C-ITS Cross-Border Testing and Validation Concept

C-Roads Platform

Working Group 2 Technical Aspects

Taskforce 5 Cross-Testing and Validation

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Publication History

Table 1 Publication History

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0.1	11.10.2018	First table of content	draft
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~~Table 1 Publication History~~

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Acronyms

Table 2 Acronyms

Term	Meaning
BI	Basic Interface
C-ITS	Cooperative ITS
CAM	Cooperative Awareness Message
DENM	Decentralized Environmental Notification Message
ETSI	European Telecommunications Standards Institute
GLOSA	Green Light Optimal Speed Advisory
HLN	Hazardous Locations Notifications
HMI	Human Machine Interface
IVIM	In-Vehicle Information Message
IVS	In Vehicle Signage
ITS	Intelligent Transport Systems
ITS-G5	ITS-G5 is a European standard for ad-hoc short-range communication of vehicles among each other (V2V) and with Road ITS Stations (V2I). ITS-G5 refers to the approved amendment of the IEEE 802.11 (standard IEEE 802.11p). This technology (possibly others) uses the 5.9 GHz frequency band to support safety- and non-safety ITS applications. In this document ITS-G5 stands for IEEE802.11p/ETSI ITS-G5.
ITS-S	ITS Station
MAPEM	MAP (topology) Extended Message
OBU	On-board Unit
PCAP	Packet Capture
R-ITS-S	Roadside ITS Station (the so-called RSU)
RSU	Roadside Unit
RWW	Road Works Warning
SPATEM	Signal Phase And Timing Extended Message
SUT	System Under Test
V-ITS-S	Vehicle ITS Station (the so-called OBU)

~~Table 2 Acronyms~~

Glossary

Table 3 Glossary

Term	Meaning	Source
Certification	Certification ensures that a product can legitimately claim to have implemented a standard correctly.	ETSI Interoperability report [1]
Compliance Assessment	Compliance assessment is an activity that helps to directly or indirectly identify the extent, to which vehicle or its constituent parts comply with the set of technical requirements, which must be validated to make the C-ITS station operational. From an operational point of view, compliance assessment is an equipment authorization issued by a compliance assessment body based on representations and test data submitted by the applicant.	EU Compliance Assessment report [2]
Conformance assessment	Conformance assessment means checking that products, materials, services, systems or people measure up to the relevant reference specifications and standards.	EU Compliance Assessment report [2]
Conformance testing	Conformance testing involves connecting a device to a test system and operating a set of stringently defined tests. This ensures that a (single) product implements the requirements laid down in a standard correctly.	ETSI Interoperability report [1]
Conformity assessment	Conformity assessment shall mean the process demonstrating whether specified requirements relating to a product, process, service, system, person or body have been fulfilled. In this report this term can be considered a less stringent synonym of compliance assessment.	EU Compliance Assessment report [2]
Conformity / Compliance Testing	Conformance testing is the process used to determine whether a product or system complies with the requirements and/or functional reference specifications.	EU Compliance Assessment report [2]
Declaration of Conformity	Declaration of Conformity is the conclusive step of a procedure where a responsible party makes measurements or takes other necessary steps to ensure that the equipment complies with the appropriate technical standards.	EU Compliance Assessment report [2]
(Functional) Evaluation	Assessing whether the system fulfills the intended business and functional needs.	
Individual approval	Approval of an individual vehicle instead of a type approval. On the basis of [5], individual approval can only be applied to specific categories of vehicles like vehicles designed and constructed for use by the armed services, civil defense, fire services and forces responsible for maintaining public order.	EU Compliance Assessment report [2]
Interoperability testing	Interoperability testing involves connecting devices from different vendors and operating them in a variety of real-life scenarios.	ETSI Interoperability report [1]

Term	Meaning	Source
(Technical) Testing	Evaluating the system's compliance with the specified technical requirements.	
Type approval	Type approval is the confirmation that production samples of a design (i.e., the type of vehicle or simply the model of a vehicle) will meet specified performance standards. The specification of the product is recorded and only that specification is approved.	EU Compliance Assessment report [2]
Verification	Verification is a procedure where the manufacturer makes measurements or takes the necessary steps to ensure that the equipment complies with the appropriate technical standards.	EU Compliance Assessment report [2]

~~*Table 3 Glossary*~~

References

Table 4 References

Reference	Document
[1]	ETSI; IOT Best Practices; Interoperability Best practices; edition 2 (www.etsi.org, www.plugtests.org)
[2]	C-ITS Platform Phase II; Working Group Compliance Assessment; Final Report; 12 July 2017. (Annex I of C-ITS platform Phase II Final Report)
[3]	C-Roads; Common C-ITS Service Definitions; Version 1.6~~3~~; Release 1.6~~3~~; ~~-~~04/02/2020~~17/09/2018~~.
[4]	C-Roads; C-ITS Infrastructure Functions and Specifications; Version 11.1~~8.0~~; release 1.6~~3~~;~~-~~18/12/2019~~17/09/2018~~.
[5]	C-Roads; Roadside ITS G5 System Profile; Version 6.2~~00.03~~; release 1.5~~3~~; 25/06/2019~~-17/09/2018~~.
[6]	C-Roads; Specification for interoperability of backend hybrid C-ITS communication, Version 1.5, 02/07/2019
[7]	Draft Report on European Security Mechanism, Version 1.7, WG2, TF1 27/07/2019

~~*Table 4 References*~~

1. Introduction

This document is a deliverable of Taskforce 5 of Working Group 2 of the C-Roads Platform as presented by the figure 1. It describes the concept for Cross-Border Testing and Validation for C-ITS.

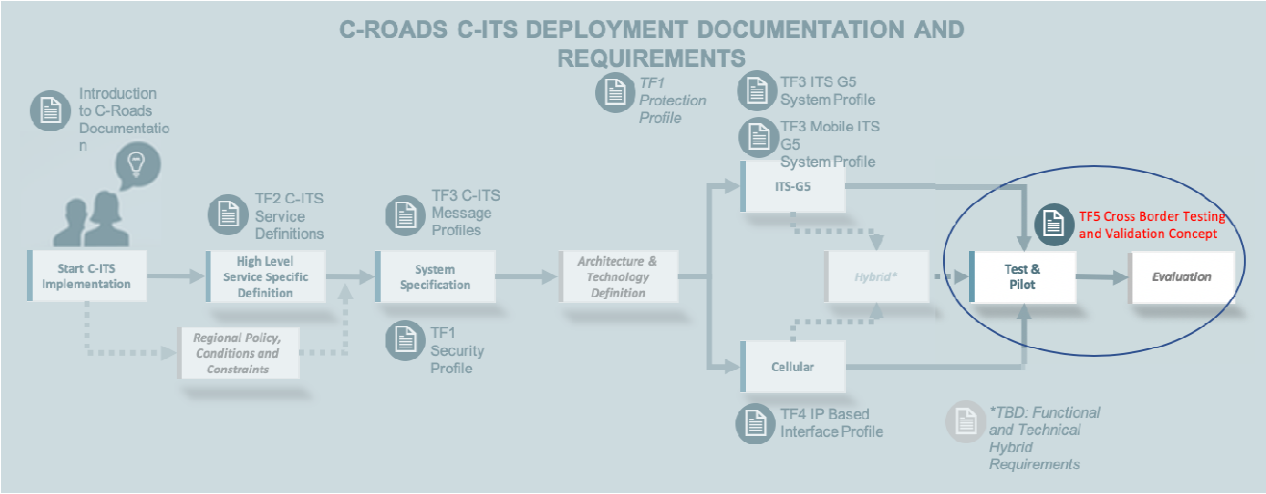

Figure 1: Overview on WG2 C-Roads deliverables

This document describes the overall concept. An additional deliverable denoted 'C-ITS Test Plan' contains the individual and detailed ~~test case~~test cases, a listing of all test cases can be found in the Appendix. Also, another deliverable "C-ITS Cross-Border Testing: PCAP Exchange Specification" contains a common procedure to execute one step of the methodology introduced in this document.

C-ITS is based on vehicle to vehicle communication and communication between vehicle and physical and/or digital infrastructure.

To ensure that this works in a European, multi-operator and multi-vendor environment, it is important to ensure interoperability. It is well-known from other systems that a way to ensure this is through compliance assessment. The objective of this report is to issue recommendations on how this compliance assessment can be performed.

The present release of this document guides through all aspects of interoperability testing for ITS-G5 systems, hybrid communication and security elements, as specified by Working Group 2 of the C-Roads Platform.
~~is a first release that will in subsequent steps be enhanced within C-Roads. This version extends the version 1.0, for testing of ITS-G5 systems, hybrid communication and security elements.~~
~~.~~

~~The present version of this document is still an incomplete draft and should not be distributed widely.~~
The flowchart below visualizes the full scale of C-Roads interoperability testing as recommended by Taskforce 5. Details and definitions of specific elements from the figure 2 will be provided in the upcoming chapters.

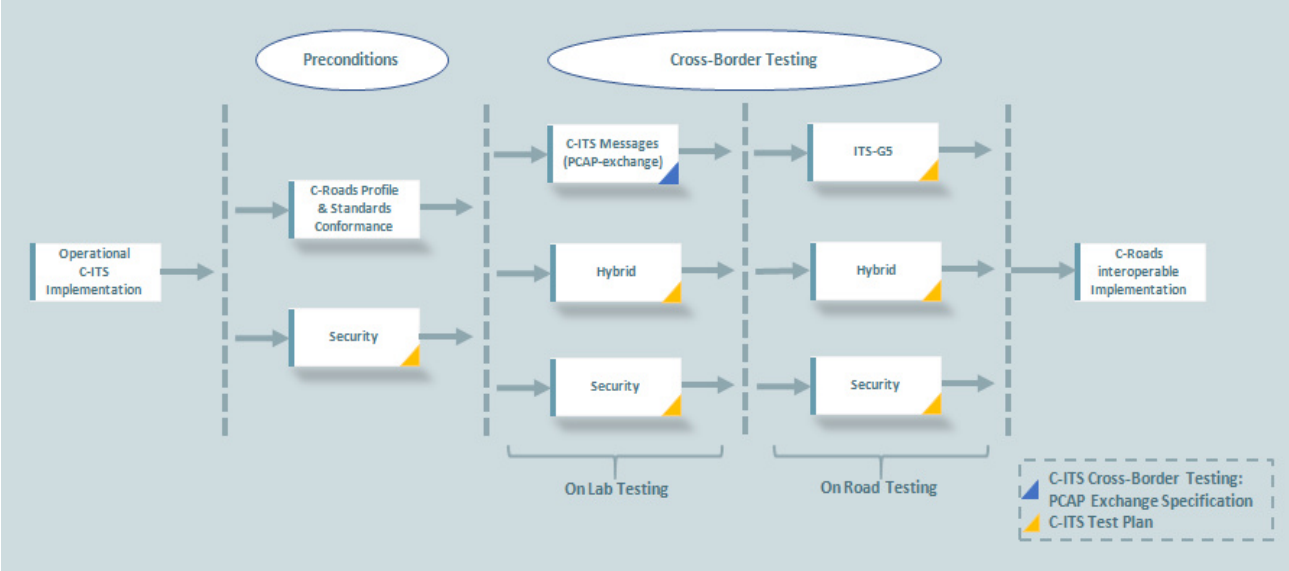

Figure 2~~2~~1: Overview on C-Roads interoperability testing

The second chapter provides a clear scope and necessary distinctions for the interoperability testing of C-Roads.

