



Cross-Border Testing and Validation Concept

C-Roads Platform

Working Group 2 Technical Aspects

Taskforce 5 Cross-Testing and Validation

Chairmanship:

- Chair: Marwane Ayaida, University of Reims, France
- Co-chair: Jan Schappacher, BASt, Germany

Publication History

Version	Date	Description, updates and changes	Status
0.1	11.10.2018	First table of content	draft
0.2	21.12.2018	First Content by Tomáš Červenka and Jan Schappacher	draft
0.3	10.01.2019	Additional content by Walter Zimmermann	draft
0.4	31.01.2019	Revised structure and chapter on test case template as agreed on Workshop #1 in Reims	draft
0.5	05.02.2019	Redrafted by Axel Zandbergen	draft
0.6	08.02.2019	Updated by Marwane Ayaida based on TF5 web-meeting comments in 07.02.2019	draft
0.7	15.02.2019	Updated by Marwane Ayaida based on TF5 members comments	distributed to WG2
0.8	08.03.2019	Updated by Axel Zandbergen after review by WG2	draft
0.9	27.05.2019	Updated by Marwane Ayaida to include PCAP Exchange Specification and on-road tests' methodology	draft
1.0	31.05.2019	Updated based on the comments of TF5 members	distributed to WG2

Table 1 Publication History

Index

Acronyms	3
Glossary	4
References	6
1. Introduction.....	7
2. Scope	8
2.1. Definitions and Limitations	8
2.2. Related to the document [EU Compliance Assessment]	9
2.3. Related to the document [ETSI Interoperability]	10
3. Framework.....	12
3.1. Test-subject.....	12
3.2. Test-category	12
3.3. Test-type	12
3.4. Test-environment	13
3.5. Test-case	13
3.6. Test-result	15
4. Process.....	17

Acronyms

Term	Meaning
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
IVIM	In-Vehicle Information Message
IVS	In Vehicle Signage
ITS	Intelligent Transport Systems
ITS-S	ITS Station
MAPEM	MAP (topology) Extended Message
OBU	Onboard Unit
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 Arconyms

Glossary

Term	Meaning	Source
Certification	Certification ensures that a product can legitimately claim to have implemented a standard correctly.	[ETSI Interoperability]
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]
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]
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]
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]
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]
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]
(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]
Interoperability testing	Interoperability testing involves connecting devices from different vendors and operating them in a variety of real-life scenarios.	[ETSI Interoperability]
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.	

Term	Meaning	Source
	In this document ITS-G5 stands for IEEE802.11p/ETSI ITS-G5.	
(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]
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]

Table 3 Glossary

References

Reference	Document
[ETSI Interoperability]	ETSI; IOT Best Practices; Interoperability Best practices; edition 2 (www.etsi.org, www.plugtests.org)
[EU Compliance Assessment]	C-ITS Platform Phase II; Working Group Compliance Assessment; Final Report; 12 July 2017.
[C-Roads Services]	C-Roads; Common C-ITS Service Definitions; Version 1.3; Release 1.3; 17/09/2018.
[C-Roads Functions&Specifications]	C-Roads; C-ITS Infrastructure Functions and Specifications; Version 8.0; release 1.3; 17/09/2018.
[C-Roads System Profile]	C-Roads; Roadside ITS G5 System Profile; Version 6.00.03; release 1.3; 17/09/2018.

Table 4 References

1. Introduction

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

This document describes the overall concept. An additional deliverable denoted 'Test Plan' contains the individual and detailed test-cases. Also, another deliverable "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 is a first release that will in subsequent steps be enhanced within C-Roads. The present release includes only ITS-G5, future releases will also include security aspects and hybrid communication.

The present version of this document is still an incomplete draft and should not be distributed widely.

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 ITS systems.

