

ERTMS/ETCS – Class 1

Methodology of testing

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3. FUNDAMENTAL BASIS

In the System Requirement Specification (Subset-026 v2.3.0 and the appertaining documents), the system requirements necessary for interoperable ETCS systems are specified.

Within the development and certification process, the fulfilment of these requirements must be proved. When proving the ETCS system requirements, the emphasis is laid on the proofs of interoperability for the realised systems.

Taking into account the CENELEC standards EN50126, EN50128 and EN50129, the present document is designed – proceeding from a uniform, generally acknowledged basis of requirements – to identify and describe the procedure of interoperability proving. In order to be able to describe all test cases in a uniform syntax, uniform possibilities, means and ways must be shown, and it shall be determined how a test case has to be created. In addition, the method formalising this creation will be described.

The formal rules for the creation of test case descriptions must also ensure that all test case descriptions contain statements/data for the clear detection of test traces and test results.

In order to make the conformity verification easier for the notified bodies, laboratory tests are specified for proving the requirements. Operational rules and procedures shall not be considered in the interoperability tests (including their specification), as they are reserved for subsequent line tests. The test specifications to be prepared must be shaped accordingly.

The proof of interoperability towards a notified body consists on principle of a practical and a theoretical part (see validation in CENELEC). The fulfilment of the interoperability requirements is mainly proved by tests. Theoretical proofs are admissible; they may be applied, if necessary, for requirements that cannot be tested.

The tests are to be carried out in comparable, uniform and comprehensible test environments and uniform test architectures.

The specifications of test cases serve several purposes:

- for proving technical interoperability,
- as input for test cases in national projects, and
- as part of tests within company-internal development works.

4. NECESSITY OF FORMAL TEST CASE DESCRIPTIONS

The interoperability tests are not complete proof of customer requirements (including safety requirements); they serve the purpose of verifying interoperability by the respective notified bodies and shall prove the fulfilment of the system requirements as completely as possible.

In order to make these proofs effective, formal rules are considered as necessary for the creation of the test case descriptions in order to save expenditure in the further handling of the test cases.

Such a formalisation is a prerequisite for:

- Uniform and comparable results in the distribution of works for test case creation,
- Automated processes of test execution,
- Equivalent preconditions for the evaluation by the notified bodies and other licensing authorities.

For this purpose, an explicit, distinctive fundamental basis must be defined. No doubt that this task is fulfilled - according to the CENELEC standards - by the system requirement specification (Subset-026 v2.3.0).

An effective requirement management must form the core of the further development process also comprising the phases of proving. Proceeding from this, completeness and traceability towards the system requirements must be ensured for the proving activities in order to successfully pass the certification and verification procedures („Assurance” of the notified body for specifications).

For these tasks, an appropriate procedure has to be established to ensure that all requirements can be effectively managed, referred to, handled and traced.

The formalised test cases shall be an auxiliary means ensuring that the test trips

- Are designed and constructed in modular manner,
- Can be flexibly shaped so that the test sequences can be adjusted to the relevant technical or operational requirements.

On this basis, test cases can be combined to form test trips, i.e. useful testing sequences.

The complete set of Test Sequences shall contain all the test cases defined, at least once. The final agreement within the WG is that to make sure that all the Testable requirements of the SRS are tested, it is enough to pass all the Test Cases at least once. Moreover, it is enough to test only one of the possible combinations of modes and levels for every test case.

In order to describe the test cases clearly and comprehensibly, and to ensure completeness and traceability towards the system requirements, an appropriate procedure is proposed for the management of test cases. This procedure is clearly described in the document “Test Sequences Generation: Methodology and Rules” SUBSET-076-4-1 v1.0.2

5. METHOD OF TEST CASE DESCRIPTION

5.1 General

Proceeding from the system requirements that can be unambiguously interpreted and referred to, the step towards the test cases must be comprehensibly made via the creation of features (see document "Methodology to prepare features").

Each validation work is based on the following essential points:

- Reference to the respective origin of the requirement to be proved,
- Testability of all requirements, and
- Effective management of all test cases.

The test cases use the view from outside onto the test object.

The test object is considered as "Black Box" with a fixed number of defined interfaces and their determined range of values. The complete interface definition can be taken from the ETCS subsets dealing with the interfaces (FFFIS).

No special test interface is provided. However, if a special interface turns out to be needed within the course of test case specification, it must be taken into account.

As a result, only those features are testable which can be influenced and observed via events occurring at the interfaces add "needed for technical interoperability".