The third chapter elaborates on the framework of interoperability testing, as established by Taskforce 5, like common definitions for test-setups and templates for test cases and -documentation.

The last chapter documents the processes how the testing requirements were derived and provides recommendations for the test execution.

2. Scope

2.1. Definitions and Limitations

Cross-border Testing and Validation focusses on describing how to, based on the C-Roads Profiles, assess cross-border interoperability of implementations of C-ITS systems.

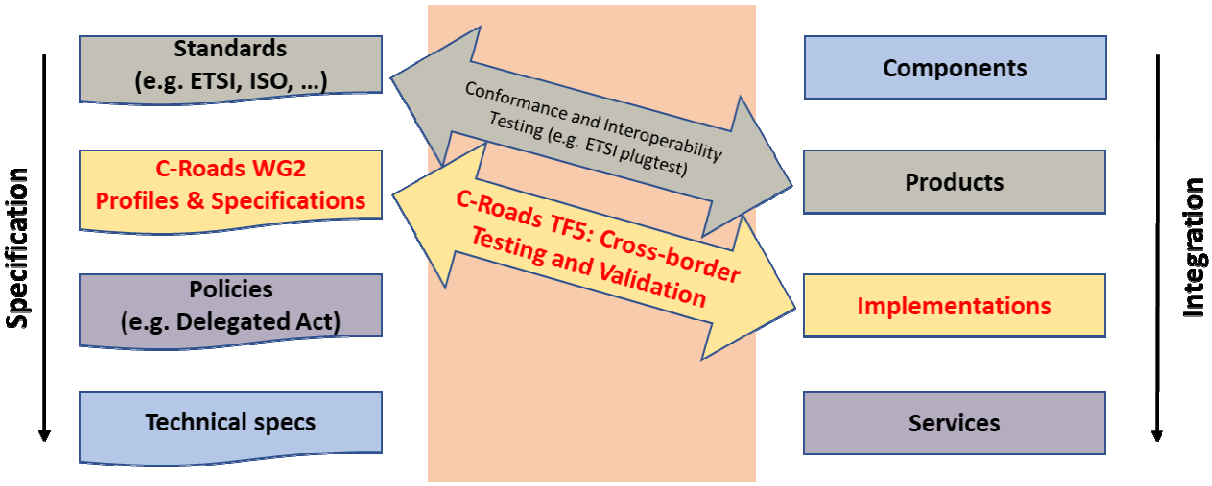

Figure ~~33~~1 Scope of C-Roads WG2/TF5

The scope of the task of Taskforce 5 is limited to:

- **Road operator**. Being part of the C-Roads Platform, the scope of TF5 only includes the road operator and infrastructure aspect of C-ITS for roadside systems and mobile systems.
- **Profiles & Specifications**. TF5 focuses on the C-Roads WG2 profiles and specifications (i.e. C-Roads Common C-ITS Service Definitions [3], C-Roads Functions and Specifications [4] and the specification for interoperability of hybrid C-ITS communications [6]., C-Roads Roadside System Profile [5]) only, not on the underlying standards and specifications. It is assumed that compliance to these underlying standards and specifications has already been assessed separately.
- **Test specifications**. The scope of TF5 does not include executing and performing actual tests, nor does it include type approval or certification. TF5 only provides specifications of tests.
- **Interoperability**. TF5 looks at the ability of end-to-end C-ITS system implementation to operate C-ITS services with foreign C-ITS-Ss, without any (re)configuration or action (e.g. a RSU from country A with an OBU from country B). TF5 does not look at conformance testing as defined by ETSI [1] nor does TF5 look at the quality of the implementation itself.
- **Implementations**. TF5 focusses on implementations of C-ITS systems only, not on individual products, equipment or components. It is assumed that the underlying products, equipment and/or components have already been tested separately and previously. Note that products are assumed to have already passed conformance tests on product level. Note also that the ETSI Plugtests also focus on interoperability but on a product- rather than on an implementation-level. The scope of TF5 thus goes beyond the ETSI Plugtest, from product to implementation.
- **Testing and Validation**. TF5 focuses exclusively on the (technical) verification and validation of systems, and not on the specification, set-up or operation of tests, nor on the (functional) assessment. The HMI can be used for validation and does not form part of the

technical testing as it is vendor specific and may vary for different pilot sites. Other tools can also be used for validation. C-Roads have not defined what the HMI shall look like.

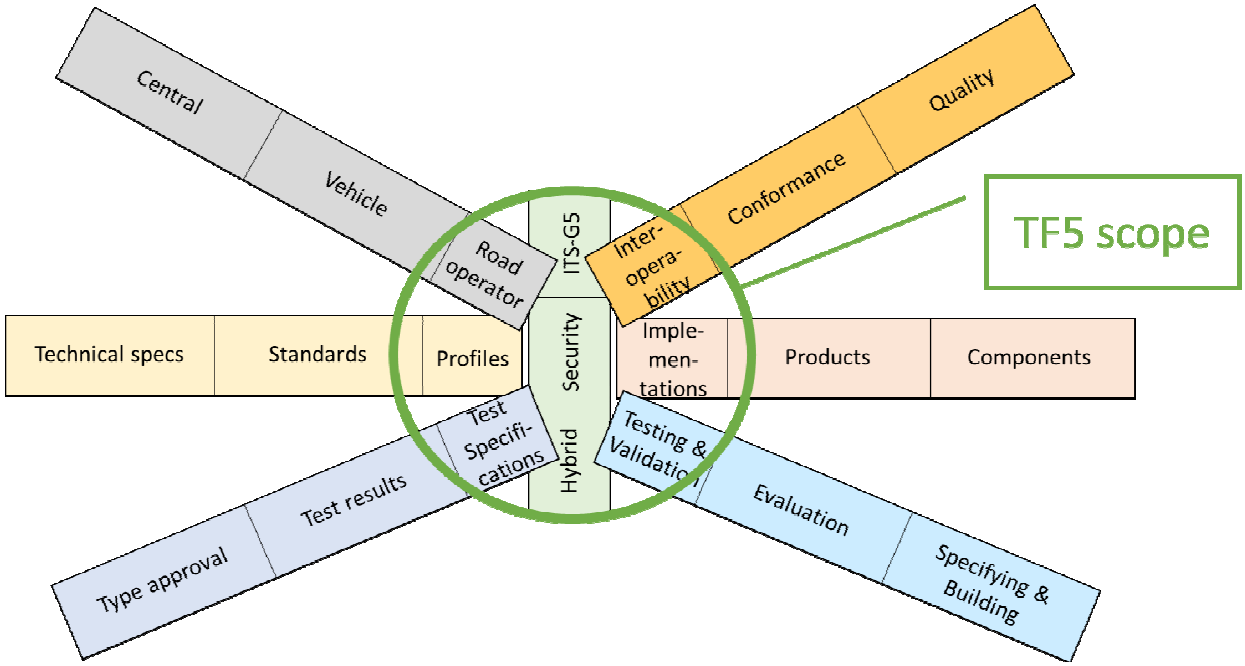

Figure 442 Limitations of the scope of TF5

2.2. Relevance to the EU Compliance Assessment report [2]

The EU report [2] describes compliance assessment as follows.

> *"The methodology for validation should make it possible that C-ITS services are perceived by the end user the same way for the same C-ITS application, and at the same time efforts for testing and validation are minimal for all C-ITS station operators / manufacturers and service providers involved.*
>
> *In this context, the generic overarching term "compliance assessment" is used, since other terms such as "type approval" or "certification" might lead to pre-conclude on specific forms of compliance assessment (which might already be established in the road transport sector)."*

- *"**Compliance/conformance testing**. Compliance/conformance testing aims to determine whether a C-ITS Station complies with the relevant standards and reference specifications. …..*
- ***Interoperability testing.** Interoperability testing aims to test two or more implementations of a set of standards and reference specifications at C-ITS station level in their communication capabilities against each other and see if they work as expected. ….*
- ***End-to-end functional testing**. For end to end functional testing procedures other settings of the validation scheme and expected outcomes apply which need to be discussed with the main stakeholders in the C-ITS domain and need to make sure that the initial start of C-ITS introduction is according to the users expectations and takes into account the future extensions of applications and C-ITS units in operation. This will be achieved within the C-ROADS platform were the single work groups can elaborate a*

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set of common documents for the national implementations and take into account mutual acceptance."

Although the terminology is confusing, the scope of TF5 relates to 'End-to-end functional testing' according to the report [2]. 'Compliance/conformance testing' and 'Interoperability testing' relate more to products whereas the 'End-to-end functional testing' relates to implementations and refers to C-Roads.

Related to the compliance assessment process as described in the EU Compliance Assessment report [2] the scope of TF5 can be defined as given by the green circle in the figure below.

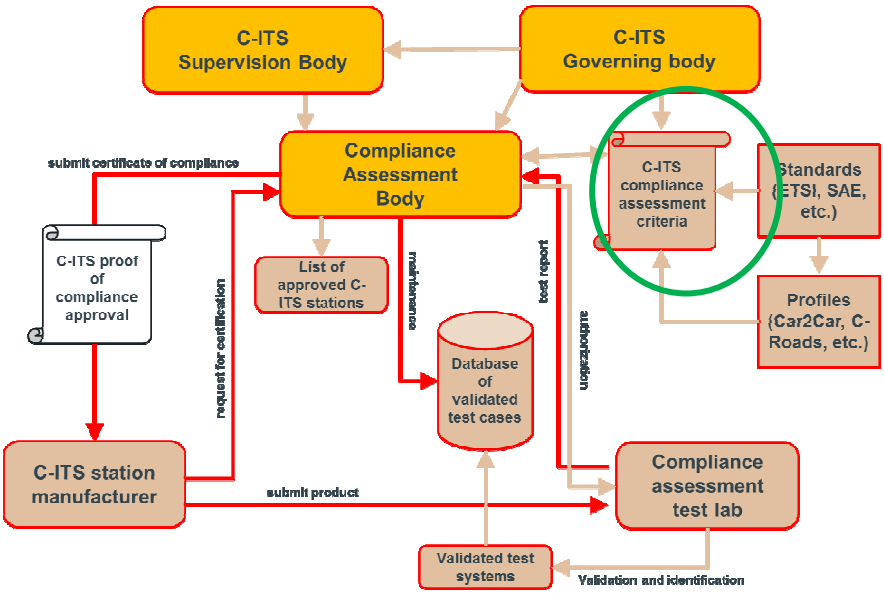

Figure 553 Overview of the compliance assessment process [2] to be updated

2.3. Relevance to the ETSI Interoperability report [1]

The ETSI report [1] defines interoperability as follows and warns for 'options'.