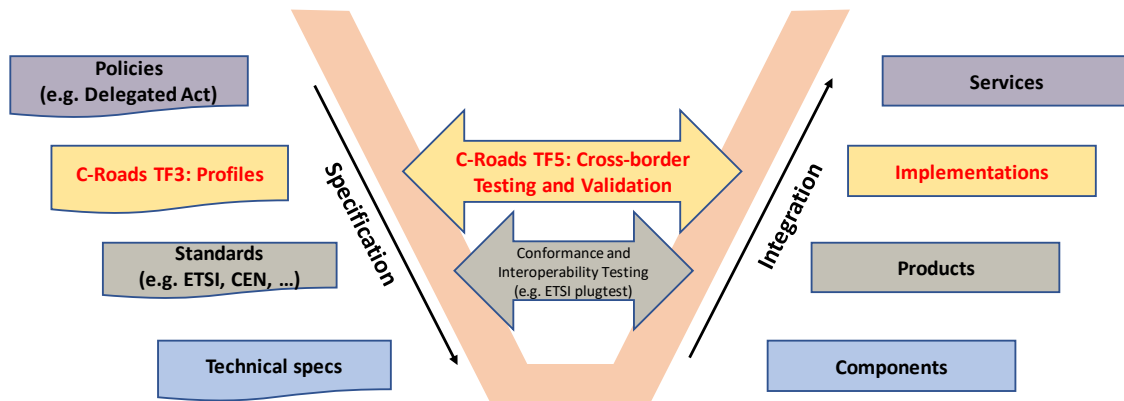


Figure 1 V-model and scope of C-Roads WG2/TF5

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 ITS.
- **Profiles.** TF5 focusses on the C-Roads Profiles (i.e. [C-Roads Services], [C-Roads Functions&Specifications], [C-Roads System Profile]) only, not on the underlying standards and specifications. It is assumed that compliance to these underlying standards and specifications has been assessed separately and previously.
- **Descriptions.** The scope of TF5 does not include executing and performing actual tests, nor does it include type approval or certification. TF5 only provides descriptions of tests.
- **Interoperability.** TF5 looks at the ability of an implementation to operate C-ITS services with foreign ITSS, 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 Interoperability] nor does TF5 look at the quality of the implementation itself.
- **Implementations.** TF5 focusses on implementations only, not on products, equipment or components. It is assumed that the underlying products, equipment and/or components have 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 on (technical) testing and validation of systems only, not on specifying, building or operating, nor on (functional) evaluation.

Note that, for the moment, the scope of the present release is also limited to ITS-G5 communication, i.e. Security and Hybrid communication are not yet included but will be in upcoming releases.

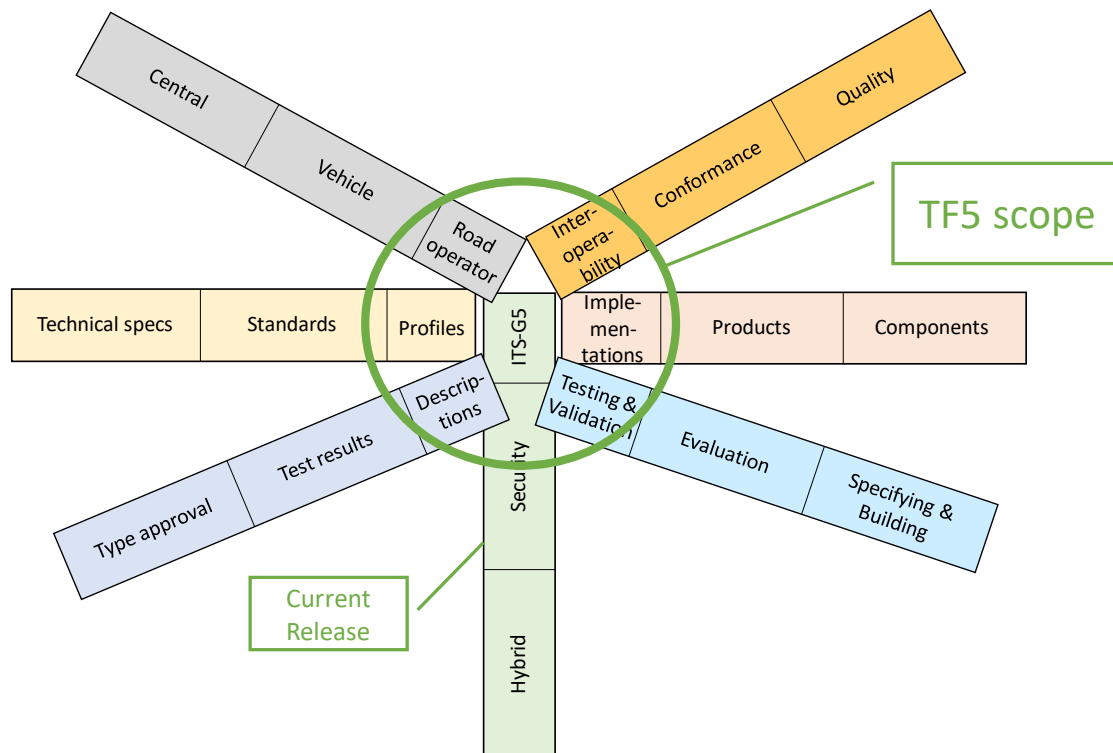


Figure 2 Limitations of the scope of TF5

2.2. Related to the document [EU Compliance Assessment]

The EU report [EU Compliance Assessment] 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 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 [EU Compliance Assessment]. ‘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 [EU Compliance Assessment] the scope of TF5 can be defined as given by the green circle in the figure below.