In conjunction with each test case, the following must be determined and documented:

- Requirement(s) to be proved,
- Test object (onboard or trackside subsystem)
- Testing method
- Comprehensible description of the testing environment (interfaces),
- Comprehensible links for automated processes,
- Input and output values,
- Finishing criteria for test execution,
- Starting and finishing time,
- Event of interruption (break-off)
- Type and meaning of error (if existing),
- Documentation of results (protocol, logging of tests), and
- Statement of the passing of test.



These descriptions shall be largely formalised, e.g. in the form of tables.

For the trackside no interfaces (beside Radio and Balises) have been specified at the system level which could be used for testing system functions and interoperability at the trackside. The intention was to achieve independence of national standards and leave the interface specification open for producers of trackside equipment. It follows, that detailed specification of test procedures, constraints, start and end conditions depends on the trackside interface specifications of producers in Europe.

5.2 Reference to Subset-026

The Subset-026 is to be used as a basis for all test cases. The principle objective of the tests is always the verification that the system requirements have been fulfilled.

The features in their summary or useful convergence of several requirements form an order criterion of the correlation/interaction in which the requirements will be tested. When creating the test cases, one must always make a reference to the requirements to be proved (for the traceability), allocation links from the test cases to the features must be established in order to reference the tested feature.

Interoperability tests are carried out at the level of the two subsystems

- “Onboard“ (ETCS vehicle equipment) and
- “Trackside“ (ETCS trackside equipment).

Tests of other components, e.g. tests of balises, will not be carried out in the frame of the works of this test specification.

In order to manage the system verification process for the onboard system as well as the trackside, test cases for the trackside specified by the working group define the test goals and demonstrate what shall be tested to prove correctness of functionality and interoperability. According to the defined test goals, producers should be able to specify detailed test procedures and test data considering their trackside equipment.

In conjunction with test cases for the trackside the following can be determined and documented:

- Tested equipment
- Tested feature/ number of feature
- Test case of feature/ number of test case
- Applicable trackside component (RBC, Balise or both)
- Version of document
- Author

- Based on requirements

These descriptions shall be formalized, e.g. in the form of tables and should support traceability of requirements based test goals to test cases as well as traceability of tested features to detailed test procedures and data sets.

For requirements that cannot be tested, it is admissible to perform the test case by a theoretical proof (see chapter 3).

Depending on the complexity of interoperability and test environment required, theoretical tests can be classified as:

- Standard test cases, which can be demonstrated relative easily and where a short description should be sufficient to specify detailed test procedures and test data. For example, the trackside receives a message and has to respond with an acknowledgement to the onboard system. The major part of the trackside test cases can be classified as standard.
- Test cases, which make specification of environmental constraints, test steps, start and end conditions necessary to prove correct functionality and operability of the system. For example, onboard or trackside test cases where timers, synchronisation of communication or special trackside hardware may be used.

The European Railway Agency, as ERTMS system authority, will provide the appropriate description for theoretical test cases based on individual decisions.

For test execution, a distinction is made between three types of events:

- Inputs for influencing the test sequence (IN),
- Outputs for evaluation of test sequence (OUT),
- Time events for the description of timing or sequence (TIME).

For the test cases, each SRS requirement must be referred to in a feature at least once.

The fulfilment of the interoperability requirements must be completely proved. The fulfilment of requirements can be shown on the basis of theoretical contemplation if they cannot be tested (technical reasons, costs ...).

A list containing all requirements which cannot be tested (technical reasons, costs...) will be attached to the document with the test cases.

The test object (on-board or trackside equipment) and the test environment or the test conditions (e. g. which level/ mode is concerned) must be explicitly referred to.

Likewise the used interfaces including input and output data must be fixed.



References for detecting the test sequence data and test results belonging to the respective test case must be clearly documented.

5.3 Contents of formal description of test cases

The test results are described in the following table in the section 'Criteria of passing the test case = sequence of test'. The expected test results are described there by fixed outputs within a certain period of time. Any deviation from the described behaviour leads to a negative test result.

General data of the test case and references to feature and Subset-026 are provided in the section 'Identification'.

The required reproducibility of tests demands for a description of the logical state of the test configuration at start of test (section 'Starting Conditions') and, if necessary, input data during the test.

A description of the logical state at the end of test enables the stringing together of test cases by linkage (section 'End Conditions'). In this case, the reached end situation can serve without being changed as starting position for the following test sequence (interconnection of test cases).

The description of state consists of the following components each:

- Internal states of the test object (e.g. vehicle has been announced),
- Internal states of test environment,
- State of interfaces.

In the following chapters, the structure of a formalised test case description is shown. This structure is independent of the other tools used for the management of the test case. It serves the sole purpose of uniformly collecting all elements necessary for the test case description and does not call for the use of a certain tool.

5.4 Inclusion of Features

Often used functionality in several different features could be separated in own features. This offers the possibility to test them with all aspects only at once, when the specific software architecture allows that.