"There is no single definition of interoperability that will satisfy all readers. The following statement can be found at Wikipedia: Interoperability is a property of a product or system, whose interfaces are completely understood, to work with other products or systems, present or future, without any restricted access or implementation.

Interoperability is often thought of as little more than a testing activity. Rather, it should be regarded as a thread running through the entire standards development process and not as an isolated issue to be fixed at the end. Of course, testing is an important part of assuring interoperability but it is almost meaningless if the initial requirements gathering and the specification process do not consider interoperability as a fundamental objective.

Although, for the sake of consensus, it may seem attractive to include options and recommendations in a standard, the more they are used, the less likely it becomes that implementations will interoperate. A product that conforms to a standard that includes only mandatory requirements is almost certain to interoperate with other similar products. If it is essential to include an optional requirement within a standard, it should be expressed with a clear indication of the criteria which must be met if the option is to be selected."

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The ETSI report [1] distinguishes between 'Conformance Test Specifications' and 'Interoperability Test Specifications'. It defines relevant documents, comparable to the C-Roads deliverables.

> *"The structure of an Interoperable Features Statement (IFS) is similar to that of an Interface Conformance Statement (ICS). Its purpose is to identify the functions specified in the base standard(s) which an implementation should support, those which are optional and those which are conditional on the support of other functions. Although not strictly part of the interoperability test suite, the IFS helps to provide a structure to the suite of tests which will subsequently be developed.*
>
> *Both the ICS and the IFS are good vehicles for the collection of testable requirements from a single base standard or even a coordinated set of specifications from a single standards organization. However, many of today's technologies are standardized as groups of related but nevertheless disjoint specifications from a variety of sources. This is particularly true of IP standardization. Building a coherent set of test specifications from disperse requirements sources can be simplified by gathering the requirements together into a single catalogue.*
>
> *A Requirements Catalogue lists all implementation requirements from the various sources and organizes them into an appropriate structure. In most cases, creating a tree structure based upon functionality is a valid approach to structuring the requirements. Each node of the tree represents a specified function. Specific requirements are then associated with the relevant function node."*

These documents described by ETSI [1] are similar to what in C-Roads is referred to as Profiles. From the ETSI Interoperability report [1] it furthermore becomes clear where the scope of ETSI Plugtests ends and thus where the scope of TF5 begins. Based on the description of the relationship between Standards, Validation and Testing as described in the report, the relation to scope of TF5 can be described as given in the figure underneath.

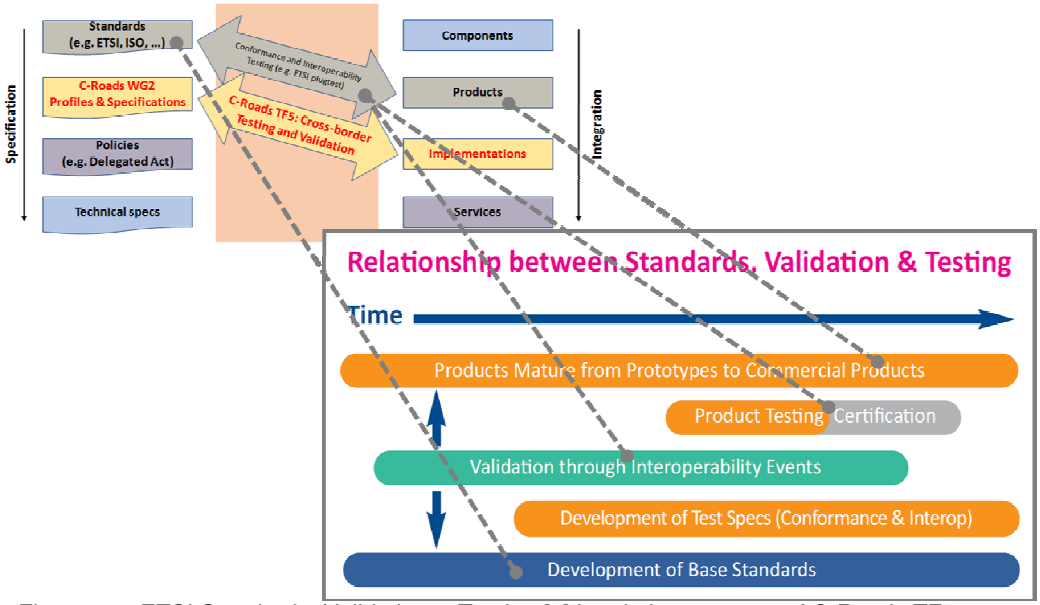

Figure ~~6~~64 ETSI Standards, Validation & Testing [1] in relation to scope of C-Roads TF5

2.4. Scope of TF5 for hybrid communications

Hybrid communication covers for transmission of C-ITS messages potentially using multiple communication channels; availability of such communication channels may vary depending on policy, location and requirements set. The Basic Interface (BI) specified in [6] relates to the data communication interface used for real time exchange of C-ITS messages in the backend communication and is independent of deployment model that the Member States or C-ITS actors choose to implement communication between backend servers. The BI is based on AMQP V1.0.
The scope of hybrid communication testing is currently restricted to the testing of BI between two C-ITS actors, say X and Y. Actors X and Y can be located in the same country or in different countries.

Both the backend servers of the actors X and Y implement an AMQP client, which takes care of the transmission and receipt of C-ITS messages. In addition to the C-ITS actors, a Broker (B) is used for routing of the C-ITS messages between the actors (Figure 7~~Figure 5~~). The Broker can be implemented as a single node or can consist of different nodes communicating with each other.

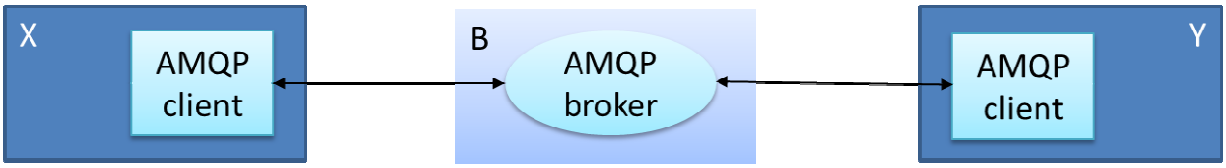

Figure ~~7~~5. Components in the C-ITS message exchange in hybrid communications

Requirements in [6] relate to both the actors X and Y as well as to the broker (B).

Actually, the TF5 scope for hybrid testing is to validate if the communication between the backends of the two C-ITS actors is according to the C-ROADS specifications. This will be extended in the future when the link to the vehicle will be specified.

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3. Framework

3.1. Introduction

This chapter describes the 'framework' for Testing and Validation as perceived by TF5. The framework includes 'building blocks' such as test-subjects, test-categories, test-types, test-environments, ~~test-case~~test cases and test-results.

3.2. Test-subject

A test-subject (comparable to 'test-purpose' in [1]) gives the specific aspect within the Profiles that is being tested. TF5 distinguishes the following test-subjects.

- **Security**
- **Facility** (message payload)
  - DENM (e.g. Road Works Warning (RWW))
  - IVIM (e.g. In-Vehicle Signage (IVS))
  - MAPEM/SPATEM (e.g. Green Light Speed Advisory (GLOSA))
- **Network and Transport**
- **Access**

3.3. Requirement-categories

TF5 has divided the requirement in the Profiles into 3 different categories.

- **Category 1 (C1)**. Requirements labelled as C1 are relevant for the local implementation and have to be tested in the country implementing it.
- **Category 2 (C2)**. Requirements labelled as C2 are relevant for cross-border interoperability but can be tested within t**he environment** of the local country, operator or manufacturer. They however are a prerequisite for further cross-border testing.
- **Category 3 (C3)**. Requirements labelled as C3 are to be validated by means of actual cross-border tests.

TF5 specifies tests for categories C2 and C3, not for C1. All tests for a service specified by TF5 are mandatory if the MS deploys this service.

The hybrid system contains of 2 types of actors: the C-ITS actors (X and Y in Figure 7~~Figure 7Figure 5~~) and the Broker (B in Figure 7~~Figure 7Figure 5~~).
The tests are classified according to the actors required in the tests:

Criteria for identifying the requirement category:

- C1: the requirement can be validated by a single C-ITS actor (X) and the broker (B). In this case the test is performed by e.g. subscribing to the part of the messages transmitted (i.e. X subscribes to a subset of the messages sent by X)
- C2: the requirement can be validated by 2 C-ITS actors from the same country (and a broker).
- C3: the requirement has to be validated by 2 C-ITS actors from two different countries (and the broker).

The broker is a key component of the system. In order to be able to perform the testing, a broker has to be made available. Other brokers will have to be tested against the specifications.

3.4. Test-type

TF5 distinguishes the following five types of tests. The ~~test-case~~test cases specified by TF5 will be among the test-types “Lab-test” and “Road-tests”.

- **Lab-test**. The laboratory testing is the first step to validate the ability of a communication unit or system to operate the basic functionalities to implement Day 1 C-ITS services and use-cases in laboratory environment where there are no risks of influencing the road safety and security. The goal of this testing is to tune the properties before implementing the C-ITS system in real environment. During this procedure the I2V interaction between R-ITS-Ss and V-ITS-Ss from different origin will be tested.
- **Controlled test**. These tests are performed outside but in a controlled environment. ITS-G5 coverage and messages (DENM, IVIM, SPATEM, MAPEM, CAM, …) need to be provided in the test area. These tests shall allow participants to drive at low speeds for a short distance within the coverage area of an R-ITS-S in order to test the correctness of received information at their V-ITS-S in an open-air ‘laboratory’ environment. This environment shall allow actual driving in short loops with the possibility to directly correct flaws if required.
- **Road-tests**. These tests are performed on actual roads, in real-life traffic. ITS-G5 coverage from multiple R-ITS-Ss spaced at relevant distances and relevant message sets (DENM, IVIM, SPATEM, MAPEM, CAM, …) representing realistic scenarios need to be provided on the road. Specific safety instructions will be required. These tests shall allow participants to test their equipment in a real live environment. Scenarios may be virtual or live. Virtual scenarios are predefined but imaginary traffic situations. These scenarios may be supported by a photo-script depicting the imaginary traffic situations. Live scenarios are actual real-life traffic situations, e.g. road works and/or traffic jams.
- **Operational tests**. These tests are, like road-tests, performed in real-life traffic situations but are stretching a longer period. Operational tests shall focus on functioning and performance of the systems over weeks or months instead of hours or days. Operational tests will in most cases be performed by technical experts or at least skilled users.
- **Pilots**. Pilots are tests over longer periods involving real end-users (road operators). The participants, although chosen specifically for the pilots, shall be representative for actual future end-users.

