



X2Rail-3

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Report on Testing of Moving Block Signalling Systems

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1 Executive Summary

This Report is one of a group of documents produced by WP4 Moving Block in the Shift2Rail X2Rail-3 in accordance with the X2Rail-3 Grant Agreement 826141:

- D4.1 Report on Testing of Moving Block Signalling Systems (this document) which defines the test cases required to test Level 3 Trackside Systems in Moving Block mode and the requirement for a test environment to support these tests
- D4.2 Moving Block Specifications
- D4.3 Future Moving Block Architectures
- D4.4 Report on Technology Demonstrators

This Report defines the test strategy and test cases required to validate the datasets required for a System running ETCS Level 3 Trackside in Full Moving Block. It also describes the requirements for a test environment where testing is performed in a test environment rather than the real railway.

The requirements, operational rules and engineering rules described in the deliverables from X2Rail-1 WP5 Moving Block are used as the basis for the tests and test environment requirements. Where work has been done in other parts of X2Rail-3 WP4 to refine these requirements using Use Cases, this document has sought to track the changes up to the publication date of this document.

During the preparation of this Report, a number of joint meetings have been held with X2Rail-2 WP4 On-board Train Integrity and X2Rail-3 WP5 Zero On-site Testing. There have also been meetings of representatives with the Open Call MovingRail and attendance at some of their meetings.

The Test Cases defined are those required to explicitly test the data associated with new or changed functionality of ETCS Level 3 Full Moving Block systems. It is expected that data associated with functionality common to ETCS Level 2 systems will be tested using existing test suites. These new Test Cases are applicable to Fixed Virtual Block systems where this is being used in place of Full Moving Block.

Developments during the production of X2Rail-3 WP4 D4.2 have been tracked and incorporated as far as possible during the production of the document, however the D4.2 work was not finished at the time this document was produced.

2 Table of Contents

1	EXECUTIVE SUMMARY	4
2	TABLE OF CONTENTS.....	5
3	ABBREVIATIONS, ACRONYMS AND DEFINITIONS	7
4	BACKGROUND	9
5	OBJECTIVE / AIM.....	10
6	TESTING MOVING BLOCK DATA	13
6.1	CATEGORIES OF DATA UNDER TEST	13
6.2	COVERAGE OF TEST CASES.....	15
6.3	FORMAT OF TEST CASES.....	19
6.4	CLEARANCE OF POINTS	20
6.5	POSITION OF RADIO HOLES.....	21
6.6	POSITION OF SHUNTING AREAS	22
6.7	EOA EXCLUSION AREAS	23
6.8	TRANSITIONS	24
6.9	HANDOVER	25
6.10	TIMERS.....	26
6.11	LOSS OF TRAIN INTEGRITY	27
6.12	REVERSING.....	28
6.13	CONFIGURABLE MINIMUM UNKNOWN	29
6.14	FIRST MOVEMENT AUTHORITY WITHOUT TRAIN INTEGRITY.....	30
6.15	AUTOMATIC EXTENSION OF MA INTO UNKNOWN AREA	31
6.16	MOVEMENT AUTHORITIES.....	32
6.17	FIRST MOVEMENT AUTHORITY.....	33
7	REQUIREMENTS TO TEST ENVIRONMENT FOR TESTING THE L3 TRACKSIDE	34
7.1	ETCS TRAINS.....	35
7.2	TRACKSIDE TRAIN DETECTION	38
7.3	NON-ETCS TRAINS	39
7.4	TMS.....	40
7.5	DATA	42
7.6	OPTIONAL REQUIREMENTS	43
8	FUTURE WORK.....	45
8.1	TEST SCENARIOS.....	45
8.2	DERIVED REQUIREMENTS	45
8.3	ETCS LEVEL 2 TEST SCENARIOS/TEST CASES.....	45
9	CONCLUSIONS.....	46
10	REFERENCES.....	47

3 Abbreviations, Acronyms and Definitions

Abbreviation / Acronyms	Description
CR	Change Request
CRE	Confirmed Rear End (of train)
EoM	End of Mission
ETCS	European Train Control System
FMB	Full Moving Block
FS	Full Supervision Mode
FVB	Fixed Virtual Block
L0	ETCS Level 0
L1	ETCS Level 1
L2	ETCS Level 2
L3	ETCS Level 3
MA	Movement Authority
mSFE	Minimum Safe Front End
MSFE	Maximum Safe Front End
mSRE	Minimum Safe Rear End
OBU	On-Board Unit [ETCS Onboard]
OS	On-Sight Mode
SoM	Start of Mission
SR	Staff Responsible Mode
SH	Shunting Mode
TI	Train Integrity
TIMS	Train Integrity Monitoring System