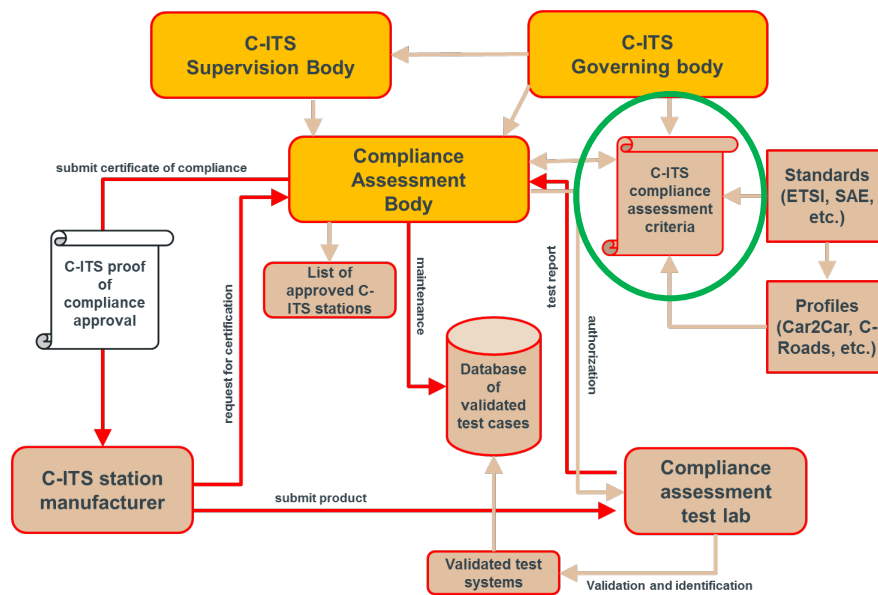


Figure 3 Overview of the compliance assessment process

2.3. Related to the document [ETSI Interoperability]

The ETSI report [ETSI Interoperability] 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.”

The ETSI report [ETSI Interoperability] 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 Interoperability] are similar to what in C-Roads is referred to as Profiles. From the [ETSI Interoperability] report 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.

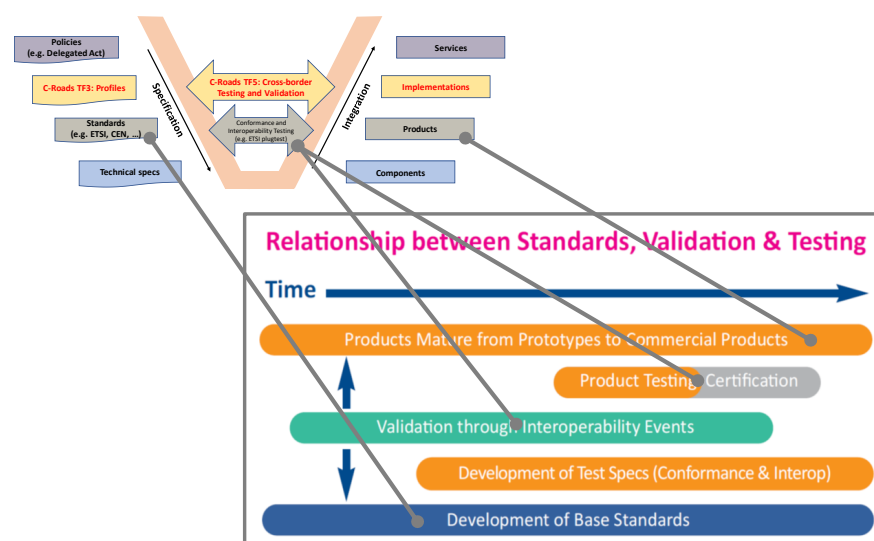


Figure 4 ETSI Standards, Validation & Testing in relation to scope of C-Roads TF5

3. Framework

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-cases and test-results.