For hybrid systems, as the main focus is on the backend communication, all the tests provided until now can be performed as **Lab tests** and as **Pilots**. TF5 will provide on-road tests to validate the whole end-to-end hybrid communication link.

3.5. Test-environment

- **Single tests**: Performed within the context of a single country.
- **Cross-border tests**: Bilateral cross-border testing involving two or more countries, operators or manufacturers.

This parameter may also include further details such as number of lanes, etc. if required.

Tests for hybrid include 3 actors, as described in section 3.3.

3.6. ~~Test-case~~Test case

The ~~test-case~~test case provides a description of the individual test. The ETSI Interoperability report [1] gives the following advice with respect to test-descriptions.

> *"A test-description should include as a minimum:*
> - *a unique test description identifier*
> - *a concise summary of the test which should reflect the purpose of the test and enable readers to easily distinguish this test from any other test in the document*
> - *a list of references to the base specification section(s), use case(s), requirement(s), TP(s) which are either used in the test or define the functionality being tested*
> - *a list of features and capabilities which are required to be supported by the System Under Test (SUT) in order to execute this test (e.g. if this list contains an optional feature to be supported, then the test is optional)*
> - *a list of all required equipment for testing and possibly also including a (reference to) an illustration (or a reference to it) of a test architecture or test configuration*
> - *a list of test specific pre-conditions that need to be met before the test sequence can commence an ordered list of manual or automated operations and observations."*

TF5 has defined a template for the description of ~~test-case~~test cases. Below is an example of the template for testing the service "Road Works Warning".

C-ROADS	TF5 Test-case description template	
Service	Road Works Warning (RWW)	
Use case	Lane Closure (and other restrictions) RWW-LC	
TC ID	TC_CROADS_RWW-LC_ITSG5-DENM_LaneClosure	
Test case name	DENM "Road Works" check the availibility of event message lane closure sent through ITS-G5	
Requirements Specifications	C-ITS Infrastructure Functions and Specifications Version 1.3, section 3.2.1.2, table 6 Common C-ITS Service Definitions Version 1.3 section 3.2.1	
Test objective (Short description)	To verify the availibility of transmitted CC and SubCC	
Test environment	On-Road	
Test setup	V-ITS-S from country A enabled to display the DENM and R-ITS-S mounted on a trailer/vehicle from countr	
Initial Conditions		
R-ITS-S is launched and transmits a DENM with a Cause Code CC and SubcauseCode SubCC. V-ITS-S is launched and moving towards the R-ITS-S		
Test scenario		
1. R-ITS-S on the trailer/vehicle is switched on 2. R-ITS-S is sending DENM with CC and SubCC 3. V-ITS-S is travelling towards R-ITS-S 4. The information about lane position provided by TCC		
Test variables		
CC =3 SubCC = 0,4 Laneposition 0,1,2,3,4...		
Expected behaviour		
1. V-ITS-S receives the DENM sent from R-ITS-S 2. The event message contains the transmitted CC, SubCC values and lane position		
Minimum number of repetitions	3	
Test's comments	The test is to be repeated with different SubCC and lane position.	
Verification Points (VP)		
VP#	**Description**	**Threshold**
1	Does the recieved DENM contain the transmitted CC and SubCC values?	Checked
Test Validation Conditions	The verification point 1 has passed in all the repetitions	

Figure 86 TF5 ~~Test-case~~Test case description for testing services defined by TF2 (example)

- **Service**: The service as defined by TF2 [3] which is tested.
- **Use case**: The use case as defined by TF2 [3] which is tested.
- **TC ID**: The ~~test-case~~test case ID, defined as: TC_CROADS_USECASE-ID_COMMUNICATION-MODE_MESSAGE-TYPE_TESTED-DATA-ELEMENT_TESTID.
  - For example:
    - *TC_CROADS_RWW-LC_ITSG5_DENM_LaneClosure.*
  - *In specific:*
    - *USECASE-ID: Abbreviation of applicable use case as defined by TF2 [3]*
    - *COMMUNICATION-MODE: either ITSG5 or HYBRID*
    - *MESSAGE-TYPE: either DENM, IVIM, SPaTEM or MAPEM*
    - *TESTED-DATA-ELEMENT: Data element from TF3 [4]*
    - *TESTID: a unique ID to take multiple ~~test-case~~test cases on the same TESTED-DATA-ELEMENT into account*
- ~~**Test-case**~~**Test case name**: Short descriptive name.
- **Requirements Specifications**: Document reference of the specific requirement, defined as: C-Roads specification XXXX Version X.X paragraph X of Section X.

- **Test-objective** (Short description): Short description of the test.
- **Test-environment**: Lab test or Road test
- **Test-setup**: List of equipment or software needed for the test, for example: Sniffer, vehicle equipped with an ITS station, mobile R-ITS-S, etc.
- **Initial Conditions**: The basic settings of the equipment and/or the pre-request tests which are assumed to have been performed in advance. For example:
  - *R-ITS-S is launched and transmits a DENM with a Cause Code CC and SubcauseCode SubCC.*
  - *V-ITS-S is launched and moving towards the R-ITS-S*
- **Test-scenario**: Description of the step-by-step scenario. For example:
  - *R-ITS-S on the trailer/vehicle is switched on*
  - *R-ITS-S is sending DENM with CC and SubCC*
  - *V-ITS-S is travelling towards R-ITS-S*
  - The information about lane position provided by TCC
- **Test-variables**: The values of the variables used in the scenarios. For example:
  - CC = 3
  - *SubCC = 0;4*
  - *Lane position 0,1,2,3,4*
- **Expected behaviour**: The expected outcome formulated positively. For example:
  - *V_ITS-S receives the DENM sent from R-ITS-S*
  - *The event message contains the transmitted CC, SubCC values and lane position*
- **Minimum number of repetitions**: The number of test repetitions needed in order to validate the requirement. 3 is the recommended number of repetitions for testing services, whereas ~~testcase~~test cases for security and hybrid communication might require only one repetition.
- **Test-comments**: Add comments if needed. For example:
  - *The test is to be repeated with different SubCC and lane position*
- **Verification Points (VP)**: The list of elements to be checked in order to validate the test. The points of verification are to be formulated as questions.
- **Test Validation Conditions**: The list of mandatory VPs to be validated against the threshold in order for the test to be successful.

Test-Case for TF1 Security:
Following is an example of a test-case for security based on requirements defined by TF1 [7].

C-ROADS	TF5 Test-case description template	
Service	To be filled…	
Use case	To be filled…	
TC ID	TC_CROADS_GENERIC_SECURITY_ECTL_Update	
Test case name	ECTL present and updated	
Requirements Specifications	Draft Report on European Security Mechanism V1.7 / B1.7. Verification of message signature / B1.7.1. Pre-Conditions	
Test objective (Short description)	The ECTL is provided to the ITS-S during the initialization phase and is updated periodically (if possible ev	
Test environment	On-Lab	
Test setup	Tested ITS-S with an ECTL about to be expired in few minutes	
Initial Conditions		
The ITS-S is laucnhed		
Test scenario		
1. ITS-S verifies the presence of a valid ECTL 2. ECTL expires 3. ITS-S downloades a new ECTL		
Test variables		
Expected behaviour		
1. Valid ECTL is downloaded and used by the ITS-S		
Minimum number of repetitions	1	
Test's comments		
Verification Points (VP)		
VP#	**Description**	**Threshold**
1	Is a valid ECTL provided in the ITS-S?	Checked
2	Is a new valid ECTL was downloaded after the expiration of the current ECTL?	Checked
Test Validation Conditions	The verification points 1 and 2 have passed	

Figure ~~7~~ 9 TF5 ~~Test case~~Test case description for testing security defined by TF1 (example)

Test--Case for TF4 Hybrid Communication:
Following is an example of a test--case for hybrid communication based on requirements defined by TF4 [6].

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C-ROADS	TF5 Test-case description template
Service	
Use case	
TC ID	TC_CROADS_GENERIC_Hybrid_DENM_Routing
Test case name	Generic DENM using Hybrid for Routing verification
Requirements Specifications	C-Roads specification Hybrid (BI) Version 1.6: HYB_025, additionally: hyb_026, HYB_027, hyb_043, hyb_049
Test objective (Short description)	The DENM is routed correctly and received by the service operator (and repeated)
Test environment	Lab test
Test setup	Actor SP1 from country 1, Broker, Actor SP2 from country 2
Initial Conditions	
1. Selecting the use-case to be tested (CC and SubCC). The message is repeated (according to the specifications) every 9 minutes 2. SP1, Broker and SP2 are connected and TLS certificates in place 3. SP1 subscribes to all events	
Test scenario	
1. SP2 publishes DENM over BI interface. The message is signed at geonet level prior to transmission. The DENM is repeated every 9 minutes 2. Broker routes the message to SP1 3. SP1 receives DENM	
Test variables	
Mandatory AMQP Application Properties Fields: publisher-ID: SP2code; orig-country: country 2; protocolVersion: DENM:1.2.2; messageType: DENM quadTree: Q1234567890abcdefg CauseCode = XX SubCauseCode = XX	
Expected behaviour	
1. The message is received and validated in the backend of SP1 (outside scope: 2. The message is sent to the vehicle and appears on the vehicle HMI)	
Minimum number of repetitions	3
Test's comments	New test run correspond to the same message repeated after 9 minutes.

Verification Points (VP)

VP#	Description	Threshold
1	The message is routed to the correct queue	Checked
2	The message is received at SP1	Checked
3	All mandatory AMQP Application Properties fields are present	Checked
4	The content of the mandatory AMQP Application Properties fields corresponds to the specific	Checked
5	The message geonet certificate is validated at SP1	Checked
6	The content of the received message is identical to the transmitted	Checked
Test Validation Conditions	The verification points 1,2,3,4,5,6 have passed in all repetitions	

Figure ~~8~~ 10 TF5 ~~Test case~~Test case description for testing hybrid communication defined by TF4 (example)

3.7. Test-result

Each test should provide a clear, preferably a Pass or Fail or Inconclusive, test-result. In case of Fail or Inconclusive the tester has to provide a comment. The document ETSI Interoperability report [1] gives the following advice.

