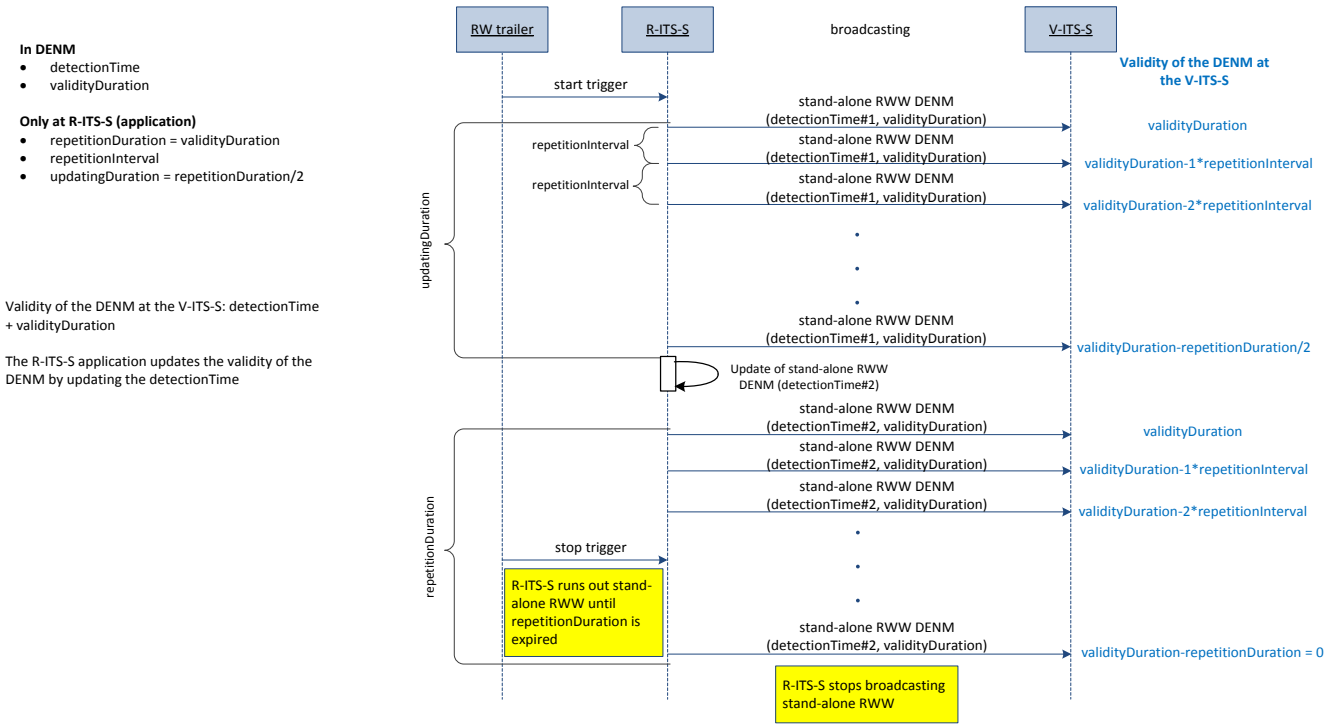

Figure 6: Update of "stand-alone RWW at R-ITS-S" regarding validityDuration

The process shown in Figure 7 and Figure 8 describes the generation of a triggerable RWW due to the information of roadworks sent from the TCC.

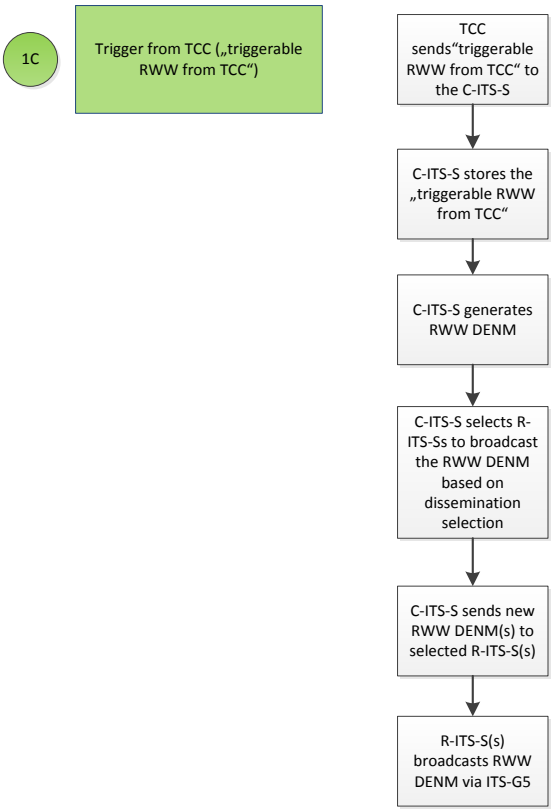

Figure 7: Generation of a triggerable RWW (Flow chart)

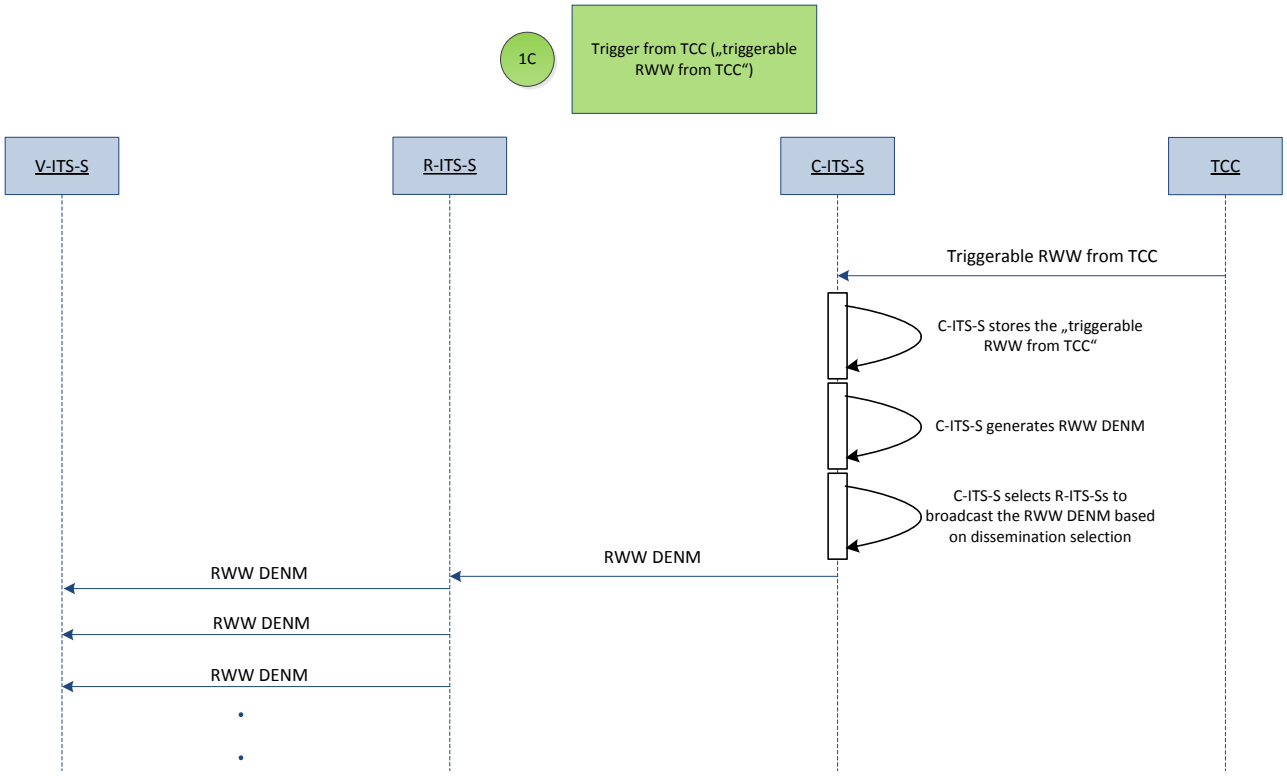

Figure 8: Generation of a triggerable RWW (Sequence diagram)

The process shown in Figure 9 and

Figure 10 is dealing with the generation of "augmented RWW" based on the augmentation of roadworks information generated by trailers and the TCC.

The run out process indicated in the drawing is described in chapter 4.4.3.6.

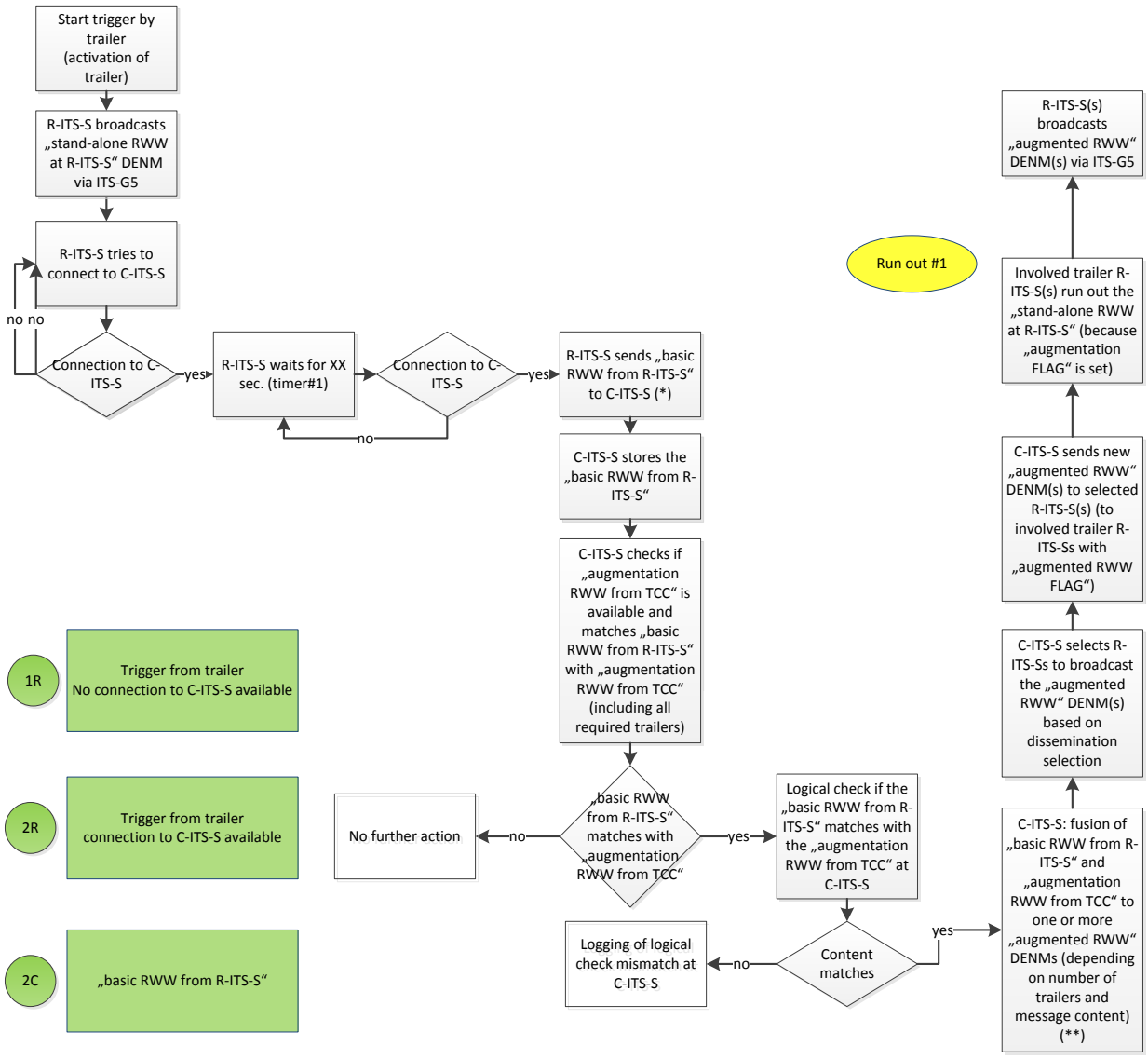

Figure 9: Generation of "augmented RWW" (Flow chart)