3.1. Test-subject

A test-subject (comparable to ‘test-purpose’ in [ETSI Interoperability]) 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**

3.2. Test-category

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 but not for cross-border interoperability.
- **Category 2 (C2).** Requirements labelled as C2 are relevant for cross-border interoperability but can be tested within the 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.

3.3. Test-type

TF5 distinguishes the following types of tests.

- **Lab-test.** The laboratory testing is the first step to validate the ability of a communication unit or system to operate day one C-ITS services basic functionality and implemented 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 of the C-ITS equipment to the real environment. During this procedure the interaction between V-ITS-Ss and R-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 on the test area. These tests shall allow participants to drive at low speeds for a short distance along a R-ITS-S in order to test proper functioning of 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 so 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. The participants, although chosen specifically for the pilots, shall be non-skilled and shall be representative for actual future end-users.

3.4. 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.

3.5. Test-case

The test-case provides a description of the individual test. The document [ETSI Interoperability] 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-cases as follows.


	TF5 Test-case description template	
Service	Road Works Warning (RWW)	
Use case	Road Works - Mobile (RWW-RM)	
TC ID	TC_CROADS_RWW-RM_ITSG5-DENM_XXXX	
Test case name	DENM "Road Works" mobile using ITS-G5 on highway	
Requirements Specifications	C-Roads specification XXXX Version X.X paragraph X of Section X C-Roads specification YYYY Version Y.Y paragraph Y of Section Y	
Test objective (Short description)	Testing the reception of a DENM XXX on the highway with ITS-G5 and mobile RSU	
Test type	Lab-test	
Test environment	Single pilot test	
Test setup	Sniffer, Vehicle equipped with an ITS station, Mobile RSU equipped with an ITS station	
Initial Conditions		
RSU is launched and sends a DENM with a Cause Code CC and Subcause Code SubCC.		
Test scenario		
1. RSU is sending DENM with CC and SubCC 2. Vehicle is moving on the highway with a speed of V		
Test variables		
CC = 3 SubCC = 0 V = 90 km/h		
Expected behaviour		
At least 100m ahead from the RSU, the vehicle displays the DENM After 400m from the RSU, the DENM is not displayed anymore Minimum DENM fields to be present for this test case are X,Y,Z plus all the mandatory fields according to specifications. DENM message field X is within values {1,2,3,4}		
Minimum number of repetitions	3	
Test's comments	The repetition could be done with other CC and SubCC and diferent movements of RSU	
Verification Points (VP)		
VP#	Description	Threshold
1	The vehide displays the DENM before 100m of RSU	Checked
2	The vehicle stops displaying the DENM after 400m of the RSU	Checked
3	Minimum DENM fields are present and well formed	Checked
4	DENM variable fields are within values described in expected behaviour	Checked
5	The vehide updates the DENM position of mobile RSU minimum each minute	DT<1 min
Test Validation Conditions	The verification points 1,2,3 and 4 have passed in all the repetitions and no verification point 5 have failed	

Table 5 TF5 Testcase description template

- **Service:** The service as defined by TF2 which is tested.
- **Use case:** The use case as defined by TF2 which is tested.
- **TC ID:** The 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_DETECTIONTIME_01.
- **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-type:** Lab-test, Controlled test, Road-test, Operational test or Pilot
- **Test-environment:** Single pilot test or Cross-border test, plus details.
- **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.
- **Test-scenario:** Description of the step-by-step scenario. For example:
 - The R-ITS-S is sending DENM with CC and SubCC;
- **Test-variables:** The values of the variables used in the scenarios. For example:
 - CC = 3;
 - SubCC = 0;

- $T = 1 \text{ min.}$
- **Expected behaviour:** The expected response formulated in a way that only yes or no answers apply. For example:
 - *Did the equipment display the event properly?*
- **Minimum number of repetitions:** The number of test repetitions needed in order to validate the requirement.
- **Test-comments:** Add comments if needed.
- **Verification Points (VP):** The list of elements to be checked in order to validate the test.
- **Test Validation Conditions:** The list of mandatory VPs to be validated against the threshold in order for the test to be successful.

3.6. 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] 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 the test-run as follows.