> *"At the end of each test case (and, where necessary, interspersed with the test steps) it is important to specify the criterion for assigning a verdict to the test case. This is probably best expressed as a question.*

Verdict criteria need to be specified as clearly and unambiguously as test steps and without restrictions. If a criterion is expressed as a question, it should be constructed in such a way that "Yes" and "No" are the only possible answers and it should be clear which result represents a "Pass" verdict and which represents a "Fail".

Although it is clear that a "Pass" verdict will always mean that, for a specific test, the connected devices interoperate correctly, it may not be the case that a "Fail" verdict implies that they do not. The interconnecting network equipment plays an essential role in almost all interoperability tests but is not usually included in the equipment being tested. A "Fail" verdict may be caused by a fault or unexpected behaviour in the network. Thus, each "Fail" verdict should be investigated thoroughly, possibly using monitoring equipment to determine its root cause before either validating the verdict as a true failure (if the root cause is within the tested devices) or retesting."

TF5 has defined a template for reporting the test result as follows.

C-ROADS	TF5 Test-run template			
Service	To be filled...			
Use case	To be filled...			
TC ID	TC_CROADS_GENERIC_ITSG5-DENM_EventPosition			
Test case name	Generic DENM using ITS-G5 for Event Position verification			
Test site/location				
Testing country				
Test case date				
Test case time				
	Run 1	**Run 2**	**Run 3**	**Comments**
Security on/off	**off**	**off**	**off**	
Verification Points (VP) #				
VP 1				
Verdict				
Test Comments				

Figure ~~9~~ 11 TF5 Test-run (example)

- **Service**: same as in ~~testcase~~test case template.
- **Use case**: same as in ~~testcase~~test case template.
- **TC ID**: same as in ~~testcase~~test case template.
- **Test-case name**: same as in ~~testcase~~test case template.
- Test site/location: location where the test has been carried out. Only valid for on road testing.
- **Testing Country**: involved country(ies) (within C-Roads, this implies also the pilot site and the tested equipment, based on a shared database for all use cases; any special configurations should be explicitly listed here). For example:
  - for Single test: Country A (special equipment)
  - for Cross-border test: Country A (special equipment) and Country B (special equipment).
- **Test-case date:** The date, test was carried out
- **Test-case time:** Time of the test
- **Security on/off:** Indicates whether the test was carried out with or without security turned on.
- **Verdict:** the overall verdict of the test. There are 3 verdicts possible:

- Pass: the Test Validation Conditions of the ~~test-case~~test case are fulfilled
- Fail: the Test Validation Conditions of the ~~test-case~~test case are not fulfilled for a certain reason
- Inconclusive: the Test Validation Conditions of the ~~test-case~~test case are not fulfilled for an unknown reason

- **Test Comments:** Add comments if needed.

3.8 Common template for reporting

- It is advised to use a common template for reporting of all C-Roads cross-border testing results.

4. Process

4.1. Introduction

The Cross-border Testing and Validation process is divided into two main parts:

1. The detailed analysis of the requirements within the Profiles to produce test cases for each of requirements
2. The actual tests are to be performed and executed in the proper order to ensure interoperability, TF5 defines 3 main steps to be performed:

    2.1. On-lab tests: these tests include ETSI conformance tests and tests that belong to C1 and C2 categories extracted from C-Roads Functions & Specifications [4] and C-Roads Roadside System Profile [5]. They are let to the responsibility of the MS to be validated. No tests will be provided by TF5 except the DENM tests that are linked to C2 category.

    2.2. PCAP exchanging: TF5 provided a complete specification for PCAP exchanging specification. A separate deliverable is provided to specify the procedure of PCAP exchanging between MS. The exchange of PCAP files is linked to tests of category C3 as a prior step for on-road testing.

    2.3. On-road tests: these tests are linked to C3 category. They will be provided by TF5 for all the use-cases included in the C-Roads Common C-ITS Service Definitions document [3]. TF5 will also provide a common log specification.

To facilitate cross-border tests, it is important that detailed information about the cross-border environment is available. This information should contain a clear access point, the locations for specific test subjects and the test equipment.

For hybrid, the process involves:

1. The detailed analysis of the requirements within the specification for interoperability of backend hybrid C-ITS communication [6] to produce test cases for each requirement.
2. The actual tests are to be performed and executed in the proper order. To ensure interoperability.
    - On-lab tests: the following tests are included:
        - C1-tests: validation of the basic functioning of the backend. Tests are performed by connecting to a broker (e.g. reference implementation of a broker), and by subscribing to queues related to the message transmitted.
        - C2 tests: exchange of messages with another C-ITS actor, which can be from the same country.
        - C3 tests: exchange of messages with a C-ITS actor from another country
3. Logging
    - For logging the following logs should be produced during the tests:
        - LOG1: log of the C-ITS messages to be transmitted
        - LOG2: log of the data transmitted over AMQP
        - LOG3: log of the data in the receiving queue
        - LOG4: log of the received messages after validation

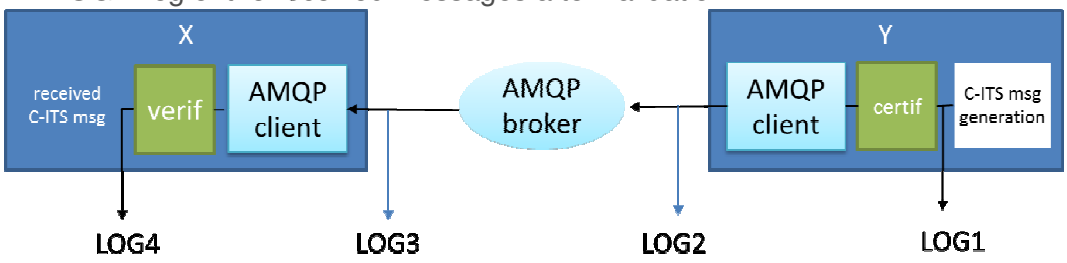

Figure 120 Overview logging

4.2. Analysis and description

The requirements contained in the C-Roads profile and specification documents C-Roads Common C-ITS Service Definitions [3], C-Roads Functions & Specifications [4], C-Roads Roadside System Profile [5] provided by TF2 and TF3 are analysed with respect to their relevance and impact on interoperability. Each requirement is carefully investigated and classified.

4.2.1 Analysis and description of TF3 deliverables

The following methodology's steps are executed[1]:

1. The input documents are discussed during regular TF5 (web-)meetings.

2. The content (e.g. the different Data Elements) is investigated according to the following philosophy:
   - Not mandatory in the profile:
     - Not critical for interoperability.
       - Verified locally by Single tests.
   - Mandatory in the profile:
     - Mandatory in the standard without requirements:
       - No tests provided, the standard is enough (conformance tests are requirements).
     - Mandatory in the standard with additional requirements:
       - TF5 will provide tests.
       - Verify the requirements (Single tests in general to be validated before Cross-border tests).
     - Optional in the standard without requirements:
       - TF5 will provide tests.
       - Check availability (Single tests in general to be validated before Cross-border tests).
     - Optional in the standard with additional requirements:
       - TF5 will provide tests.
       - Check availability and additional requirements (Single tests in general to be validated before Cross-border tests)

3. The requirements are classified based on the previous analysis as follows:
   - Category 1: Not critical for interoperability.
     - TF5 will not provide tests, these requirements will have to be validated locally.
   - Category 2: Important for interoperability but could be tested locally.
     - TF5 will provide tests, these requirements will have to be validated locally before cross-border testing.
   - Category 3: Critical for interoperability and have to be tested bilaterally.
     - TF5 will provide tests, these requirements will have to be tested on field with two countries.

4. The resulting classifications are sent to TF3 for feedback.

5. The classifications are updated based on the TF3 feedback.

[1] Note that this procedure applies to DENM for the moment. It will not be performed to IVIM, MAPEM and SPATEM. This is let to the responsibility of the MS.

6. The use-cases to be tested are selected (risk-based):
   - There are (too) many services and use cases and providing tests and executing them requires a lot of time.
   - Therefore, TF5 selects the most deployed use-case for each service:
     - Road Works Warning - Lane Closure (RWW-LC); causeCode 3 and subCauseCode 0, 1, 2, 4 or 5.
     - Hazardous Location Notification - Stationary vehicle (HLN-SV); causeCode 94 and subCauseCode 0 or 2.

7. The ~~test case~~test cases for the selected use-cases are written.

The table underneath gives an example.

Table 5: Analysis of requirements of TF3 deliverable (example)