This kind of feature could be part of the table "sequence of test" of a test case of another feature. The meaning is that each test case of the used feature has to be included, one at each time, in the calling test case like a subroutine (forward reference). To prove the calling test case, each combination with each test case of the used feature has to be proven.

At testing a test case with using another feature, the complete used feature is proved. No further testing of the used feature is necessary.

In case that it can be proven, by using the specific software architecture, that the separated functionality is realised exactly in the same way for the calling test cases, it is not needed to make the

proof by testing the same functionality again and again for all calling test cases. It is sufficiently to test each test case of the used feature at least one time. At the next calling of the used feature only one of the possible test cases of the used feature is needed to complete the calling test case. To maintain the consistency of calling and used test cases a backward reference from the used feature – to be exact, from the set of test cases of a certain feature - to the calling test case is necessary (table “dependencies”).

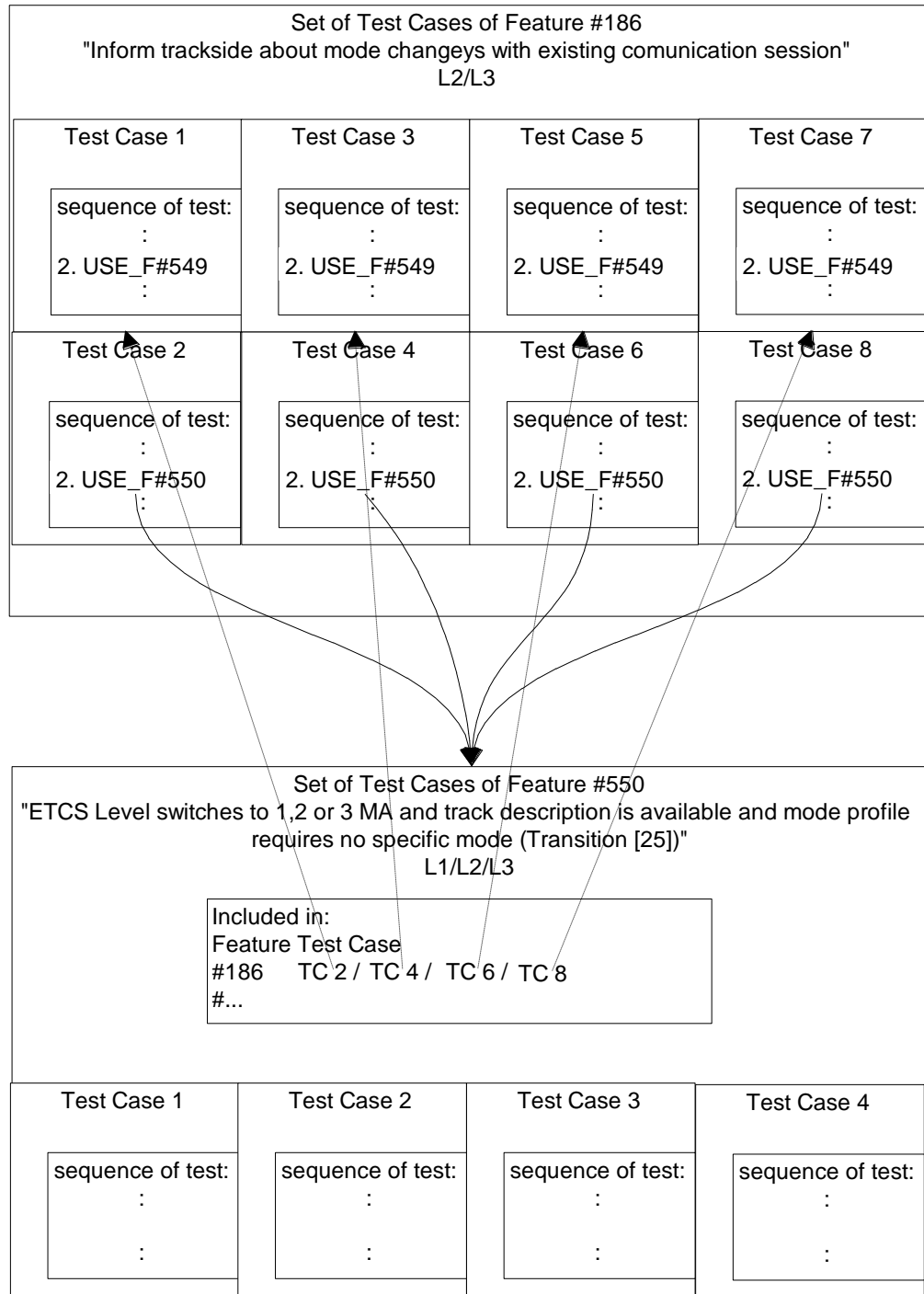




Figure 1: Principle of Inclusion of Features

5.5 Content of the Set of Test Cases for a Feature

1. Header
 - Explicit identifier of the feature to be tested
 - Designation of the feature to be tested
 - Total number of test cases to be tested
2. Dependencies
 - Identifiers of the features, which refer to that set of test cases
 - Identifiers of the test cases, which refer to that set of test cases