Additional comments to Figure 9:

(*) if there is a connection established between the R-ITS-S and C-ITS-S, the R-ITS-S sends the „basic RWW from R-ITS-S“ info only once to the C-ITS-S. Only if there is any change in the content of the „basic RWW from R-ITS-S“, it shall be resent from the R-ITS-S to the C-ITS-S. The C-ITS-S stores the „basic RWW

from R-ITS-S“ and in case of a match with „augmentation RWW from TCC“ it continous with generation of „augmented RWW“ DENM.
In the case of connection loss between the R-ITS-S and the C-ITS-S the R-ITS-S resends the „basic RWW from R-ITS-S“ to the C-ITS-S after the connection is reastablished (does not matter if the R-ITS-S is in „stand-alone mode“ or „augmented mode“).
Distinction between „basic RWW from R-ITS-S“ and forwarded DENMs (from other ITS-S).
„basic RWW from R-ITS-S“: augmentation FLAG on IF3 is set to true
Forwarded DENM: augmentation FLAG on IF3 is set to false

(**) The C-ITS-S has to remember the R-ITS-S from where the „basic RWW from R-ITS-S“ was sent and has to link it with the „augmented RWW“. This is important if there will be an updated „basic RWW from the R-ITS-S“ from the same R-ITS-S.
If there is an updated „basic RWW from R-ITS-S“ or a resent „basic RWW from R-ITS-S“ (after connection loss and reestablishment) and augmentation is possible, the C-ITS-S shall send an updated „augmented RWW“ DENM (with the same actionID). This means it will be an update of the same RW. As indicator the ID of the RW on IF1 can be used.
In case of the first augmentation the „augmented RWW“ DENMs shall have a new actionID generated by the C-ITS-S (compared to the „basic RWW from R-ITS-S“).

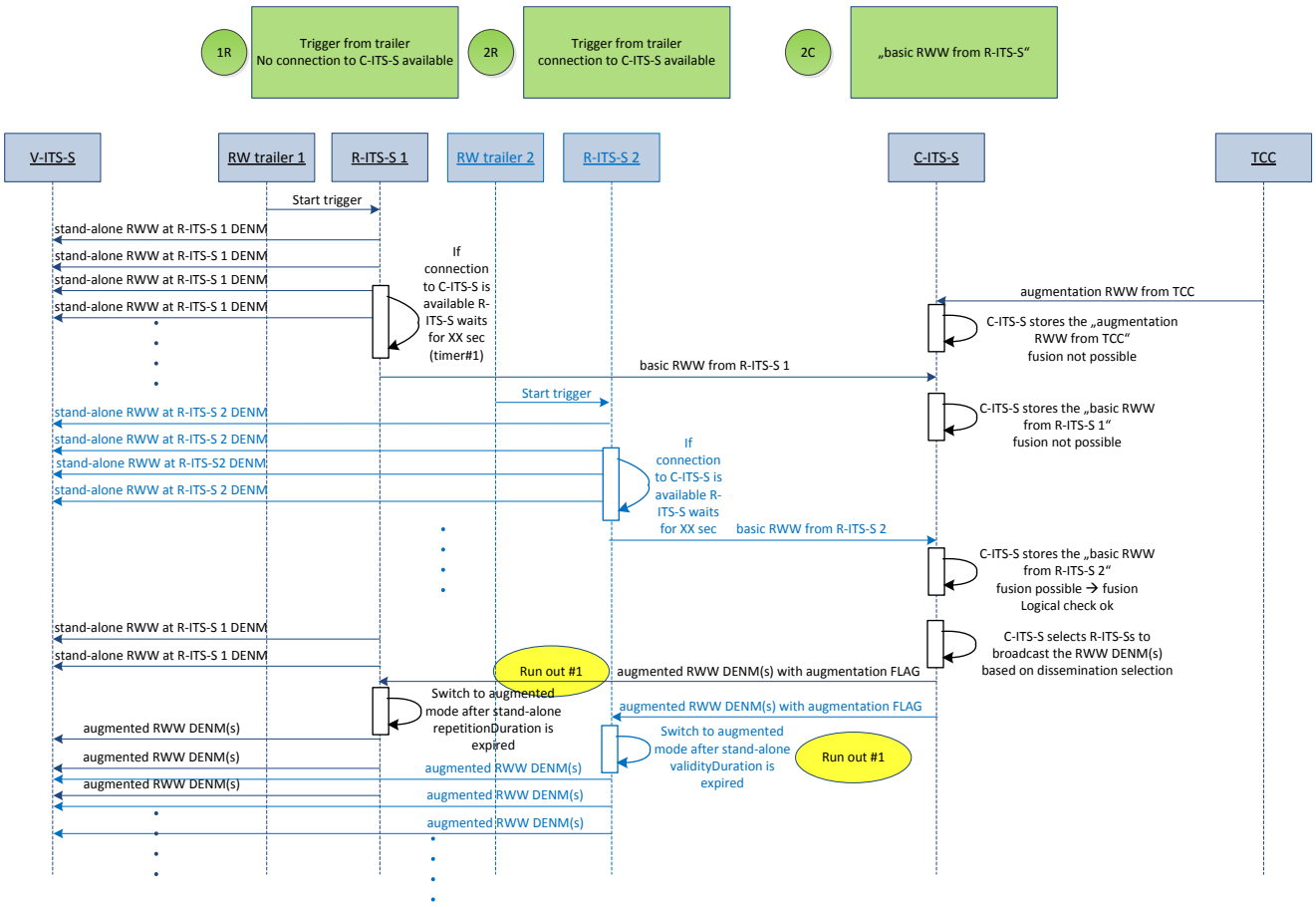

Figure 10: Generation of "augmented RWW" (Sequence diagram)

The process shown in Figure 11,.Figure 12 and Figure 13 is dealing with the continuation of the sending of RWW after a connection loss between R-ITS-S and C-ITS-S.

The run out process indicated in the drawing is described in chapter 4.4.3.6.

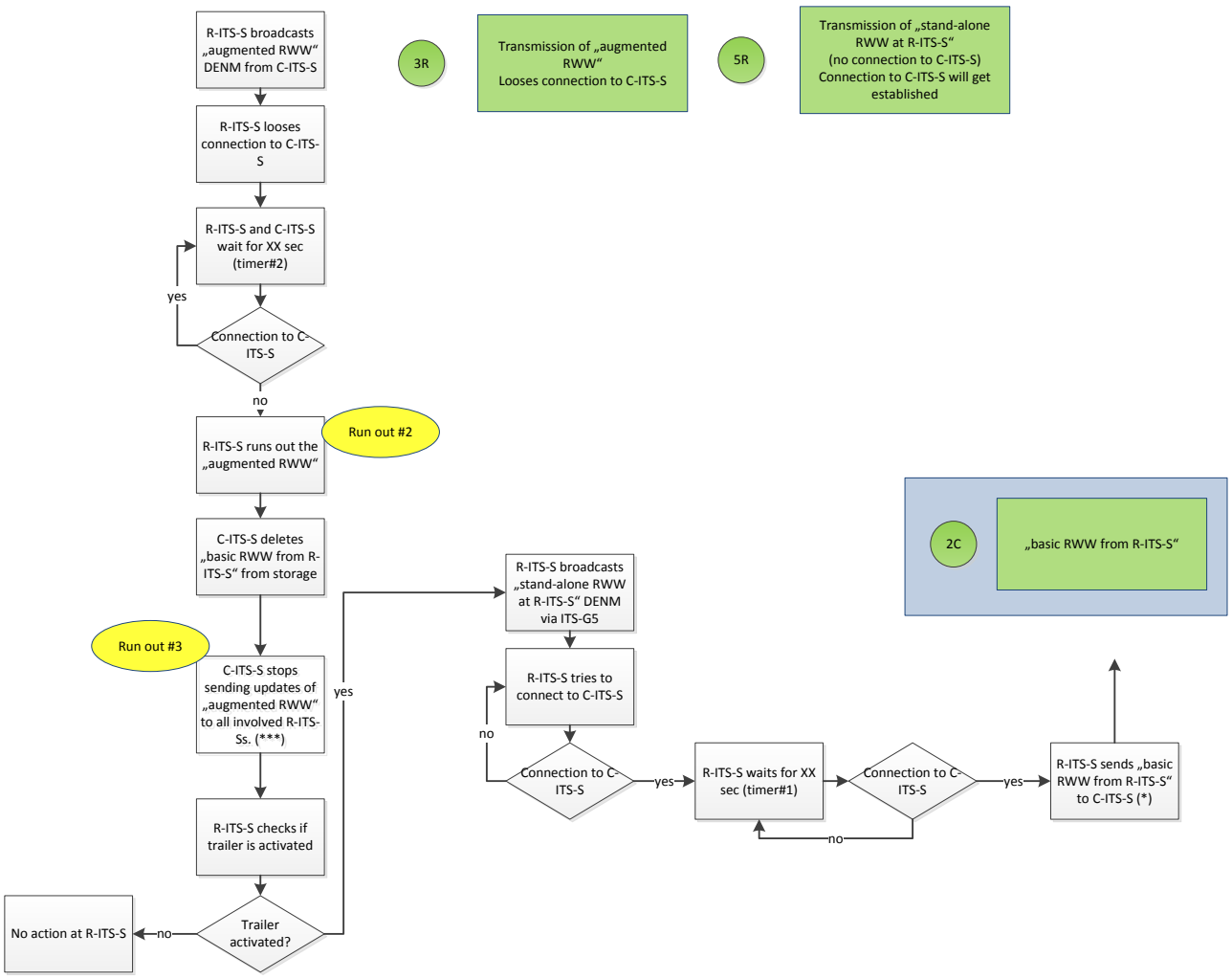

Figure 11: Follow up process to a connection loss between R-ITS-S and C-ITS-S (Flow chart)

Additional comments to Figure 11:

(***) since the R-ITS-S are not receiving updates of the „augmented RWW“ they will run out the currently broadcast of the „augmented RWW“. All trailer R-ITS-S that are in „augmented mode“ will change to the „stand-alone mode“, because they don‘t have an „augmentation FLAG“