Type of Message	Service	Requirement #	Document Reference	Requirement or Data Element	To be tested	Type of test C1/C2/C3	What?	Actions	Comments
		1	Section 2.1	5.8 GHz DSRC / 5.9 GHz C-ITS Coexistence System FLS	No	C1		No action	No important for interoperability
DENM	DENM in general	2	Table 3 in section 3.2.1.1	actionID	Yes	C2	Availability	Specify tests for all different types of DENM	
		3		detectionTime	Yes	C2	Availability	Specify tests for all different types of DENM	
		4		referenceTime	Yes	C2	Availability and value	Specify tests for all different types of DENM	the synchronization is important (perhaps C3)
		5		termination	No	C1	Not mandatory	No action	No important for interoperability
		6		eventPosition	Yes	C2	Availability and value	Specify tests for all different types of DENM	set a position by the tester and then verify the generated message
		7		relevanceDistance	No	C1	Not mandatory	No action	No important for interoperability
		8		relevanceTrafficDirection	Yes	C2	Availability and value = {1}	Specify tests for all different types of DENM	
		9		validityDuration	Yes	C2	Availability	Specify tests for all different types of DENM	
		10		TransmissionInterval	No	C1	Not mandatory	No action	No important for interoperability
		11		stationType	Yes	C2	Availability and value = {9, 10, 15}	Specify tests for all different types of DENM	
		12		informationQuality	Yes	C2	Availability and value = {0, 2, 4, 6, 7}	Specify tests for all different types of DENM	if informationQuality = 0 --> message rejected
		13		eventType	Yes	C2	Availability	Specify tests for all different types of DENM	
		14		linkedCause	No	C1	Not mandatory	No action	No important for interoperability
		15		eventHistory	Yes	C2	Availability	Specify tests for all different types of DENM	
		16		eventSpeed	No	C1	Not mandatory	No action	No important for interoperability
		17		eventPositionHeading	Yes	C2	Availability	Specify tests for all different types of DENM	
		18		traces	Yes	C2	Availability	Specify tests for all different types of DENM	
		19		Alacarte Container	No	C1	Not mandatory	No action	No important for interoperability
		20	Table 4 in section 3.2.1.1	Service parameters for DENM in general	No	C1	Not important for interoerability for TF3	Contact TF3	
	DENM for RWW	20	Table 6 in section 3.2.1.2	eventPosition	No	C2	Already tested for DENM in general	No action	
		21		relevanceDistance	No	C1	Not mandatory	No action	No important for interoperability
		22		causeCode	Yes	C2	Availability and value = {3}	Specify tests only for RWW	
		23		subCauseCode	Yes	C2	Availability and value = {0, 1, 2, 3, 4, 5}	Specify tests only for RWW	0 is used for unknown Alert planned road works – mobile: 3 Closure of part of a lane, whole lane or several lanes: 0,1,2,4,5 Alert planned closure of road or a carriageway: 1,4
		24		lanePosition	Yes	C2	Availability	Specify tests only for RWW	
		25		closedLanes	Yes	C2	Availability	Specify tests only for RWW	Choosing some closed lines and verify the generated message
		26		speedLimit	No	C1	Not mandatory	No action	No important for interoperability
		27		recommendedPath	No	C1	Not mandatory	No action	No important for interoperability
		28		startingPointSpeedLimit	No	C1	Not mandatory	No action	No important for interoperability
		29		trafficFlowRule	No	C1	Not mandatory	No action	No important for interoperability
		30		reference DENMs	No	C1	Not mandatory	No action	No important for interoperability
		31	Table 7 in section 3.2.1.2	Service parameters for RWW	No	C1	Not important for interoerability for TF3	Contact TF3	
	DENM for HLN	31	Table 8 in section 3.2.1.3	relevanceDistance	No	C1	Not mandatory	No action	No important for interoperability
		32		eventType (causeCode and subCauseCode)	Yes	C2	Availaibility and value extracted from Usage Column	Contact TF3	Test the reception mandatory, but the sending have to be discussed...
		33	Table 9 in section 3.2.1.2	Service parameters for HLN	No	C1	Not important for interoerability for TF3	Contact TF3	
IVIM	IVIM in general	34	Table 10 in section 3.2.2.1	serviceProviderId	Yes	C2	Availability and value is correct and unique	Specify tests for all different types of IVIM	
		35	Table 10 in section 3.2.2.1	ivIdentificationNumber	Yes	C2	Availability and value is the same for repetition	Specify tests for all different types of IVIM	
		36	Table 10 in section 3.2.2.1	timestamp	Yes	C2	Availability and value	Specify tests for all different types of IVIM	
		37	Table 10 in section 3.2.2.1	validFrom	No	C1	Not mandatory	No action	No important for interoperability
		38	Table 10 in section 3.2.2.1	validTo	Yes	C2	Availability and value time in the future	Specify tests for all different types of IVIM	for TF3 "An update shall be sent before the message times out." means an update and not a new message, but have not to be tested
		39	Table 10 in section 3.2.2.1	connectedIviStructures	No	C1	Not mandatory	No action	No important for interoperability
		40	Table 10 in section 3.2.2.1	iviStatus	Yes	C2	Availability and value = {0, 1, 2, 3}	Specify tests for all different types of IVIM	
		41	Table 10 in section 3.2.2.1	referencePosition	Yes	C2	Availability and value	Specify tests for all different types of IVIM	set a position by the tester and then verify the generated message
		42	Table 10 in section 3.2.2.1	referencePositionTime	No	C1	Not mandatory	No action	No important for interoperability
		43	Table 10 in section 3.2.2.1	referencePositionHeading	No	C1	Not mandatory	No action	No important for interoperability
		44	Table 10 in section 3.2.2.1	referencePositionSpeed	No	C1	Not mandatory	No action	No important for interoperability

~~*Table 1 Analysis of requirements of TF3 deliverable (example)*~~

4.2.2 Analysis and description of TF2 deliverable

The following methodology steps are executed:

1. The input documents are discussed during regular TF5 (web-)meetings.

2. Few test generic subjects are extracted for the different use-cases that are based on the same type of messages, namely DENM, IVIM, SPATEM and MAPEM. Some examples of these subject are: Event Position, Timing, Update/Cancel, etc.

3. The different services and the use-cases are investigated to extract some specific subject to be tested that are related only to a specific use-case.

4. The resulting classifications are sent to TF2 for feedback.

5. The classifications are updated based on the TF2 feedback.

6. The ~~test case~~test cases are written for all the specified use-cases.

Table 6: Analysis of requirements of TF2 deliverable (example)

Service	Use Cases	Type of Message	Document Reference	Requirement #	Requirement or Data Element	Requirement Dependencie Level [Service, UC, Scenario]	Testsubject	Type of test C1/C2/C3	To be tested	Comments
Hazardous Locations Notification (HLN) and Road Works Warning (RWW)	Generic		Common C-ITS Service Definitions Version 1.3 / Section 2 and Section 3	1	Position of Event	Service Generic	The event is allocated on the correct positon	C3	No	Already written together
				2	Traces	Service Generic	The traces lead to the event	C3	Yes	
				3	Timing	Service Generic	The DENM is recieved in advance to the event	C3	Yes	
				4	Update/ Cancel	Service Generic	The test subject is still percievable	C3	Yes	
	Accident Zone (HLN-AZ)		Common C-ITS Service Definitions Version 1.3 / Section 2.2.1	5	causeCode & subCauseCode	Use-case Specific	For this use-case, causeCode is 2 (accident) and subCauseCode is between 0 and 7 except 6 (vehicle ; which is implicit for an accident).	C3	Yes	
	Traffic Jam Ahead (OHLN-TJA)		Common C-ITS Service Definitions Version 1.3 / Section 2.2.2	6	causeCode & subCauseCode	Use-case Specific	CauseCode shall be set to 27 (dangerous end of queue) and subCauseCode shall be set to 0	C3	Yes	
	Stationary vehicle (HLN - SV)		ITS Service Definitions Version 1.3 / Section 2.2.3	7	I2V broadcast, (with V2I combined with V2V broadcast as additional input source) - same requirement as "Use Case Scenario".	Use-case Specific		C3	No	
				8	Each lane (including shoulder) in the direction of travel (upstream) should be received the SV warning.	Use-case Specific		C3	Yes	
				9	If the lane is recognized by detection of camera, road user should also be informed of the lane information of the stationary vehicle.	Use-case Specific		C3	No	
				10	There may be more stationary vehicles in the same lacation. All SV warnings shall be received.	Use-case Specific		C3	No	Not included in the specification
				11	Stationary vehicle can also be special vehicle(s), like emergency vehicle with shined light bar. In this case, the status of the emergency lights/StationTyp ect. shall be checked.	Use-case Specific		C3	No	Not included in the specification
				12	For generating the vehicle based warning in the same way for a fast detection of slow or stationary vehicles at the Roadside a common implementation of the triggering conditions in the vehicles is requested.	Use-case Specific		C3	No	
				13	The corresponding CauseCode and SubCauseCode for different reasons of the stationary vehicle shall be correct sent. For this use-case, causeCode is 94 (stationary vehicle) and subCauseCode is 0 (unavailable) or 2 (breakdown vehicle).	Use-case Specific		C3	Yes	

~~Table 2 Analysis of requirements of TF2 deliverable (example)~~

4.2.3 Analysis and description of TF4 deliverable (BI interface)

The following methodology steps are executed:

1. The input documents are discussed during regular TF5 (web-)meetings.

2. The content is investigated according to the following philosophy:
   a. Not mandatory: verified locally by Single tests
   b. Mandatory requirements:
      i. assessment of the amount of partners needed for performing the tests:
         1. Can the test be performed by a single operator and by subscribing to the own input?
         2. Is the requirement critical for guaranteeing interoperability?
         3. Can the requirement be validated with another operator of the same country?

3. For those tests, requiring operators from different countries, test cases are specified addressing the data fields are critical.

4. The resulting classifications are sent to TF4 for feedback.

5. The classifications are updated based on the TF4 feedback.

6. The ~~test-case~~test cases are written for all the specified use-cases.

4.2.4 Analysis and description of TF1 deliverable (Security)

The following methodology steps are executed:

1. The input documents are discussed during regular TF5 (web-)meetings.

2. The content is investigated according to the following philosophy:
   a. Not mandatory: verified locally by Single tests (e.g. Stations are able to request valid AT to a PKI, sign messages and produce a C or SP compliance report).
   b. Mandatory requirements:
      ii. assessment of the amount of partners needed for performing the tests:
         1. Can the test be performed by a single operator and by subscribing to the own input?
         2. Is the requirement critical for guaranteeing interoperability?
         3. Can the requirement be validated with another operator of the same country?

3. For those tests, requiring operators from different countries, test cases are specified addressing the data fields which are critical.

4. The resulting classifications are sent to TF1 for feedback.

5. The classifications are updated based on the TF1 feedback.

6. The ~~test-case~~test cases are written for all the specified use-cases.

Table 7: Analysis of requirements of Secutiy TF1 deliverable (example)

		test cases	
ormats of certificates shall be compliant with section B1.1 of 0190827_TF1_Security_report_v1.7 [8].	see B 1.1	1	RSU sends out message, certificate needs to be verified
alidity times of certificates shall be compliant with section B1.2 of 0190827_TF1_Security_report_v1.7 [8].	see B 1.2	1	RSU sends out message, certificate needs to be verified
-ITS station shall use ATs with the permissions defined in section B1.5 of 0190827_TF1_Security_report_v1.7 [8].	see B.1.5	many	Values needs to be verified, depending on use case. Security expertise is needed
eceiving C-ITS station shall operate the initial verifications as described in the section B1.7.1 f 20190827_TF1_Security_report_v1.7 [8].	see B1.7.1	many	Values needs to be verified, depending on use case. Security expertise is needed. Negative test cases also need to be provided
t each reception of message, the C-ITS station shall operate the signature verifications as escribed in the section B1.7.2 of 20190827_TF1_Security_report_v1.7 [8].	see B1.7.2	many	Values needs ot be verified, depending on use case. Security expertise is needed. Negative test cases also need ot be provided

~~*Table 3 Analysis of requirements of Secutiy TF1 deliverable (example)*~~

The design of the test cases is based on the following considerations:

- Some requirements are easier to test in a “lab” mode (stations operators in the same place). For instance, tests of the signature verification in this mode are more efficient than in an “on road” mode.
- Tests of service specific permissions (section 3.5.2) are message specific (DENM, IVIM…) whereas tests of security initialisation (section 3.5.3) and verification of message signature (section 3.5.4) are independent of use cases.