Area Track Status	Description
Clear	The L3 Trackside considers that there are no obstacles present on the track
Occupied	The L3 Trackside considers that there is a communicating train with train integrity confirmed present on the track
Radio Hole	An area where trains are known to lose radio connection with the L3 Trackside. It is possible to define a normal transit time for a Radio hole area.
Unknown	The L3 Trackside is unsure whether there is a train or obstacle present on the track (neither Occupied nor Clear).
Area Track Status Qualifiers	Description
EoA Exclusion Area	An area where EoA of an MA cannot be located. MA will not be extended until the exit area beyond is Clear for at least a train length.
Non-Sweepable Area	Unknown Area that cannot be cleared by "Sweeping Train"
Reserved Area	Area reserved by Level 3 Trackside for authorised train movement
Shunting Area	Area where shunting is allowed. The L3 trackside is unaware of exact train locations within the shunting area.
Sweepable Area	Unknown Area that can be cleared by "Sweeping Train"

4 Background

The Report constitutes the first issue of Deliverable D4.1 REPORT ON TESTING MOVING BLOCK SIGNALLING SYSTEMS in the framework of the Project titled “Enhancing railway signalling systems based on train satellite positioning, on-board safe train integrity, formal methods approach and standard interfaces, enhancing traffic management system functions” (Project Acronym: X2Rail-3; Grant Agreement No 826141).

This work follows on from X2Rail-1 WP5 and uses those outputs as the main input to this task. The outputs that were used are:

- D5.1 Moving Block System Specification
- D5.2 Moving Block Operational and Engineering Rules

All of the definitions and assumptions that were made in those documents are still applicable to this task and continue to be assumed.

New Test Cases are required for Level 3 Trackside signalling systems because it is not possible to extrapolate from traditional signalling systems testing to Moving Block.

Testing of L3 Trackside functionality per se is not covered by this set of test cases. Individual functions can be tested in isolation as part of development by equipment suppliers. The focus of this report is the L3 Trackside as a whole for a specific deployment. Therefore, this set of Test Cases is designed to exercise the dataset required for a specific instance of L3 Trackside to ensure it operates as designed.

During the development of this Report, liaison with X2Rail-2 WP4 On-board Train Integrity and X2Rail-3 WP5 Zero On-site Testing was maintained by a series of joint meetings to ensure that there was a common understanding on which group was covering particular aspects. There have also been meetings of representatives with the Open Call MovingRail, review of their draft deliverables and attendance at some of their meetings. All of these groups have been sent the draft Report for review

5 Objective / Aim

The objective of this deliverable is to define a set of test cases for testing the data required for Full Moving Block (FMB) trackside systems that address functionality that is changed or additional to the tests normally executed for ETCS Level 2 systems. These test cases are also applicable to Fixed Virtual Block (FVB) Systems operating at Level 3.

Within the Grant Agreement, there are four types of railway considered for Task 4.6 Moving Block Technical Demonstrators:

- Urban/Suburban Railways
- Overlay Systems
- High Speed Lines
- Low Traffic and Freight Lines

The Test Cases defined in this document are based on the different system types defined in D5.1. They can be applied to any Railway Type amongst those defined within the X2Rail-3 Grant Agreement and as listed above.

This set of Test Cases is designed to test the data required for Level 3 Trackside systems. In order to perform this testing, OBU systems (or simulations of OBU systems) will be required. However the test cases do not include consideration for the OBU data set testing as no specific changes to the OBU data has been proposed. Tests for the interoperability of the OBU with the ETCS Trackside are covered by Subset 110-112. Testing of the OBU itself is covered by Subset-076.

The data will always comprise candidate live data which requires detailed testing before the system can be signed off for entry into service. The data can be tested on the real railway during specific testing periods or it can be tested off-site on a representative set of equipment with a simulation environment. It is usually much more efficient to test the data off-site. The site-specific data testing is a critical point in the test cycle as it enables the various stakeholders and assessment bodies to gauge how the real railway will perform. Figure 5-1 shows the levels of testing and where these specific data tests fit within the overall testing programme at a generic level. Different countries may have different or additional assessment steps required before a system can be signed off for installation and use on the real railway. The data testing level is highlighted in yellow.