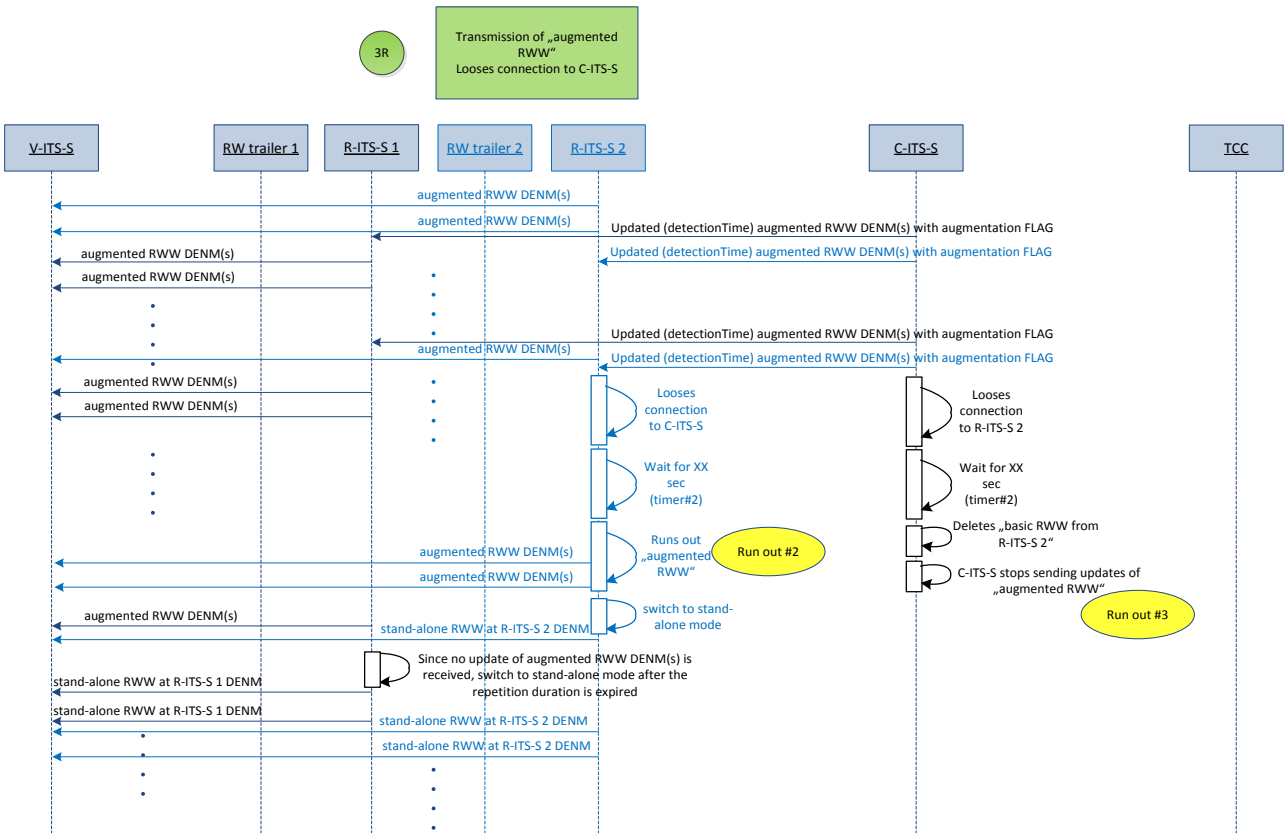

Figure 12: Follow up process to a connection loss between R-ITS-S and C-ITS-S (Sequence diagram)

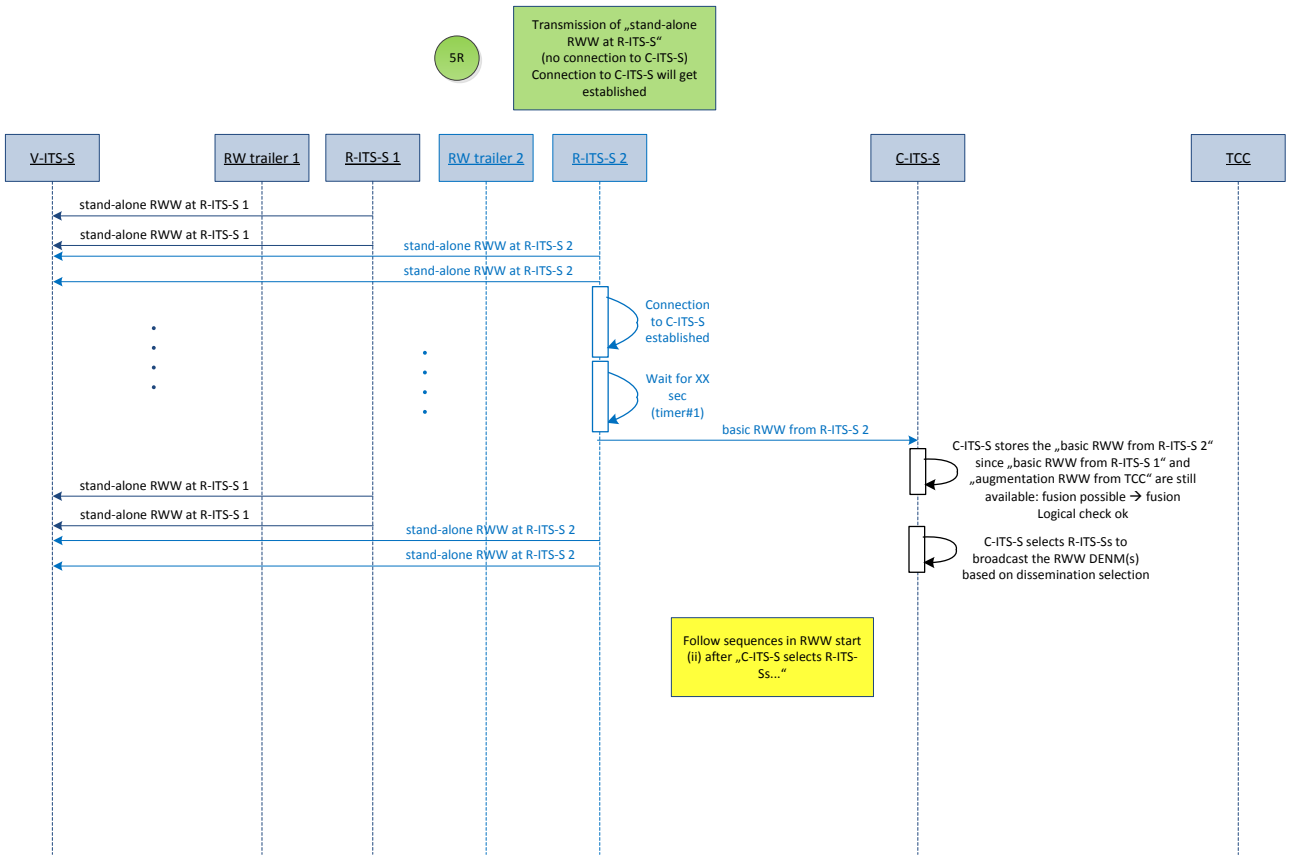

Figure 13: Sending of "stand alone RWW at R-ITS-S" after connection loss between C-ITS-S and R-ITS-S (Sequence diagram)

The process shown in Figure 14 and Figure 15 describes the stop of sending triggerable RWW due to a loss of connection between R-ITS-S and C-ITS-S.

The run out process indicated in the drawing is described in chapter 4.4.3.6.

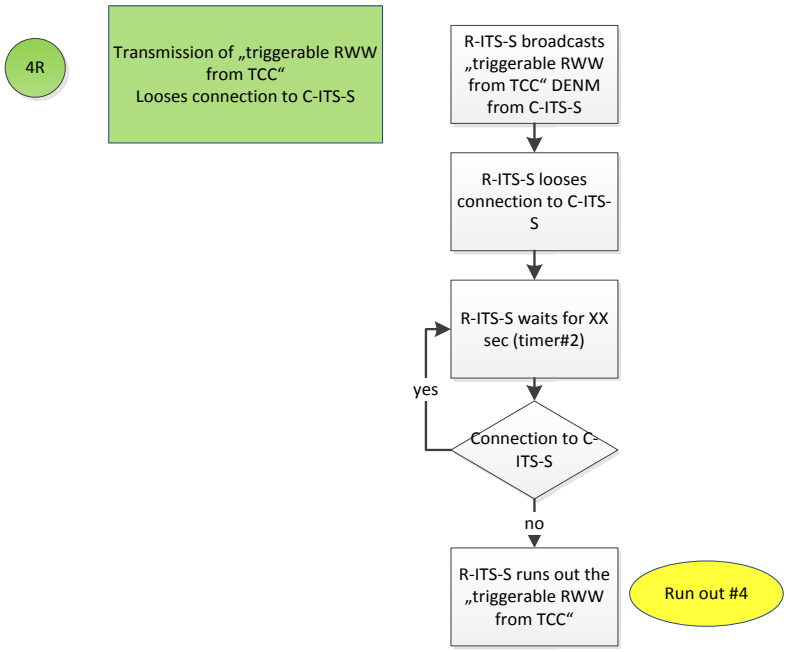

Figure 14: Loss of connection between R-ITS-S and CITS-S during the transmission of triggerable RWW (Flow chart)