- Validation (especially for TF1 report requirements) requires negative testing scenarios (i.e. error cases). This requires several test sets with specific security elements, including (non-exhaustive):
    - Invalid TLM certificate or ECTL
    - Revoked ACs
    - Expired certificates
    - Untrusted ACs
    - ATs without proper permissions

Before participating to Cross-testing security, each MS is asked to validate its equipments' security implementation. For that, the security pre-requisites are validating the following security ~~Test case~~Test cases :

- C-Roads_TF5_Test-cases_DENM_Security_CertifFormat_1
- C-Roads_TF5_Test-cases_DENM_Security_CertifValidity_2
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_IVI_R-ITS-S (RSU)_3
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_IVI_R-ITS-S (VRO)_3
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_RLT_R-ITS-S (RSU)_3
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_RLT_R-ITS-S (VRO)_3
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLC_R-ITS-S (RSU)_3
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLC_R-ITS-S (VRO)_3
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLM_R-ITS-S (RSU)_3
- TC-CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLM_R-ITS-S (VRO)_3
- TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_CAM_RSU_3
- TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_CAM_VRO_3
- TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_DENM_RSU_3
- TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_DENM_VRO_3
- TC_CROADS_GENERIC_SECURITY_ECTL_Update_4
- TC_CROADS_GENERIC_SECURITY_RCA-CTL_Available_4
- TC_CROADS_GENERIC_SECURITY_HOME_RCA_Verification_4
- TC_CROADS_GENERIC_SECURITY_CRL_Verification_4
- TC_CROADS_GENERIC_SECURITY_CTL_Verification_4
- TC_CROADS_GENERIC_SECURITY_TLM_ECTL_4
- TC_CROADS_GENERIC_SECURITY_TLM_CERTIFICATE_VALIDATION_4
- C-Roads_TF5_Test-cases_SECURITY_AA_NOMINAL_5
- C-Roads_TF5_Test-cases_SECURITY_AT_NOMINAL_5
- C-Roads_TF5_Test-cases_SECURITY_RCA_NOMINAL_5
- C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NOMINAL_5

4.3. Test execution

The organization of actual tests is not within the scope of TF5. TF5 will however specify minimum common logs for road-tests, operational tests and pilots. This section provides a guideline for the process of executing these tests.

Tests will be based on an overall test-plan describing the process of testing the individual ~~test-case~~test cases. Not all tests are mandatory, only those elements/services/uses cases which are relevant for the implementation on each pilot site need to be tested. If the test case contain descriptions of elements not defined as "mandatory" by the C-Roads specifications used for the pilot phase, the execution of these parts is not a requirement. The test case (or the specific part) will be considered "not applicable" to the specific pilot that does not support the optional features described in the test cases.

Firstly, all underlying tests (i.e. C1 and C2) shall be performed within the context of the individual country. After successful conclusion of these tests the subsequent C3 tests will be performed in a cross-border environment. In this step the I2V interaction between R-ITS-Ss and V-ITS-Ss from different origins will be tested.

Each of these steps will start with the generic requirements, followed by the more specific requirements. For TF3 specification, tests for generic requirements will be performed only once for the representative service or use case, unless it is – based on risk-assessment – required to perform it again for a specific situation (e.g. the eventPosition in case of moving RWW as compared to static RWW). For TF2 specification, tests are performed for all the use-cases.

Each step in the test-process will have its own results. At the end, the final test-results will have to be evaluated and a final report will have to be prepared.

Appendix

C-ITS Test Plan – List of test cases

Table 8: Security test cases

Category	Test case ID
Preconditions Validation	See chapter "4.2.4 Analysis and description of TF1 deliverable (Security)"
Certificate Format Validation	C-Roads_TF5_Test-cases_DENM_Security_CertifFormat_1 C-Roads_TF5_Test-cases_DENM_Security_CertifFormat_Negative_1
Certificate Timing Validation	C-Roads_TF5_Test-cases_DENM_Security_CertifValidity_2 C-Roads_TF5_Test-cases_DENM_Security_CertifValidity_Negative1_2 C-Roads_TF5_Test-cases_DENM_Security_CertifValidity_Negative2_2 C-Roads_TF5_Test-cases_DENM_Security_CertifValidity_Negative3_2
Signature Verification	
AA Validation	C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_1_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_2_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_3_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_4_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_5_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_6_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_7_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_8_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_9_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_10_5 C-Roads_TF5_Test-cases_SECURITY_AA_NEGATIVE_11_5 C-Roads_TF5_Test-cases_SECURITY_AA_NOMINAL_5
AT Validation	C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_1_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_2_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_3_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_4_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_5_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_6_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_7_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_8_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_9_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_10_5 C-Roads_TF5_Test-cases_SECURITY_AT_NEGATIVE_11_5 C-Roads_TF5_Test-cases_SECURITY_AT_NOMINAL_5
RCA Validation	C-Roads_TF5_Test-cases_SECURITY_RCA_NEGATIVE_1_5 C-Roads_TF5_Test-cases_SECURITY_RCA_NEGATIVE_2_5 C-Roads_TF5_Test-cases_SECURITY_RCA_NEGATIVE_3_5 C-Roads_TF5_Test-cases_SECURITY_RCA_NEGATIVE_4_5 C-Roads_TF5_Test-cases_SECURITY_RCA_NEGATIVE_5_5 C-Roads_TF5_Test-cases_SECURITY_RCA_NOMINAL_5
Signature Validation	C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_1_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_2_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_3_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_4_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_5_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_6_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_7_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NEGATIVE_8_5 C-Roads_TF5_Test-cases_SECURITY_SIGNATURE_NOMINAL_1_5

SSP Validation	TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_CAM_RSU_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_CAM_VRO_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_DENM_RSU_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_DENM_VRO_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_IVI_R-ITS-S (RSU)_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_IVI_R-ITS-S (VRO)_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_RLT_R-ITS-S (RSU)_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_RLT_R-ITS-S (VRO)_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLC_R-ITS-S (RSU)_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLC_R-ITS-S (VRO)_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLM_R-ITS-S (RSU)_3 TC_CROADS_GENERIC_SECURITY_HOME_AT-Permission_TLM_R-ITS-S (VRO)_3

Table 9: Hybrid test cases

Category	Test case ID
BI Implementation	C-Roads_TF5_Test-cases_DENM_Hybrid_Rou C-Roads_TF5_Test-cases_Filtering C-Roads_TF5_Test-cases_Filtering_Negative C-Roads_TF5_Test-cases_Filtering_Publish_QuadtreeComplexShape C-Roads_TF5_Test-cases_Filtering_Quadtree C-Roads_TF5_Test-cases_Filtering_Subscribe_QuadtreeComplexShape C-Roads_TF5_Test-cases_General_Routing C-Roads_TF5_Test-cases_IVIM_Hybrid_Rou C-Roads_TF5_Test-cases_PublishMultipleReceivers C-Roads_TF5_Test-cases_SubscribeMultipleProviders

Table 10: On-road ITS-G5 test cases

Category	Test case ID
DENM	TC_CROADS_Generic_ITSG5_DENM_Position_01 TC_CROADS_Generic_ITSG5_DENM_Traces_02 TC_CROADS_GENERIC_ITSG5-DENM_TIMING_03 TC_CROADS_GENERIC_ITSG5-DENM_CANCEL_UPDATE_04 TC_CROADS_HLN-AZ_ITSG5-DENM_Causecodes_05 TC_CROADS_HLN-TJA_ITSG5-DENM_Causecodes_06 TC_CROADS_HLN-SV_ITSG5-DENM_Lanes_08 TC_CROADS_HLN-SV_ITSG5-DENM_Causecodes_13 TC_CROADS_HLN-TSR_ITSG5-DENM_CAUSECODE-SUBCC_17 TC_CROADS_HLN-WCW_ITSG5-DENM_CAUSECODE-SUBCC_18 TC_CROADS_HLN-APR_ITSG5_DENM_AnimalOrPersonOnTheRoad_19 TC_CROADS_HLN-OR_ITSG5_DENM_ObstacleOnTheRoad_20 TC_CROADS_RWW-Mobile_ITSG5_DENM_cc3_scc3_21 TC_CROADS_RWW-Mobile_ITSG5_DENM_stand-alone-mode_22 TC_CROADS_RWW-Mobile_ITSG5_DENM_TCC-triggered-mode_23 TC_CROADS_RWW-Mobile_ITSG5_DENM_Augmented_24 TC_CROADS_RWW-LC_ITSG5-DENM_LaneClosure_26 TC_CROADS_RWW-LC-SA_ITSG5-DENM_StandAloneLaneClosure_31 TC_CROADS_RWW-LC-TCC_ITSG5-DENM_TccTriggeredLaneClosure_32 TC_CROADS_RWW-LC-AUG_ITSG5-DENM_33 TC_CROADS_RWW_RC_ITSG5_DENM_RoadClosure_34 TC_CROADS_GENERIC_ITS-G5_DENM_relevanceTrafficDirection_35 TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36