Type of Testing	Type of Data	Level of Testing	Tested by	Provides evidence for
Functional (off-site)	Test	Product	Supplier	Product Safety Case Independent Safety Advisor Notified Body (NoBo) Assessment
Functional (off-site)	Test	System	Systems Integrator	System Safety Case Independent Safety Advisor Notified Body (NoBo) Assessment
Data (off-site or on-site)	Site Specific	System	Systems Integrator and/or Acceptance Body	Specific Application Safety Case Independent Safety Advisor Notified Body (NoBo) Assessment Assessment Body (AsBo) Assessment Infrastructure Owner Approval Board Governmental Safety Approval Board

Figure 5-1: Levels of Testing

Typical processes for the achievement of Interoperability Authorisation and Safety Approvals is shown in Figure 5-2. The Site Specific Data Testing feeds into both of these processes as proof of safe and predictable operation for the L3 Trackside.

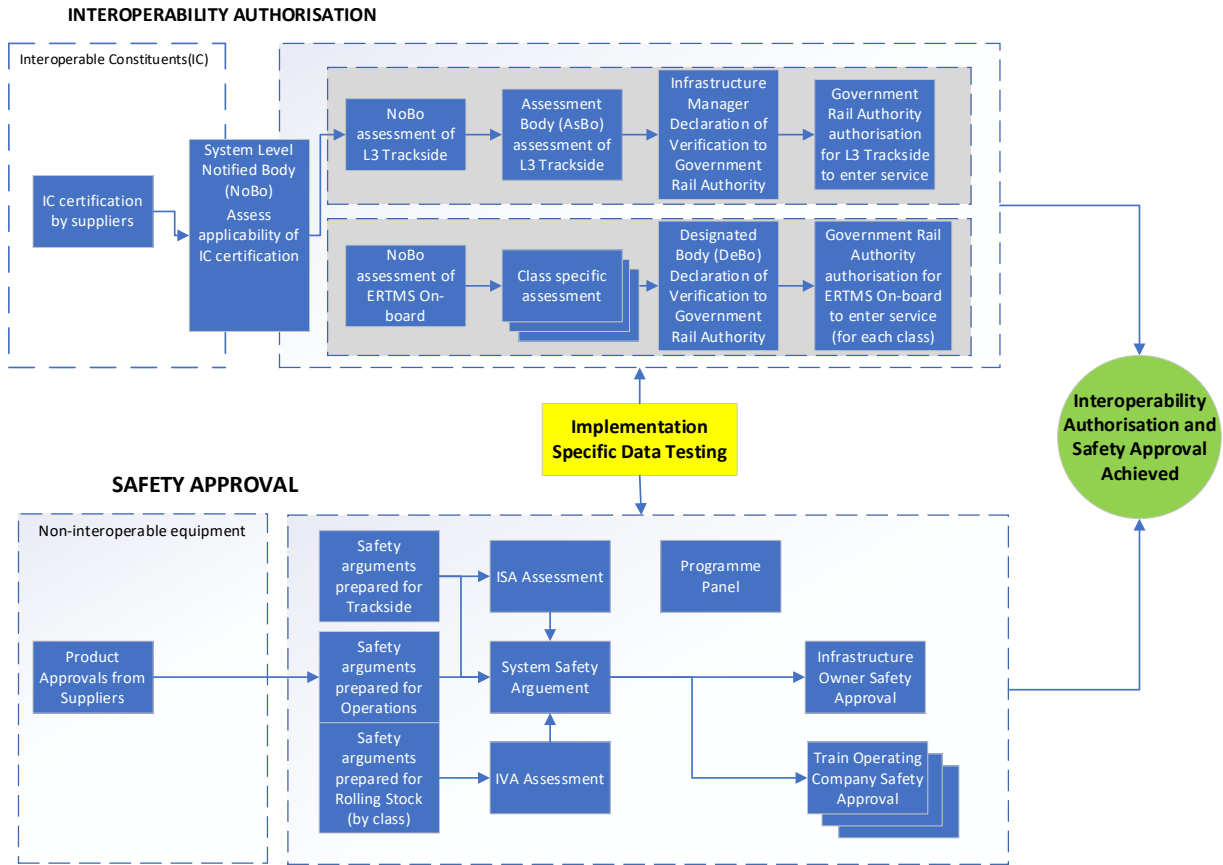


Figure 5-2: Interoperability Authorisation and Safety Approval Process

This report also includes a set of proposed requirements considered necessary for a test environment in which these tests should be performed, assuming that this testing is usually required to be performed away from the operational railway as far as is possible.

The functional requirements, operational and engineering rules developed in X2Rail-1 WP5 are the original source of our requirements. Generating these tests has highlighted areas where additional requirements or rules may be required and these areas have been fed into X2Rail-3 WP4 and the development of D4.2 – Moving Block Specification.

6 Testing Moving Block Data

This chapter defines the test cases to test the data required for Moving Block trackside systems (L3 Trackside). Only the data required for changed or additional functionalities to those of an ETCS Level 2 system are included.