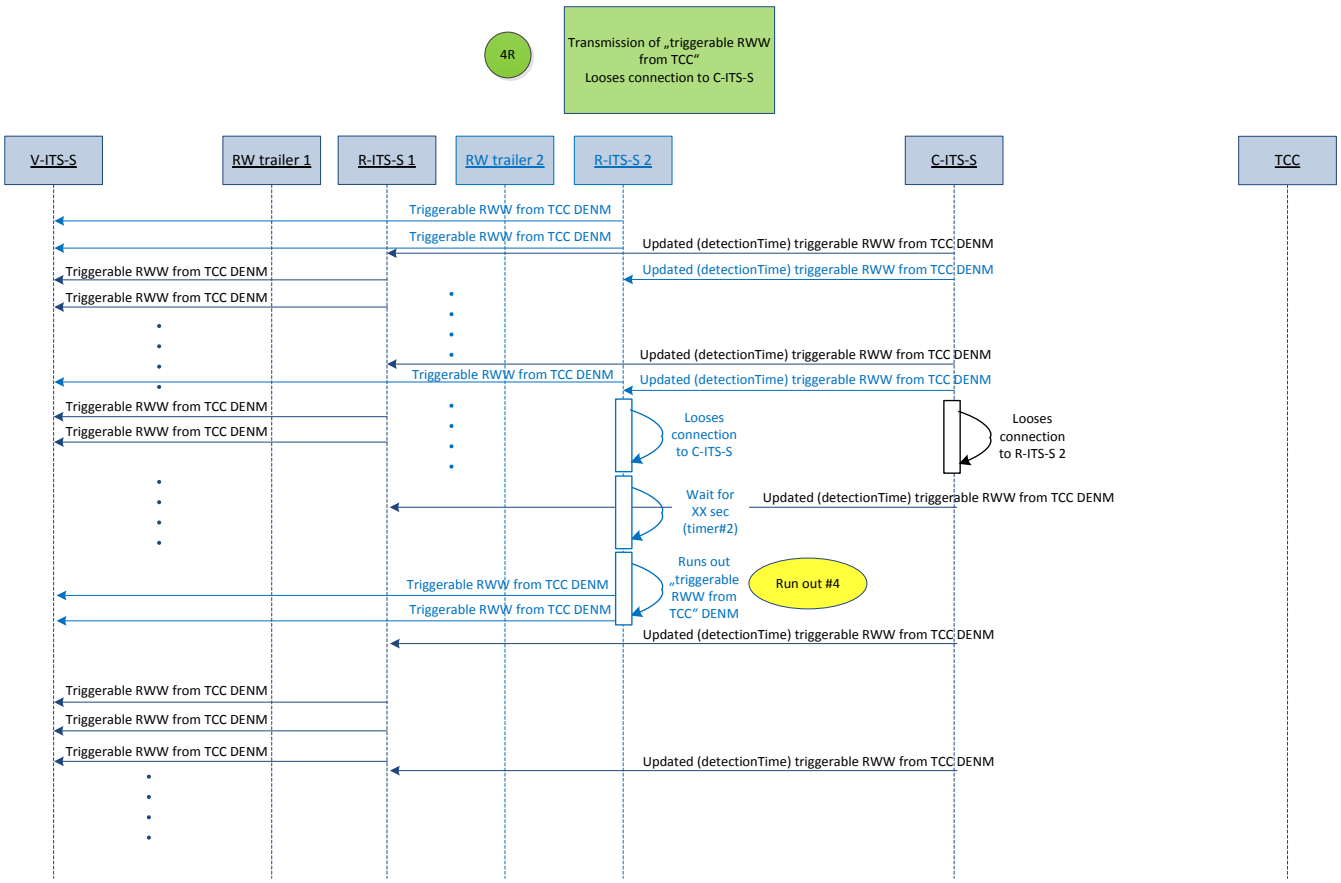

Figure 15: Loss of connection between R-ITS-S and CITS-S during the transmission of triggerable RWW (Sequence diagram)

The process shown in Figure 16, Figure 17 and Figure 18 describes the generation of "augemented RWW" on the basis of "augmentation RWW from TCC" and "basic RWW from the R-ITS-S" at the trailer for the two cases of updating either "augmentation RWW from TCC" (4C) and "basic RWW from R-ITS-S" (3C).

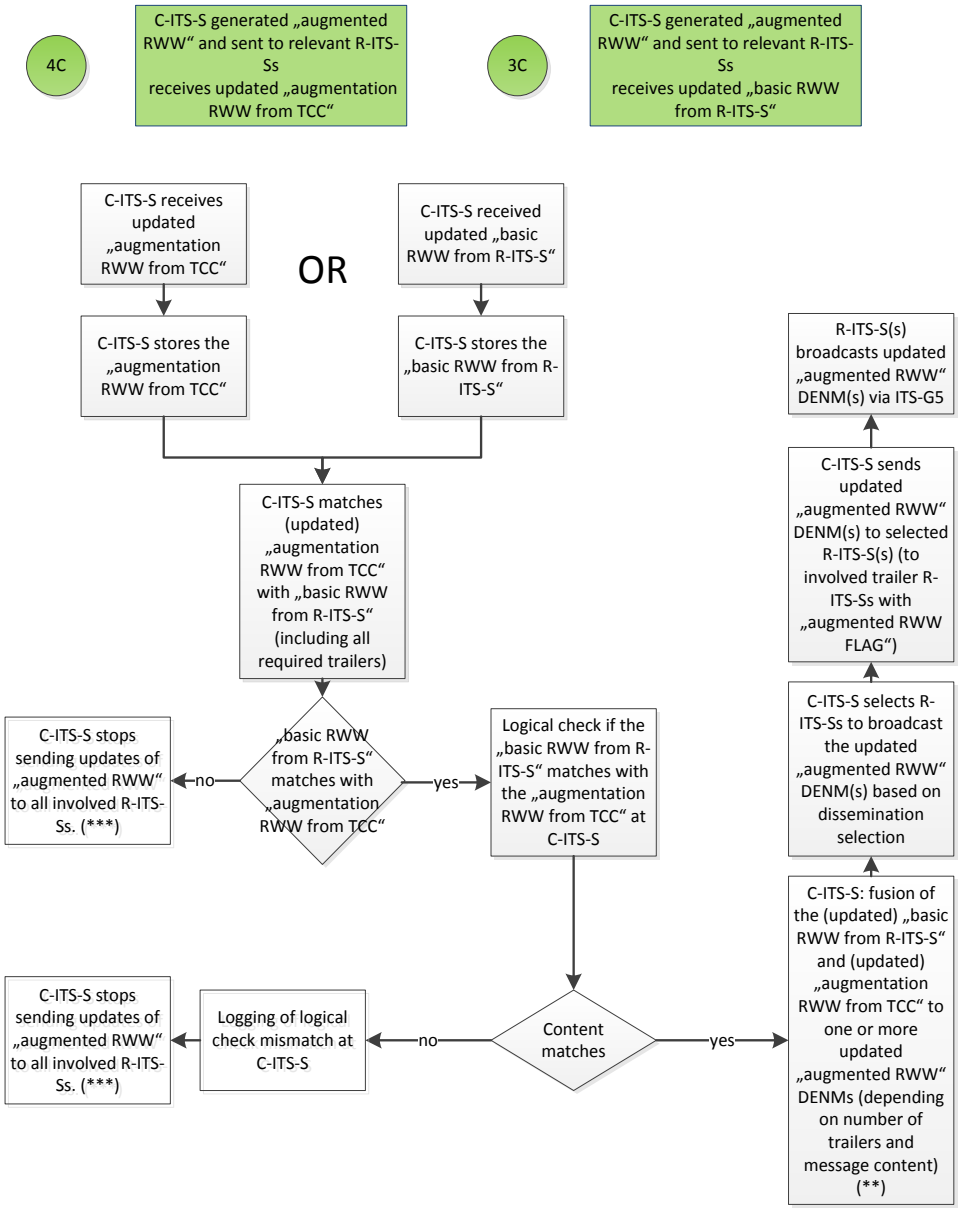

Figure 16: Process of generating and updating "augmented RWW" (Flow chart)

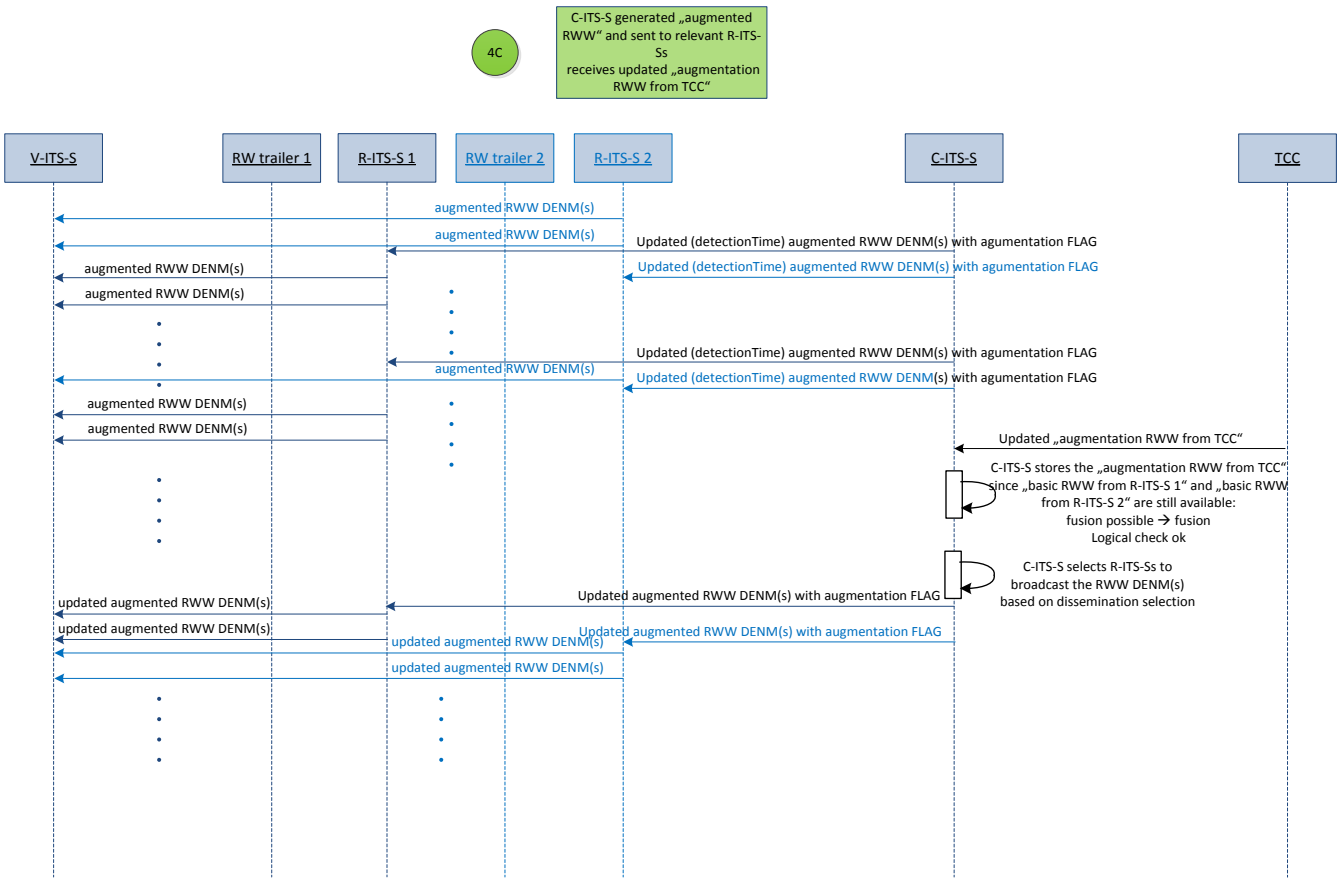

Figure 17: Process of generating and updating "augmented RWW" based on updated "augmentation RWW from TCC"

(Sequence diagram)