DENM	TC_CROADS_GENERIC_ITS-G5_DENM_relevanceTrafficDirection_35 TC_CROADS_GENERIC_ITSG5-DENM_referenceDenms_36 TC_CROADS_HLN-EVA_ITSG5-DENM_CC-sCC_37 TC_CROADS_HLN-EVA_ITSG5-DENM_relevanceTrafficDirection_38 TC_CROADS_HLN-EVI_ITSG5-DENM_CC-sCC_39 TC_CROADS_HLN-RLX_ITSG5_DENM_eventType_40 TC_CROADS_HLN-RLX_ITSG5_DENM_relevanceTrafficDirection_41 TC_CROADS_HLN-RLX_ITSG5_DENM_BasicWarning_42 TC_CROADS_HLN-RLX_ITSG5_DENM_ApproachingTrainWarning_43 TC_CROADS_HLN-RLX_ITSG5_DENM_Crossing Out of Order Warning_44 TC_CROADS_HLN-UBR_ITSG5_DENM_UnsecuredBlockageofaRoad_48 TC_CROADS_HLN-AWWD_ITSG5-DENM_Causcodes_49 TC_CROADS_HLN-AWWD_ITSG5-DENM_RelevanceZone_50 TC_CROADS_HLN-PTVC_ITSG5_DENM_PublicTransportVehicleCrossing_CauseCodes_51-2 TC_CROADS_HLN-PTVC_ITSG5-DENM_PublicTransportVehicleCrossing_ReleveanceZone_52 TC_CROADS_HLN-PTVS_ITSG5-DENM_PublicTransportAtAStop_CauseCodes_53-1 TC_CROADS_HLN-PTVS_ITSG5-DENM_PublicTransportAtAStop_ReleveanceZone_54 TC_CROADS_RWW-WM_ITSG5-DENM_Winter Maintenance_55 TC_CROADS_RWW-ROVI_ITSG5-DENM_Road Operator Vehicle in Intervention_56 TC_CROADS_RWW-ROVA_ITSG5-DENM_Road Operator Vehicle Approaching_57
IVIM	C-Roads_TF5_Test-cases_IVIM_Generic_reference position_01 TC_CROADS_GENERIC_ITSG5-IVIM_ZONES_02 TC_CROADS_GENERIC_ITSG5-IVIM_Timing_03 TC_CROADS_GENERIC_ITSG5-IVIM_Update_Cancel_04 TC_CROADS_IVS-DSLI_ITSG5-IVIM_RSCode_11 TC_CROADS_IVS-DSLI_ITSG5-IVIM_timinigLocationReception_12 TC_CROADS_IVS-DSLI_ITSG5-IVIM_ISO14823Code_17 TC_CROADS_IVS-DSLI_ITSG5-IVIM_ISO14823Code_18 TC_CROADS_IVS-DSLI_ITSG5-IVIM_vehicleCharacteristics_19 TC_CROADS_IVS-DSLI_ITSG5-IVIM_applicableLanes_20 TC_CROADS_IVS-EVFT_ITSG5-IVIM_FreeText_25 TC_CROADS_IVS-EVFT_ITSG5-IVIM_ISO14823Code_30 TC_CROADS_IVS-EVFT_ITSG5-IVIM_vehicleCharacteristics_31 TC_CROADS_IVS-EVFT_ITSG5-IVIM_applicableLanes_32 TC_CROADS_IVS-DSLI_EVFT_OSI_ITSG5-IVIM_serviceProviderId_34 TC_CROADS_IVS-DSLI_EVFT_OSI_ITSG5-IVIM_ivIdentificationNumber_35 TC_CROADS_IVS-OSI_ITSG5-IVIM_ISO14823Code_DLM_1_40 TC_CROADS_IVS-OSI_ITSG5-IVIM_ISO14823Code_DLM_2_41 TC_CROADS_IVS-DSLI_EVFT_OSI_ITSG5-IVIM_referencePositionTime_42 TC_CROADS_IVS-OSI_ITSG5-IVIM_applicableLanes_43 TC_CROADS_IVS-OSI_ITSG5-IVIM_extraText_44 TC_CROADS_IVS-DSLI_EVFT_OSI_ITSG5-IVIM_zoneId_45 TC_CROADS_IVS-SWD_ITSG5-IVIM_maxSpeedAdvice_46 TC_CROADS_IVS-SWD_ITSG5-IVIM_ISO14823Code_47 TC_CROADS_IVS-SWD_ITSG5-IVIM_vehicleCharacteristics_48 TC_CROADS_IVS-SWD_ITSG5-IVIM_applicableLanes_49
SPaTEM-MAPEM	TC_CROADS_GENERIC_ITSG5_SPaTEM-MAPEM_timing_01 TC_CROADS_SI-GENERIC_ITSG5_MAPEM_SPATEM_Generic-Relation_02. TC_CROADS_SI-GENERIC_ITSG5_MAPEM_Location_03 TC_CROADS_SI-SPTI_ITSG5_SPATEM_SignalPhaseAndTimingInformation_08 TC_CROADS_SI-GLOSA_ITSG5_SPaTEM-MAPEM_speedLimit_13 TC_CROADS_SI-ISVW_ITSG5_SPATEM_ImminentSignalViolationWarning-SignalPhaseAndTimingInformation_14 TC_CROADS_SI-ISVW_ITSG5_SPATEM_ImminentSignalViolationWarning-Latency_15

Table 11: On-road Hybrid test cases

Category	Test case ID
DENM	TC_CROADS_GENERIC_HYBRID-DENM_EventPosition_01 TC_CROADS_Generic_HYBRID_DENM_Traces_02 TC_CROADS_GENERIC_HYBRID-DENM_Timing_03 TC_CROADS_GENERIC_HYBRID-DENM_Cancel_Update_04 TC_CROADS_HLN-AZ_Hybrid_DENM_Causecodes_05 TC_CROADS_HLN-TJA_Hybrid_DENM_Causecodes_06 TC_CROADS_HLN-SV_Hybrid_DENM_Lanes_08 TC_CROADS_OHLN-SV_Hybrid_DENM_Causecodes_13 TC_CROADS_OHLN-TSR-DENM_Causecode-Subcc_17 TC_CROADS_OHLN-WCW_HYBRID-DENM_Causecode-Subcc_18 TC_CROADS_HLN-APR_HYBRID_DENM_AnimalOrPersonOnTheRoad_19 TC_CROADS_HLN-OR_HYBRID_DENM_ObstacleOnTheRoad_20 TC_CROADS_RWW-Mobile_Hybrid_DENM_cc3_scc3_21 TC_CROADS_RWW-Mobile_Hybrid_DENM_stand-alone-mode_22 TC_CROADS_RWW-Mobile_Hybrid_DENM_TCC-triggered-mode_23 TC_CROADS_RWW-Mobile_Hybrid_DENM_Augmented_24 TC_CROADS_RWW-LC_Hybrid-DENM_LaneClosure_26 TC_CROADS_RWW_RC_Hybrid_DENM_RoadClosure_34 TC_CROADS_GENERIC_HYBRID_DENM_relevanceTrafficDirection_35 TC_CROADS_GENERIC_HYBRID_DENM_referenceDenms_36 TC_CROADS_HLN-EVA_Hybrid-DENM_CC-sCC_37 TC_CROADS_HLN-EVA_Hybrid-DENM_relevanceTrafficDirection_38 TC_CROADS_HLN-EVI_Hybrid-DENM_CC-sCC_39 TC_CROADS_HLN-RLX_Hybrid_DENM_eventType_40 TC_CROADS_HLN-RLX_Hybrid_DENM_relevanceTrafficDirection_41 TC_CROADS_HLN-RLX_Hybrid_DENM_Basic Warning_42 TC_CROADS_HLN-RLX_Hybrid_DENM_Approaching Train Warning_43 TC_CROADS_HLN-RLX_Hybrid_DENM_Crossing Out of Order Warning_44 TC_CROADS_HLN-UBR_HYBRID_DENM_UnsecuredBlockageofaRoad_48. TC_CROADS_HLN-AWWD_Hybrid-DENM_CAUSECODE-SUBCC_49 TC_CROADS_HLN-AWWD_Hybrid-DENM_RelevanceZone_50 TC_CROADS_HLN-PTVC_Hybrid_DENM_PublicTransportVehicleCrossing_CauseCodes_51-2 TC_CROADS_HLN-PTVC_Hybrid-DENM_PublicTransportVehicleCrossing_ReleveanceZone_52 TC_CROADS_HLN-PTVS_Hybrid-DENM_PublicTransportAtAStop_CauseCodes_53-1 TC_CROADS_HLN-PTVS_Hybrid-DENM_PublicTransportAtAStop_ReleveanceZone_54 TC_CROADS_RWW-WM_Hybrid-DENM_Winter Maintenance_55 TC_CROADS_RWW-ROVI_Hybrid-DENM_Road Operator Vehicle in Intervention_56 TC_CROADS_RWW-ROVA_Hybrid-DENM_Road Operator Vehicle Approaching_57
IVIM	C-Roads_TF5_Test-cases_Hybrid_IVIM_Generic_reference position_01 TC_CROADS_GENERIC_HYBRID-IVIM_ZONES_02 TC_CROADS_GENERIC_hybrid-IVIM_Timing_03 TC_CROADS_GENERIC_HYBRID-IVIM_Update_Cancel_04 TC_CROADS_IVS-DSLI_Hybrid-IVIM_RSCode_11 TC_CROADS_IVS-DSLI_HYBRID-IVIM_timinigLocationReception_12 TC_CROADS_IVS-DSLI_HYBRID-IVIM_ISO14823Code_17 TC_CROADS_IVS-DSLI_HYBRID-IVIM_ISO14823Code_18 TC_CROADS_IVS-DSLI_Hybrid-IVIM_vehicleCharacteristics_19 TC_CROADS_IVS-DSLI_Hybrid-IVIM_applicableLanes_20 TC_CROADS_IVS-EVFT_HYBRID-IVIM_FreeText_25 TC_CROADS_IVS-EVFT_Hybrid-IVIM_ISO14823Code_30 TC_CROADS_IVS-EVFT_Hybrid-IVIM_vehicleCharacteristics_31 TC_CROADS_IVS-EVFT_Hybrid-IVIM_applicableLanes_32

IVIM	TC_CROADS_IVS-DSLI_EVFT_OSI_HYBRID-IVIM_serviceProviderId_34 TC_CROADS_IVS-DSLI_EVFT_OSI_HYBRID-IVIM_ivIdentificationNumber_35 TC_CROADS_IVS-OSI_hybrid-IVIM_ISO14823Code_DLM_1_40 TC_CROADS_IVS-OSI_hybrid-IVIM_ISO14823Code_DLM_2_41 TC_CROADS_IVS-DSLI_EVFT_OSI_HYBRID-IVIM_referencePositionTime_42 TC_CROADS_IVS-OSI_HYBRID-IVIM_applicableLanes_43 TC_CROADS_IVS-OSI_HYBRID-IVIM_extraText_44 TC_CROADS_IVS-DSLI_EVFT_OSI_HYBRID-IVIM_zoneId_45 TC_CROADS_IVS-SWD_ITSG5-IVIM_maxSpeedAdvice_46 TC_CROADS_IVS-SWD_ITSG5-IVIM_ISO14823Code_47 TC_CROADS_IVS-SWD_ITSG5-IVIM_vehicleCharacteristics_48 TC_CROADS_IVS-SWD_ITSG5-IVIM_applicableLanes_49
SPaTEM-MAPEM	TC_CROADS_GENERIC_HYBRID_SPaTEM-MAPEM_timing_01 TC_CROADS_SI-GENERIC_HYBRID_MAPEM_SPATEM_Generic-Relation_02. TC_CROADS_SI-GENERIC_HYBRID_MAPEM_Location_03 TC_CROADS_SI-SPTI_Hybrid_SPATEM_SignalPhaseAndTimingInformation_08 TC_CROADS_SI-GLOSA_HYBRID_SPaTEM-MAPEM_speedLimit_13 TC_CROADS_SI-ISVW_Hybrid_SPATEM_ImminentSignalViolationWarning-SignalPhaseAndTimingInformation_14 TC_CROADS_SI-ISVW_Hybrid_SPATEM_ImminentSignalViolationWarning-Latency_15