5.6 Content of a Test Case

1. Identification
 - Explicit number of test object
 - Designation of test object
 - Explicit number of the feature to be tested
 - Designation of the feature to be tested
 - Test case number within the feature to be tested
 - Test case name within the feature to be tested
 - Target of Test
 - SRS Requirement references
 - Test case version
 - Name of author
2. Method of Test
 - Text description of test method
 - Text description of test conditions
3. Start Conditions
 - Internal states of the test object
<logical information> = <value>
 - States of interfaces
<interface information> IN: *Information* | OUT: *Information*
4. Criteria of Passing the Test Case = Sequence of Test
 - IN: *Information*
 - OUT: *Information*



Information consisting of:

<interface>.<structure>.<timing> = <value>

<interface> = Designation of interface

<structure> = Structure of information

<timing> = buffered | unbuffered | all (all = optional)

- TIME≤: <value> (further sequence must occur within the defined time)
- TIME=: <value> (further sequence must exactly occur at the defined time)
- TIME≥: <value> (further sequence is allowed to occur after the defined time only)

5. End Conditions

- Internal states of the test object
<logical information> = <value>
- States of the interfaces
<interface information> IN: *Information* | OUT: *Information*

Note:

For uniformly designating the logical information, it is necessary to keep On-board Data Dictionary. In Annex 1, an example of a formalised test case description is represented.



6. ANNEX 1: TEMPLATE OF A FORMALISED SET OF TEST CASES FOR A FEATURE



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Test cases of Feature <identifier>

(<designation of the feature to be tested>)

Total: <number> Test Cases

REF : Subset-076-5-2-<identifier>

ISSUE : Version <number>

DATE : <dd/mm/yyyy>

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Modification History

Issue Number Date	Section Number	Modification / Description	Author

Dependencies

Set of Test Cases is included in	
Feature	Test Cases

Test cases

Important: All columns called 'Test Results' are only placeholders for results of the test execution. They shall not be used for the description of test cases. A test is passed if **all** cells of 'Test Result' are passed.



Test Case 1

IDENTIFICATION		
	Title	Unique Number
Tested Equipment		
Tested Feature		
Test Case of Feature		
Applicable Mode/Level Combinations		
Target of Test		
Version		
Author		
Based on Requirements	Subset-026 v2.3.0	

METHOD OF TEST	
Method	
Constraints	



STARTING CONDITIONS (INTERNAL STATES)

States of ERTMS/ETCS variables	Value	Description

*) One of the applicable Mode-Level combinations.

REQUIRED STARTING CONDITIONS ON INTERFACES

State of interfaces	I/O	Interface	Comments
		RTM	
		TIU	
		DMI	
		BTM	
		LTM	
		JRU	



SEQUENCE OF TEST					
Step	Description of Events	I/O	Interface	Comments	Test Result
1.					
2.					
3.					
...					

Optionally, rows “Preceded by” and “Followed by” can be included only when the concatenation of Test Cases is completely unambiguous. If there is no references to the preceded of followed features, the rows shall not be added.

If the sequence of test includes “Preceded by” and/or “Followed by”, included the appropriate rows in the table:

SEQUENCE OF TEST					
Step	Description of Events	I/O	Interface	Comments	Test Result
Preceded by					
1.					
2.					
Followed by					

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If the test case is associated with a Mode or Level Transition, the SEQUENCE OF TEST Table to be used is as follows:

SEQUENCE OF TEST									
Step	Previous		Description of Events	I/O	Interface	Comments	Next		Test Result
	Levels	Modes					Levels	Modes	
1.									
2.									
3.									
...									

This table is also compatible with the addition of “Preceded by” and/or “Followed by” rows.

SEQUENCE OF TEST									
Step	Previous		Description of Events	I/O	Interface	Comments	Next		Test Result
	Levels	Modes					Levels	Modes	
Preceded by									
4.									
5.									
6.									
...									
Followed by									



END CONDITIONS (INTERNAL STATES)

States of ERTMS/ETCS variables	Value	Description

*) One of the applicable Mode-Level combinations.

END CONDITIONS ON INTERFACES

State of interfaces	I/O	Interface	Comments
		RTM	
		TIU	
		DMI	
		BTM	
		LTM	
		JRU	

Test case 1 can be followed by further test cases if necessary.