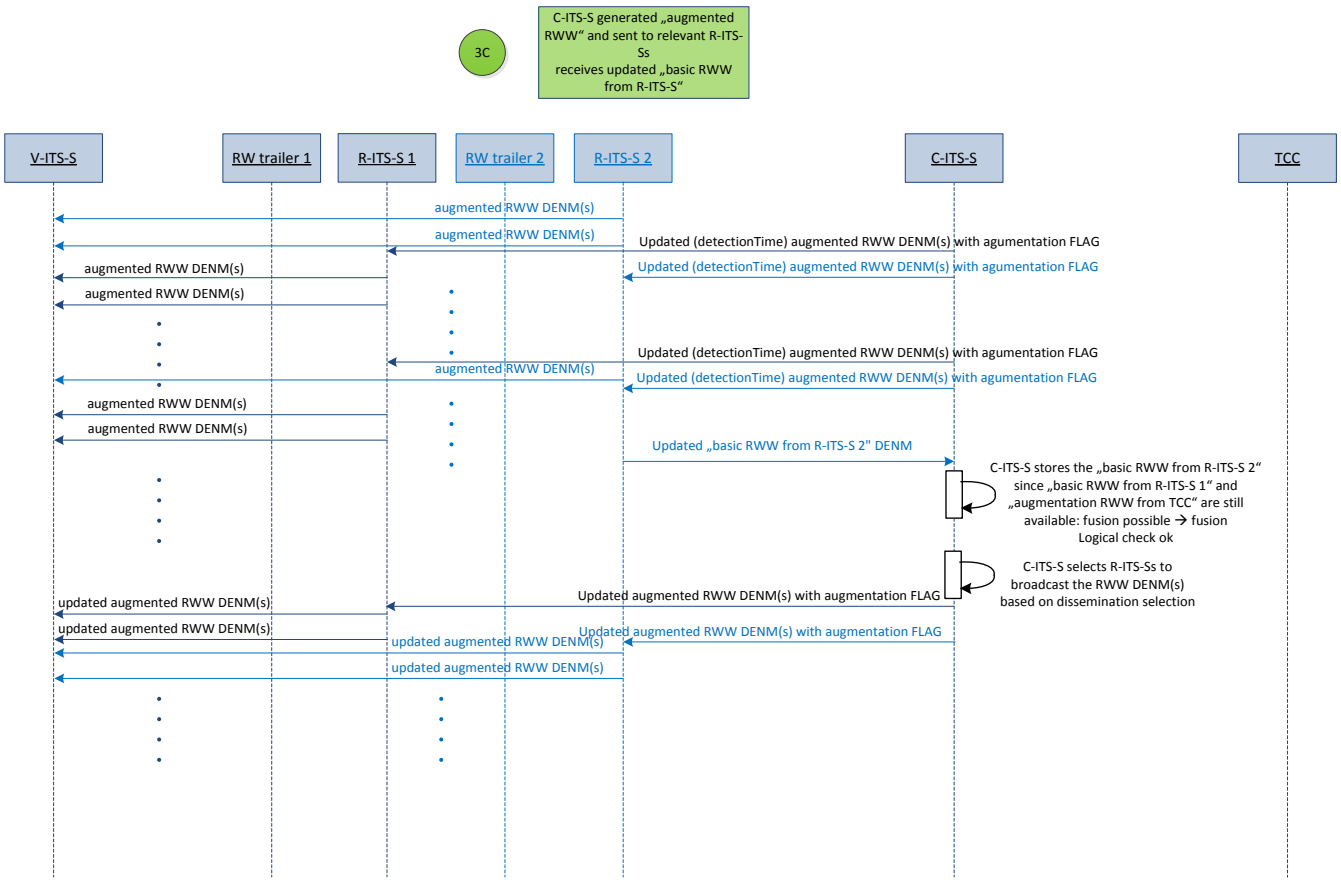

Figure 18: Process of generating and updating "augmented RWW" based on updated "basic RWW from R-ITS-S" (Sequence diagram)

4.4.3.4 Process Flow Charts and Sequence Diagrams for Stop - Processes

Note: The concept of stopping a RWW DENM on the R-ITS-S is done by running out the DENM (it will be broadcasted with the repetition duration as defined by the C-ITS-S). After the repetition duration is expired the DENM will not be broadcasted anymore, i.e. no active cancelation of the DENM.

This concept has to be reconsidered if very long validityDurations (i.e. also very long repetition durations) are used.

The process shown in Figure 19 and Figure 20 describes the stop of sending RWW based on the shut down of the trailer (= stop of communication)

The run out process indicated in the drawing is described in chapter 4.4.3.6.

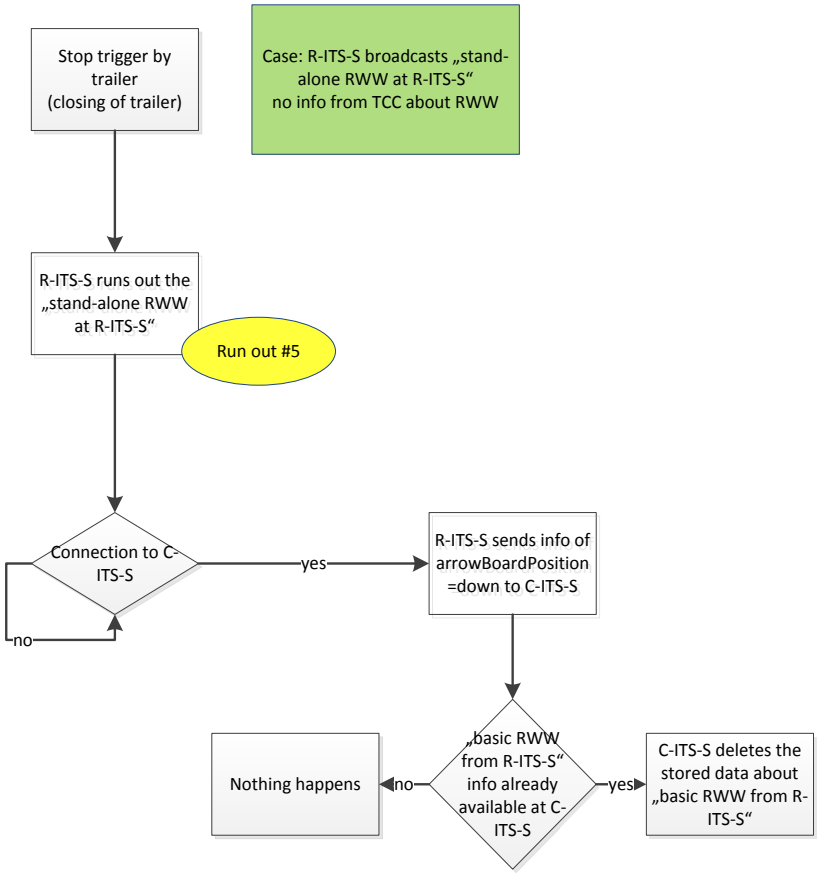

Figure 19: Stop of RWW-messages due to a shutdown of the trailer (Flow chart)

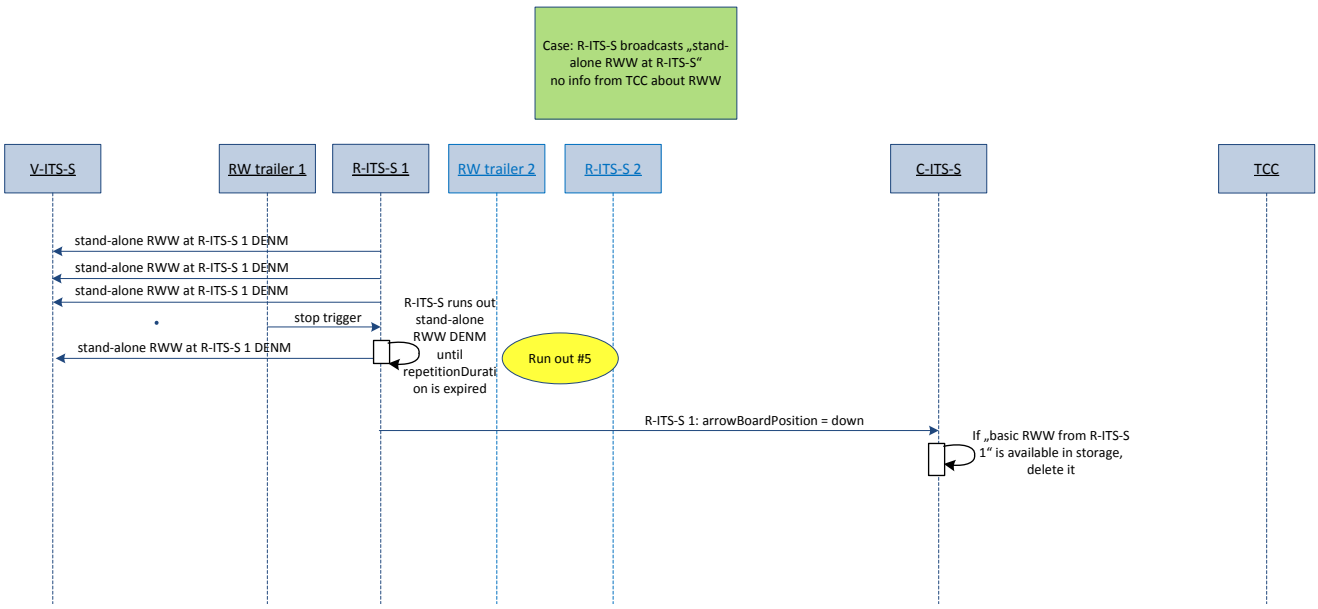

Figure 20: Stop of RWW-messages due to a shutdown of the trailer (Sequence diagram)

The process shown in Figure 21 and Figure 22 describes the stop of sending "augmented RWW" due to a stop auf "augementation RWW from TCC".

The run out process indicated in the drawing is described in chapter 4.4.3.6.

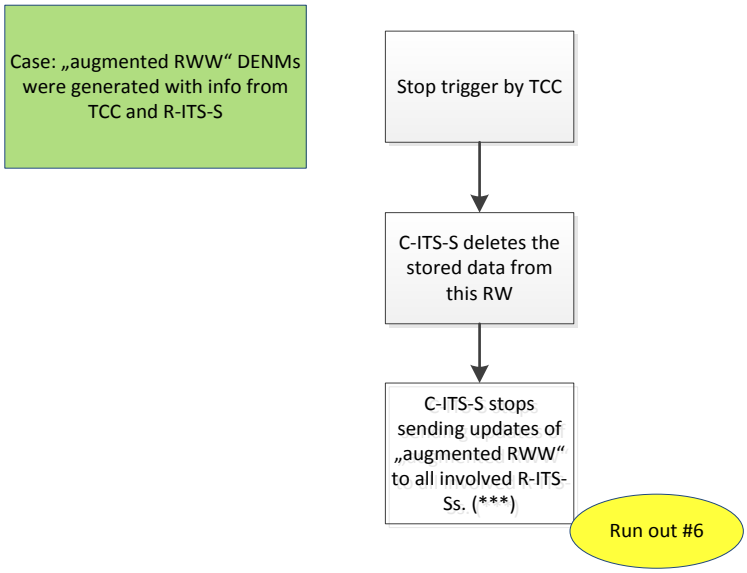

Figure 21: Stop of RWW-messages due to stop of "augmentation RWW from TCC" (Flow chart)