	TF5 Test-run						
Service	Road Works Warning (RWW)						
Use case	Lane Closure (RWW –LC)						
TC ID	TC_CROADS_RWW-LC_ITSG5_DENM_01						
Test case name	DENM "Road Works" test of usage of detectionTime through ITS-G5						
Country	Equipment X from France						
Verification Points (VP) #	Run 1	Run 2	Run 3	Comments			
VP 1	Pass	Pass	Pass				
VP 2	Pass	Pass	Pass				
VP 3	Pass	Pass	Pass				
VP 4	Pass	Pass	Inconclusive	Could not be verified for technical reasons			
Verdict	Pass			The inconclusive does not impact the result			
Test Comments	Test validated						

Table 6 TF5 Test-run (example)

- **Service:** same as in test-cases.
- **Use case:** same as in test-cases.
- **TC ID:** same as in test-cases.
- **Test-case name:** same as in test-cases.
- **Country:** the tested equipments. For example:
 - for Single test: Equipment X from Country A
 - for Cross-border test: Equipment X from Country A and Equipment Y from Country B.
- **Verdict:** the overall verdict of the test.
- **Test Comments:** Add comments if needed.

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

C-ROADS		TF5 Test-case result template	
TC ID	Verdict	Comments	
TC_CROADS_ITSG5_DENM_XXXX	Fail	Not Ok : function not well implemented	
TC_CROADS_ITSG5_SECU_YYYY	Pass	Ok	
TC_CROADS_HYBRID_XXXX		Not tested yet	
TC_CROADS_HYBRID_SECU_YYYY	Inconclusive	Could not be tested because...	
TC_CROADS_RWW-RM_ITSG5-DENM_XXXX	Pass	Final run was inconclusive	

Table 7 TF5 Test-case result (example)

4. Process

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:

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] and [C-Roads System Profile]. 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. 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.
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 Services] specification. TF5 will also provide a common log specification.

4.1. Analysis and description

The requirements contained in the C-Roads Profile documents [C-Roads Services], [C-Roads Functions&Specifications] and [C-Roads System Profile] provided by TF2 and TF3 are analysed with respect to their relevance and impact on interoperability. Each requirement is carefully investigated and classified.

4.1.1 Analysis and description of TF3 deliverables

The following methodology's steps are executed¹:

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.

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

- 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.
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-cases for the selected use-cases are written.

The table underneath gives an example.

Type of Message	Service	Requirement #	Document Reference	Requirement or Data Element	To be tested	Type of test C1/C2/C3	What?	Actions	Comments
DENM	DENM in general	1	Section 2.1	5.8 GHz DSRC / 5.9 GHz C-ITS Coexistence System FLS	No	C1		No action	No important for interoperability
		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		locationType	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		linkCause	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		source	Yes	C2	Availability	Specify tests for all different types of DENM	
		19		Allocated 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 interoperability 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 lanes 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
IVIM	IVIM in general	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 interoperability for TF3	Contact TF3	
		32	Table 8 in section 3.2.1.3	eventPosition	No	C1	Not mandatory	No action	No important for interoperability
		32		eventType (causeCode and subCauseCode)	Yes	C2	Availability 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 interoperability for TF3	Contact TF3	
		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	identificationNumber	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	connectedToStructures	No	C1	Not mandatory	No action	No important for interoperability
		40	Table 10 in section 3.2.2.1	ivStatus	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 8 Analysis of requirements of TF3 deliverable (example)

4.1.2 Analysis and description of TF2 deliverable

The following methodology's 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-cases are written for all the specified use-cases.

Service	Use Cases	Type of Message	Document Reference	Requirement #	Requirement or Data Element	Requirement Dependence Level [Service, UC, Scenario]	Testsubject	Type of test C1/C2/C3	To be tested	Comments
Hazardous Locations Notification (HUN) and Road Works Warning (RWW)	Generic		Common CITS Service Definitions Version 1.3 / Section 2 and Section 3	1	Position of Event	Service Generic	The event is allocated on the correct position	C3	No	Already written together
				2	Traces	Service Generic	The traces lead to the event	C3	Yes	
				3	Timing	Service Generic	The DENM is received in advance to the event	C3	Yes	
				4	Update/ Cancel	Service Generic	The test subject is still perceivable	C3	Yes	
	Accident Zone (HUN-AZ)		Common CITS 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 CITS 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 (HUN-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 location. 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 9 Analysis of requirements of TF2 deliverable (example)

4.2. 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-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 interaction between V-ITS-Ss and R-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.

A test-log is required to record relevant details about the execution of tests covered in each of the individual steps. Any unexpected software, system test script behaviour or application data output (incident) encountered during the execution of any test script must be recorded by the tester. After each test step all test logs should be collected. Logs will include system details concerning the problems encountered with any supporting documents, debug files, or screen dumps. TF5 will provide also a specification for common logs to be implemented by MS and used for tests.

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.