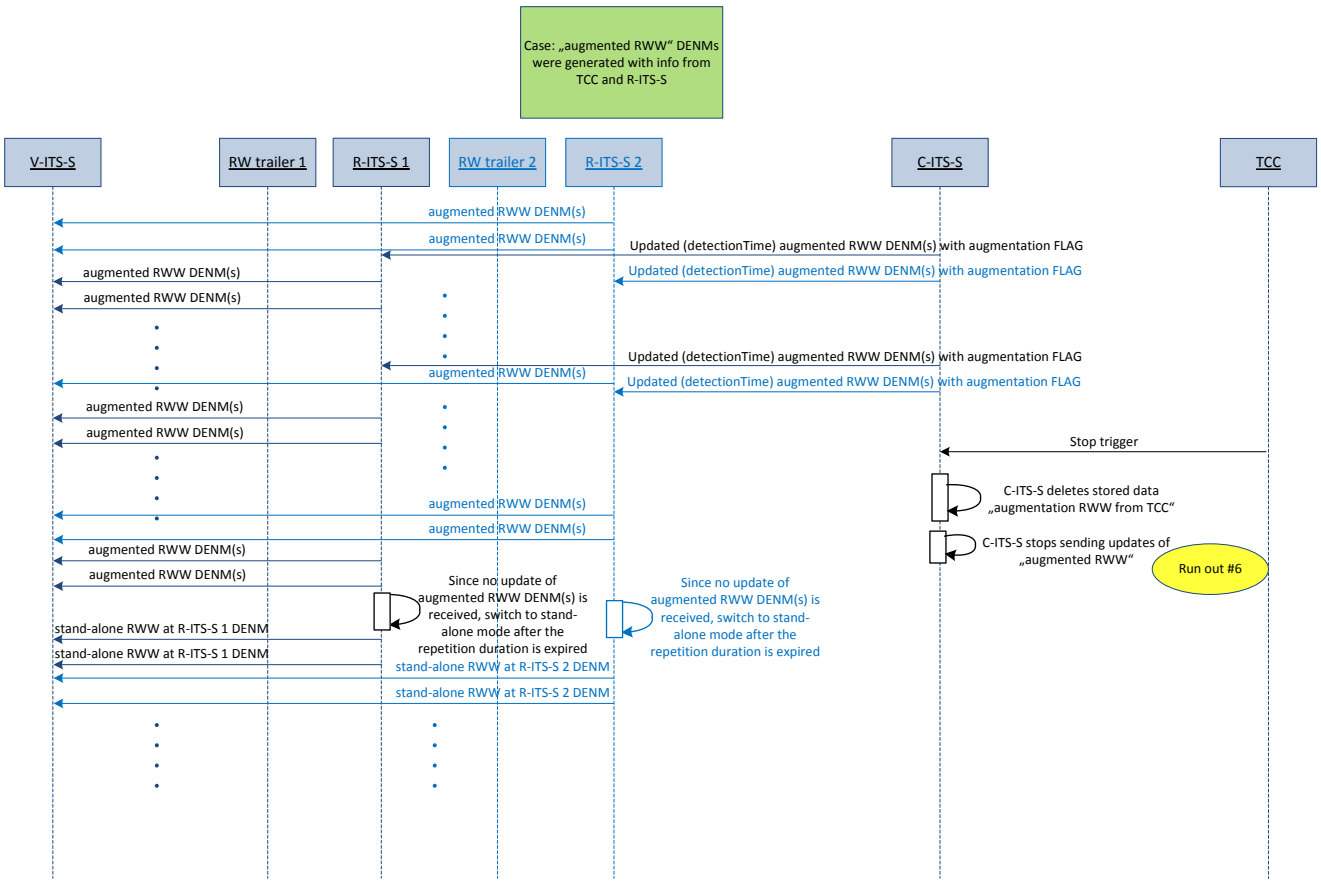

Figure 22: Stop of RWW-messages due to stop of "augmentation RWW from TCC" (Sequence diagram)

The process shown in Figure 23 and Figure 24 describes the stop of sending "augmented RWW" messages due to a shutdown of the trailer.

The run out process indicated in the drawing is described in chapter 4.4.3.6.

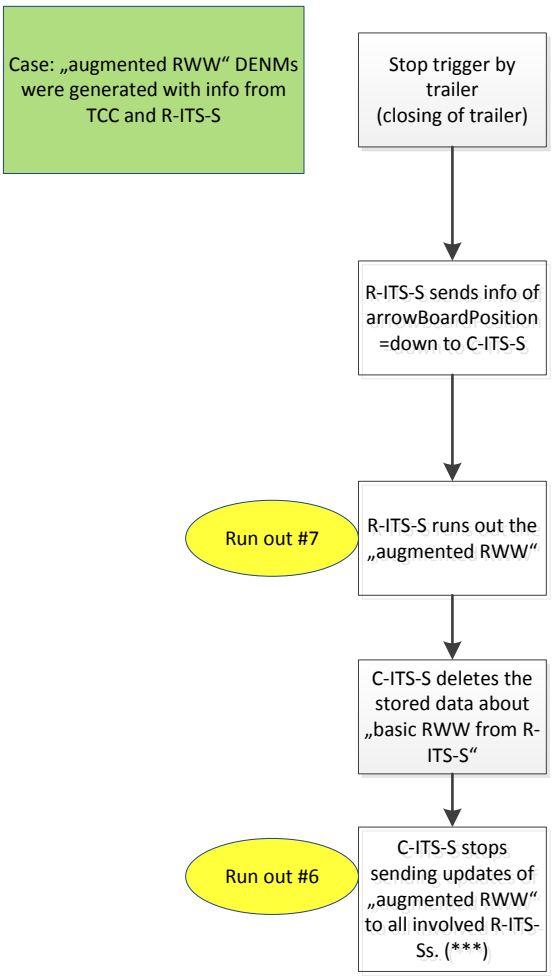

Figure 23: Stop of sending "augmented RWW" messages due to a shutdown of the trailer (Flow chart)

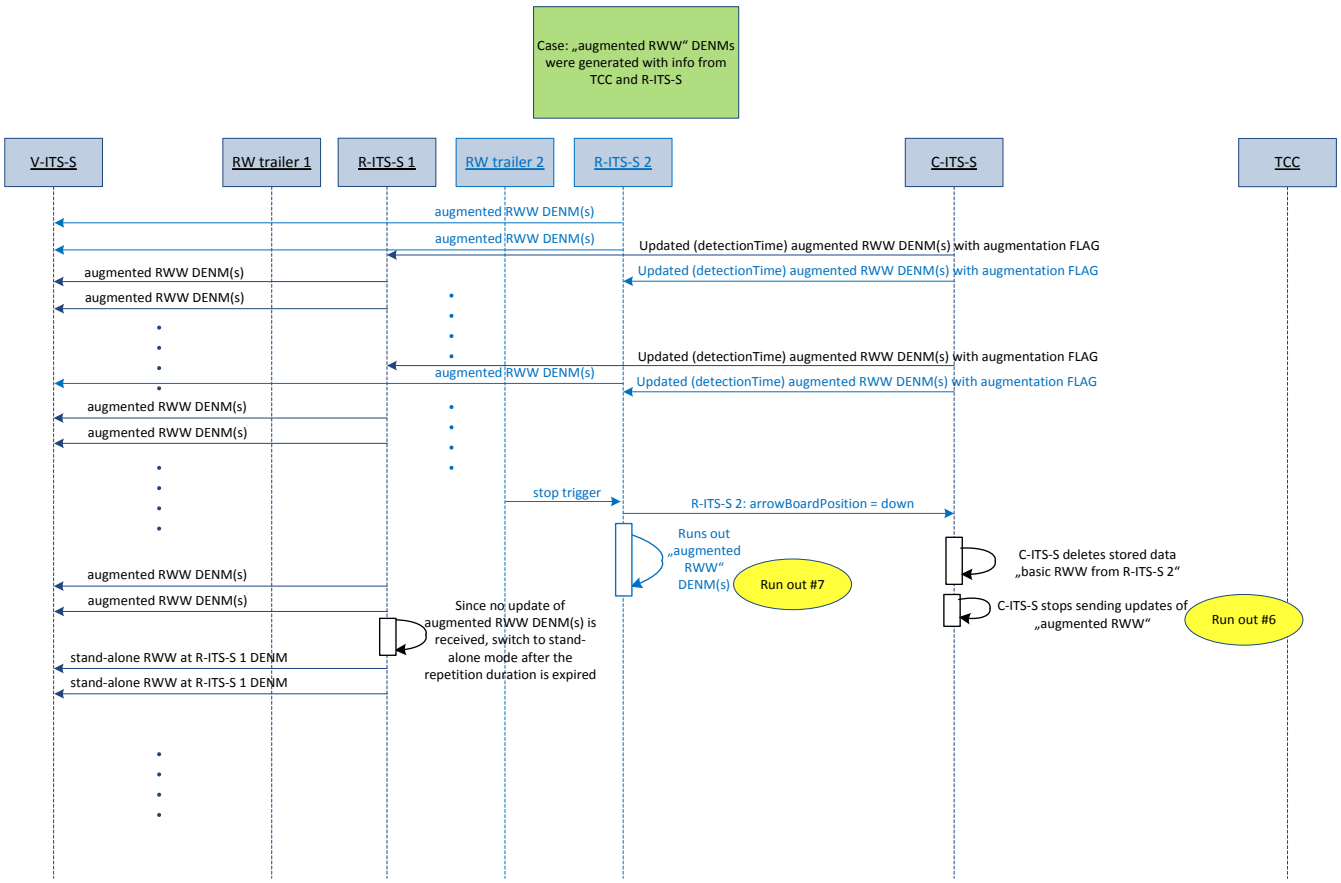

Figure 24: Stop of sending augmented RWW messages due to a shutdown of the trailer (Sequence diagram)

4.4.3.5 Parameters

The following list shows the parameters which are required to handle the processes of generating, sending and stopping the RWW-messages. The values listed here can be seen as initial / default values, which have to be adjusted during the first tests.

- validityDuration (DENM): 720s
- validityDuration (stand-alone DENM): 20s
- repetitionDuration (DENM): 720s
- repetitionDuration (stand-alone DENM): 20s
- repetitionInterval (DENM): 1s (TBC)
- repetitionInterval (stand-alone DENM): 0.5s (TBC)
- updatingDuration (DENM): 360s

- UpdatingDuration (stand-alone DENM): 10s
- timer#1 (connection): 20s
- timer#2 (no connection): 20s

4.4.3.6 Run out possibilities

- Run out #1: R-ITS-S in „stand-alone mode“ receives augmented RWW DENM with augmentation FLAG: R-ITS-S runs out the stand-alone RWW DENM → stops broadcasting stand-alone RWW DENM → switches to augmented mode → broadcasts augmented RWW DENM
- Run out #2: R-ITS-S in „augmented mode“, broadcasts augmented RWW and looses connection to C-ITS-S: after timer#2 expired the R-ITS-S runs out augmented DENMs → stops broadcasting augmented DENMs → switches to stand-alone mode → broadcasts stand-alone DENM
- Run out #3: C-ITS-S generated augmented RWW and looses connection to one involved R-ITS-S: after timer#2 expired C-ITS-S stops sending updates (based on detectionTime) of the augmented RWW
- Run out #4: R-ITS-S broadcasts triggerable RWW DENM and looses connection to C-ITS-S. (similar to Run out #2): after timer#2 expired the R-ITS-S runs out triggerable RWW DENM → stops broadcasting triggerable RWW DENM
- Run out #5: R-ITS-S in „stand-alone mode“ receives stop trigger from trailer: R-ITS-S runs out stand-alone RWW until repetitionDuration is expired
- Run out #6: C-ITS-S generated augmented RWW and receives stop trigger from TCC or from R-ITS-S. (similar to Run out #3): C-ITS-S stops sending updates (based on detectionTime) of the augmented RWW
- Run out #7: R-ITS-S in „augmented mode“ and receives stop trigger from trailer: R-ITS-S runs out augmented RWW DENMs

4.4.4 DENM from Vehicles

In case that a vehicle has encountered a critical situation worth to send a DENM it will generate the message and transmit it to the R-ITS-S.

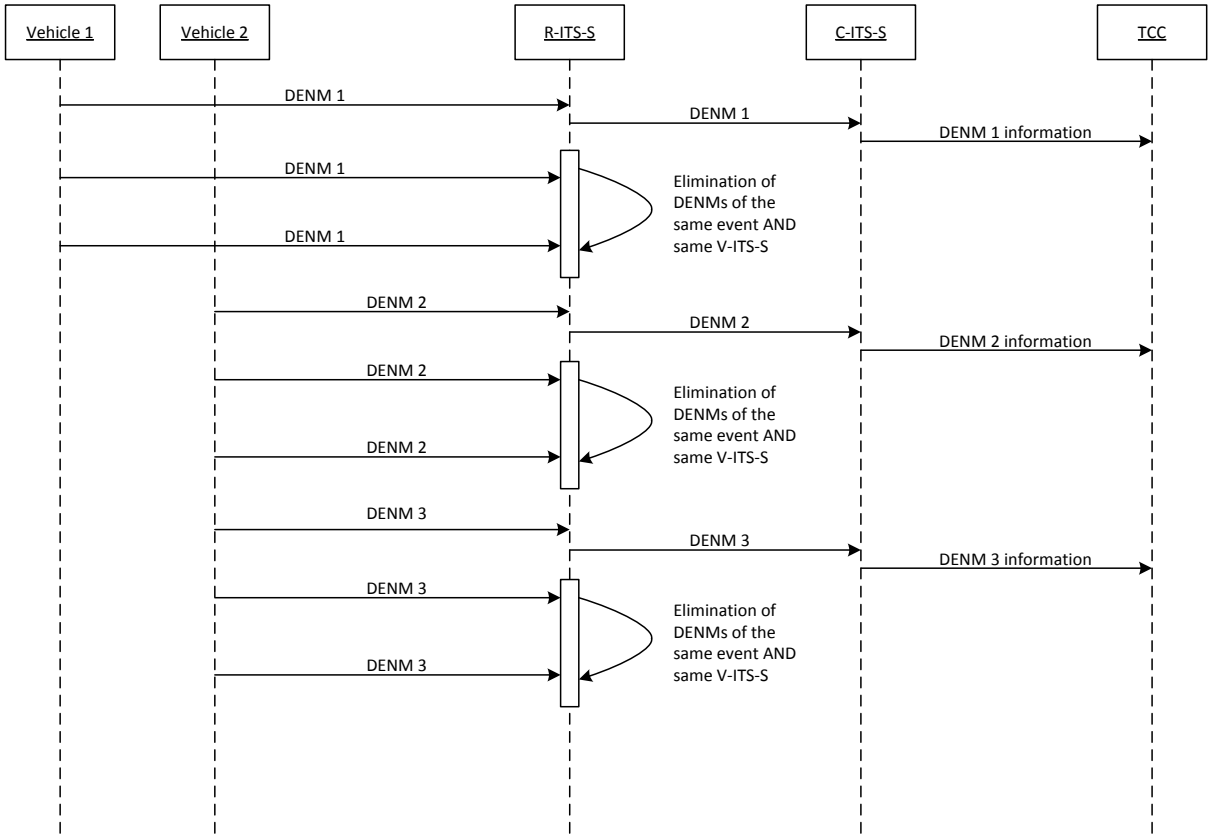

Figure 25: Handling and processing of DENM sent from V-ITS-S

Vehicles are broadcasting DENMs that will be received by R-ITS-Ss. The DENMs received by the R-ITS-S can be from different V-ITS-Ss and can contain different events. The sequence diagram above shows an example of 2 vehicles are broadcasting periodical DENMs (vehicle 1 is broadcasting a sequence of DENMs containing the same event (DENM 1), vehicle 2 is broadcasting sequences of DENMs containing 2 different events (DENM 2 and DENM 3)). In the figure above the arrows of DENM 1 to 3 lead only to the R-ITS-S. Of course the broadcasted DENM would be also received by the other vehicle, but this is not relevant for this scenario. Therefore this arrow is not shown for simplicity reasons. The R-ITS-S eliminates DENM duplicates, i.e., originated by the same V-ITS-S AND containing the same event information (updates from a DENM containing new/changed information shall not be eliminated). Therefore the R-ITS-S eliminates all DENMs fulfilling these conditions, except of the first one. Only the unique DENMs are sent by the R-ITS-S to the C-ITS-S. The C-ITS-S does not filter any DENMs, but forwards the information of the DENMs to the TCC.

In order to eliminate DENM duplicates, the R-ITS-S has to remember the DENM for a specific duration. This duration shall be set to at least the maximum repetition duration specified in the triggering conditions for DENM (e.g. 300s: traction loss caused by slipperiness).

With this concept the TCC receives just one single information about a specific event from each vehicle. If more vehicles are sending the same event, the TCC can use these multiple DENM information (same event

but from a different vehicle) as quality information (if the event is reported by many vehicles the information has a higher quality).

4.4.5 DENM references

For informing the V-ITS-S about a specific traffic situation one or more DENM are needed. Therefore the message have to be releated each other.

- In the case of RWW the DENM data element “alacart/roadworks/referenceDenms” is used to reference the action ID of related DENM each other.
- In the case of OtherDENM the DENM data element “situation/linkedCause” is used to reference related cause codes.

Remark:
A common solution for referencing DENM will be requested by a change request from the ECO-AT members to ETSI

4.4.6 IVI Processing

4.4.6.1 IVI Message data flow

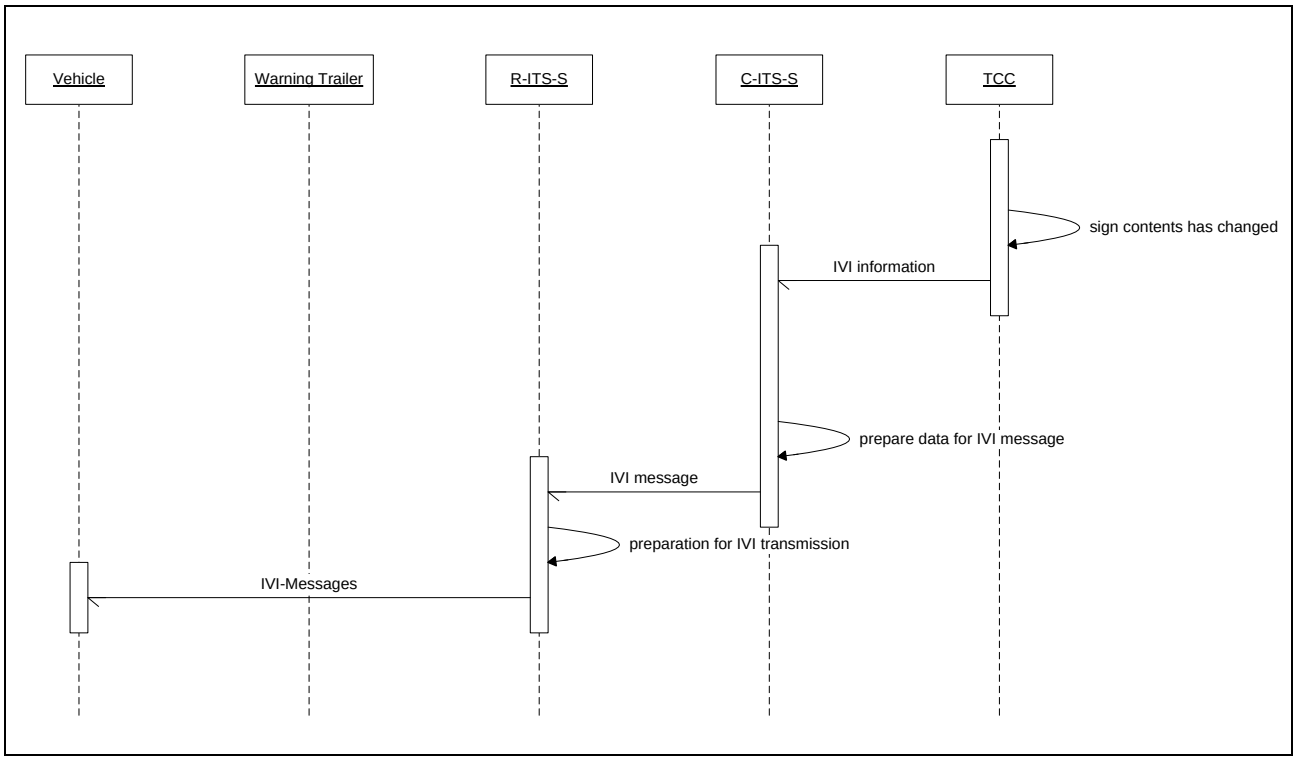

Figure 26 Generation and Procession of IVI

4.4.6.2 IVI message validity update process

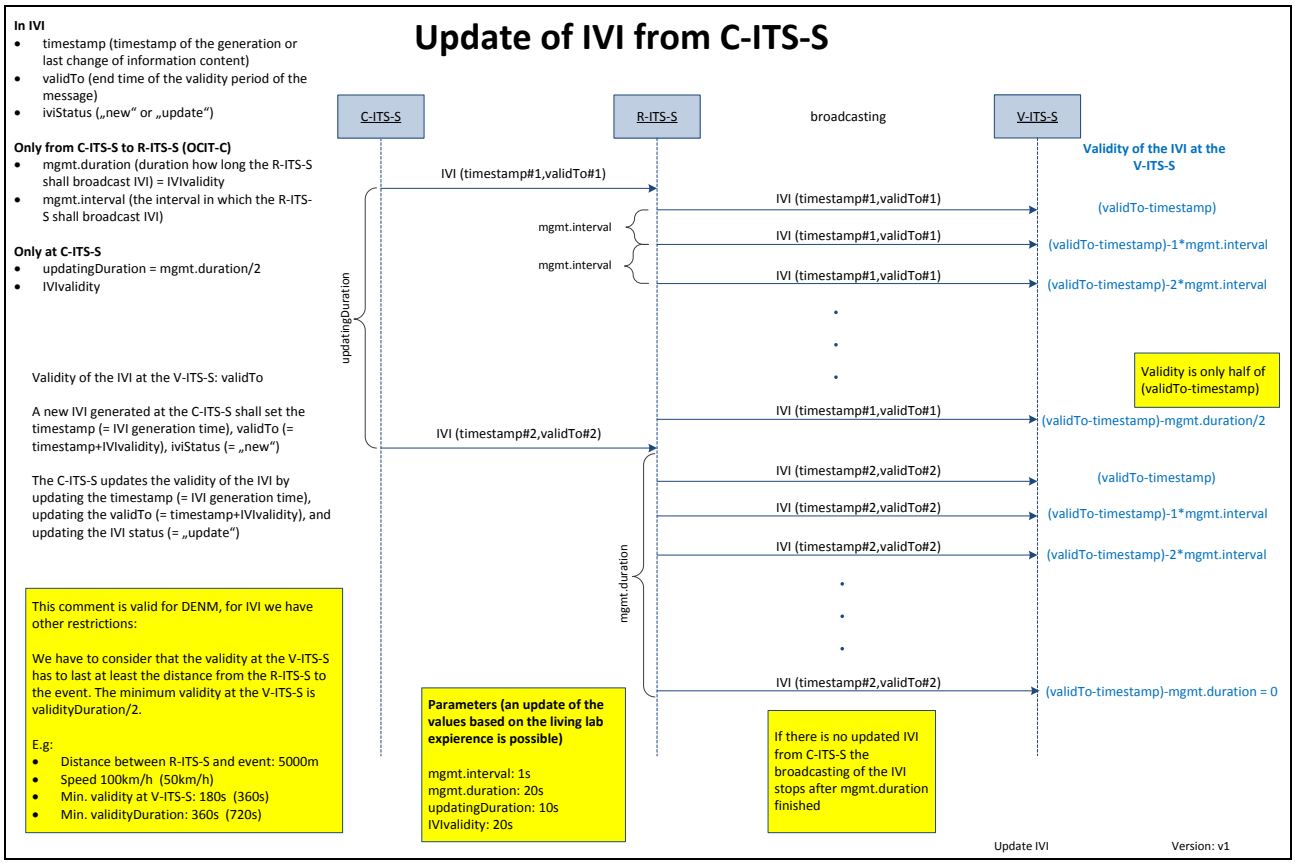

Figure 27 IVI message validity update

4.4.7 SPAT / MAP Processing

Not required for interurban use cases of Day 1 use cases. May be required for long term roadworks to provide changed lane structure.

4.4.8 Mapping of Data

Data received from and sent to the TCC via IF1 are structured according to the DATEX II standard. Data which are sent to the R-ITS-S via IF3 are structured according to the G5-standard telegram definitions for DENM, IVI and RWW. In between both interfaces the C-ITS-S will carry out a mapping of the data from one standard into the other. The mapping tables for all UC can be found in [ECo-AT SWP3.1 DATEX II mapping].

4.4.9 Data Dissemination

This description is based on the following requirements:

R_T_001 The TCC shall send DENM information to the C-ITS-S, as described in Ref. [ECo-AT UC RWW] and Ref. [ECo-AT UC other DENM] (UC RWW and UC other DENM applications). The information is sent to the C-ITS-S for a new DENM and for an update to an existing DENM.

R_T_003 The TCC shall send IVI information to the C-ITS-S, as described in Ref. [ECo-AT UC IVI]. The information is sent to the C-ITS-S for a new IVI and for an update to an existing IVI.

R_C_003 The C-ITS-S shall receive DENM information from the TCC, as described in Ref. [ECo-AT UC RWW] and Ref. [ECo-AT UC other DENM] (UC RWW and UC other DENM applications).The information is received from the TCC for a new DENM and for an update to an existing DENM.

R_C_083 The C-ITS-S shall forward DENM information (DENM data / UC other DENM applications) to the TCC.

R_C_084 The C-ITS-S shall send DENM data to the R-ITS-S, as described in Ref. [ECo-AT UC RWW] and Ref. [ECo-AT UC other DENM] (UC RWW and UC other DENM applications). The information is sent to the R-ITS-S for a new DENM and for an update to an existing DENM.

R_C_085 The C-ITS-S shall send IVI data to the R-ITS-S, as described in Ref. [ECo-AT UC IVI]. The information is sent to the R-ITS-S for a new IVI and for an update to an existing IVI.

R_C_017 The C-ITS-S shall be able to send DENM data and IVI data to a subset of R-ITS-Ss. This subset shall be chosen, based on the R-ITS-S dissemination selection method, as described in Ref. [ECo-AT SWP3.1 C-ITS-S].

The module Data Dissemination is responsible for the selection of the appropriate R-ITS-S for broadcasting to the vehicles. The messages shall not be disseminated to all R-ITS-Ss in the system, but to selected R-ITS-S that are in the vicinity of the event. The ECo-AT approach for R-ITS-S selection during Day 1 of C-ITS is not to select the first R-ITS-S in upstream traffic direction, but a set of R-ITS-S. The selection result (i.e. which R-ITS-S) shall distribute the message, depends on the location of the event (the TCC can define the radius). Therefore the location of the event determines the selection of the distribution area.
All information, events and alarms are referenced to a geo position (coordinates).

- Roadworks
- Hazardous spot information provided by vehicles
- Hazardous spot information provided by the TCC

Based on that reference the distribution area is selected. The distribution area is defined as a circle around that reference point.

The C-ITS-S will disseminate the messages to any R-ITS-S which is inside of a circle which is defined by a center point at the *eventPosition* and a radius equal to the *disseminationRadius*, as shown in Figure 28.

The information dissemination of traffic situations like roadworks warning is carried out using one or more DENM messages related to each other. The dissemination algorithm of the C-ITS-S has to take care, that the related DENM of a specific traffic situation are not split over different R-ITS-S. All related DENM of a traffic situation shall be sent using the same R-ITS-S.

The *eventPosition* (latitude / longitude coordinates of the location of the event) shall be furnished to the C-ITS-S by the TCC.

The *disseminationRadius* may be furnished to the C-ITS-S by the TCC. If the TCC does not furnish the *disseminationRadius*, the C-ITS-S will utilize the *defaultDisseminationRadius*, which is a C-ITS-S configurable item: 500..50000m

The default value shall be based on:

- Use case (well-known and unambiguous per UC, furnished by TCC)
- Number of R-ITS-S to be selected (set of an upper boundary for *defaultDisseminationRadius*)
- Distance between the R-ITS-S after roll-out (tbd: min, max, average)

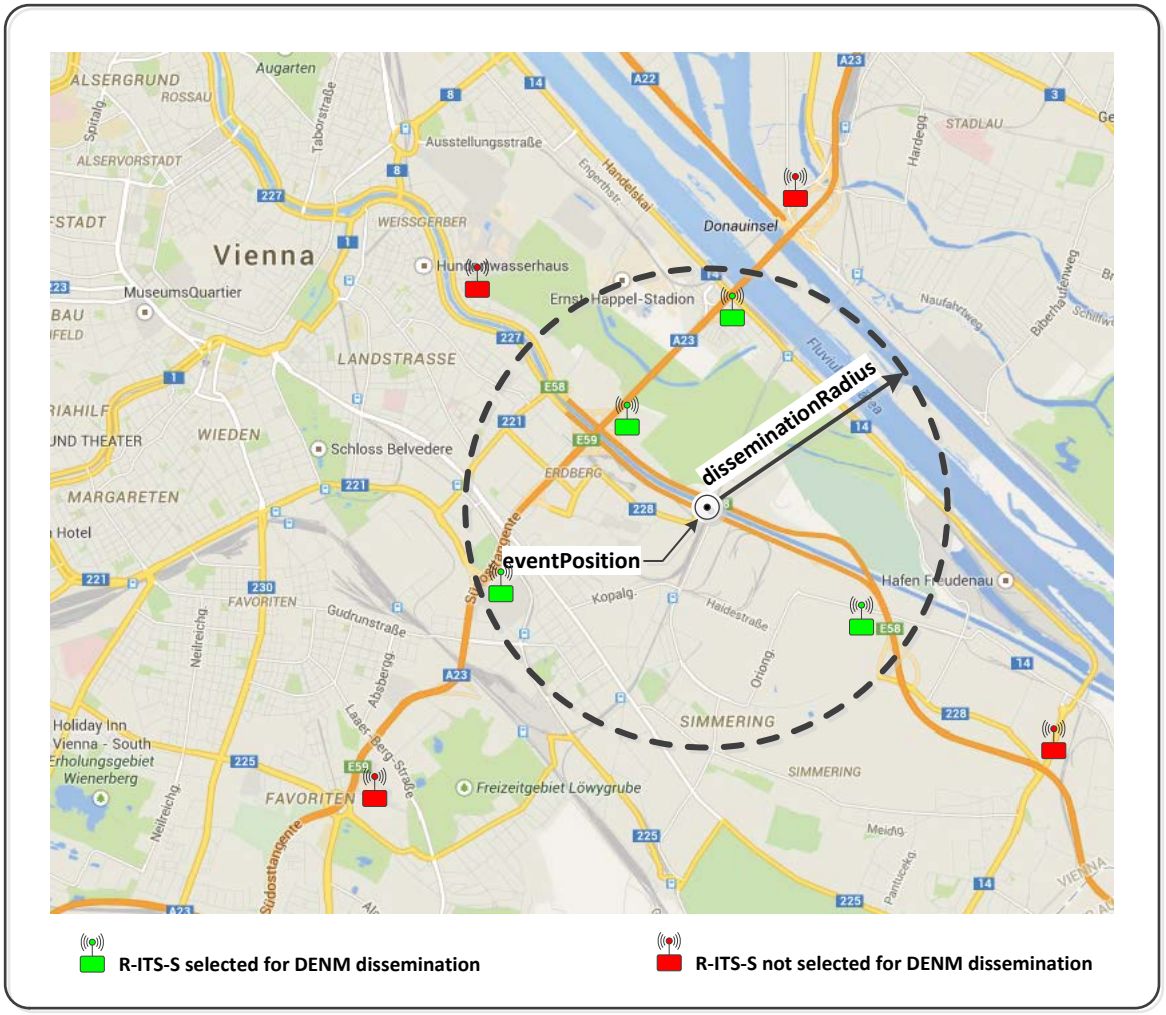

Figure 28: Circle method for R-ITS-S dissemination selection

4.5 Security / PKI Management

R_C_087 C-ITS-S shall fulfill the overall system security.

The functionality of the system component PKI (certification authotity) is not yet standardized. There is a propriatary PKI-server implementation existing within the the C2C-CC consortium. The usage of the C2C-CC PKI server is reserved for C2C-CC members and needs special agreement if the manufacturer is not member of the the C2C-CC. The C2C-CC pilot PKI will be just used for the Living Lab, not for the final specification.

The C-ITS-S will be an element of the overall interurban network like the TCC and all roadside equipment. All fixed R-ITS-S will be connected directly via cable. Internal security is fulfilled by the security mechanisms of this network. Mobile R-ITS-S will be connected via the 3G/4G which will be secured by a VPN-tunnel.

4.6 C-ITS-S Hardware

The hardware of the C-ITS-S is mainly defined by the proprietary system architecture and system requirements. There are various concepts for the HW-architecture consisting of e.g. a C-ITS-S main server, an archive server and one or more user clients to provide access to the server for several parties.

5 Subworkpackage Description

5.1.1 Development

The basic functionality of the C-ITS-S described in this document will be implemented and pre-tested in the labs of the manufacturers.

A prototype of the C-ITS-S development will be released to SWP4 (living Lab) for integration in the TCC system.

More detailed tests for validation of the C-ITS-S functionality will be specified in the sub work package SWP3.7

6 Deliverables

This document is one of several documents related to SWP 3.1. The following table lists the deliverables related to the sub-workpackage 3.1.

Table 10: List of Deliverables

C-ITS-S functional description	[ECo-AT SWP3.1 C-ITS-S]
IF3 (C-ITS-S <> R-ITS-S) interface	[ECo-AT SWP3.1 IF3 management] [ECo-AT SWP3.1 IF3 comm]
IF1 (TCC<> C_ITS-S) interface	[ECo-AT SWP3.1 IF1 data]
IF1 <-> IF3 mapping tables	[ECo-AT SWP3.1 DATEX II mapping]
IF3 XML schema definitions	[ECo-AT SWP3.1 IF3 XSD]