6.1 Categories of Data under Test

The data under test falls into two main categories; that which can be 100% tested and that which can be only be sample tested. Static data that can be 100% tested includes the geographic data associated with the railway configuration of the project, for example position of clearance areas around points and fixed data such as timers. The data that can only be sample tested is the dynamic data such as the contents of an MA of which there are a huge number of combinations, as and the End of Authority can be at any point within the L3 Trackside Area of Interest. The number of possible combinations makes complete testing impracticable. Each category of data is discussed in turn.

6.1.1 Static data that can be completely tested

Items of data that can be 100% tested in a L3 Trackside system are:

- Position of points and non-fouling (clearance) points around them
- Position of (predefined) Radio Holes
- Position of (predefined) Shunting areas
- EoA Exclusion Areas
- Interfaces
 - Transitions in and out of the L3 Area
 - Handover between L3 Trackside Areas
- Timers
 - Session
 - Mute (optional)
 - Latency (TTD)
 - Train Integrity
 - Radio Holes (optional)
- Loss of Train Integrity
 - Train Integrity by Driver accepted
 - Issuing an MA depending on Train Integrity
- Reversing
- Configurable Minimum Unknown
- First Movement Authority (if there is no confirmed Train Integrity)
- Automatic Extension of an MA into Unknown Area

6.1.2 Dynamic data that can only be sample tested

Items of data that can be sample tested in a L3 Trackside system are:

- Movement Authorities (MA)
 - Movement Authority
 - First Movement Authority (from anywhere within L3 Trackside Area of Interest)

The exact size of the sample will depend on a number of factors:

- the level of confidence in the data preparation process (SIL 4)
- the evidence needs of the Safety Assurance teams from the various authorities involved with signing off the data as fit for purpose, such as
 - L3 Trackside Systems Integrator Safety Assurance Team
 - Independent Safety Advisor (ISA)
 - Designated Body (DeBo)
 - Nominated Body (NoBo)
 - Assessment Body (AsBo)
 - Infrastructure Owner Approvals Board/Panel
 - Governmental Safety Approvals Board

6.2 Coverage of Test Cases

6.2.1 Introduction

This section shows the coverage of the tests for new data items across the requirements as envisaged in X2Rail-1 D5.1. Some functions do not require new data items and are marked as n/a. Two requirements (REQ-LossTI-4 and REQ-LossTI-10) are covered by application specific implementations. One requirement (REQ-TrackStatus-9) is not yet fully defined. Table 6-1 also shows those requirements that require additional test environment requirements in order to be met.

D5-1 Requirement	Test Environment requirement	Data Test
REQ-TrainLoc-1		n/a
REQ-TrainLoc-2		n/a
REQ-TrainLoc-3		n/a
REQ-TrainLoc-4		n/a
REQ-TrainLoc-5		n/a
REQ-TrainLoc-6		n/a
REQ-TrainLoc-7		n/a
REQ-TrainLoc-8		n/a
REQ-TrainLoc-9	TSTENV-OBUS-3	n/a
REQ-TrainLoc-10		n/a
REQ-TrackStatus-1		n/a
REQ-TrackStatus-2		n/a
REQ-TrackStatus-3		n/a
REQ-TrackStatus-4		n/a
REQ-TrackStatus-5	TSTENV-TMS-1	n/a
REQ-TrackStatus-6		n/a
REQ-TrackStatus-7		n/a
REQ-TrackStatus-8	TSTENV-TMS-1	n/a
REQ-TrackStatus-9	TSTENV-DATA-1	not yet defined
REQ-TrackStatus-10	TSTENV-DATA-1	n/a
REQ-TrackStatus-11	TSTENV-DATA-1	TC-TrackStatus-1
REQ-TrackStatus-12		n/a
REQ-TrackStatus-13		n/a
REQ-TrackStatus-14		n/a
REQ-TrackStatus-15		n/a
REQ-TrackStatus-16		n/a
REQ-Reserved-1		n/a
REQ-Reserved-2		n/a

Report on Testing of Moving Block Signalling Systems

D5-1 Requirement	Test Environment requirement	Data Test
REQ-Reserved-3		n/a
REQ-FVB-1		n/a
REQ-TTD-1	TSTENV-NONETCS-1	TC-TIMER-1
REQ-TTD-2	TSTENV-TTD-2	n/a
REQ-TTD-3		n/a
REQ-TTD-4		n/a
REQ-PTS-1		TC-PTS-1
REQ-PTS-2		TC-PTS-2
REQ-PTS-3		n/a
REQ-PTS-4		n/a
REQ-MA-1		TC-MA-1
REQ-MA-2		TC-MA-1
REQ-MA-3		TC-MA-1
REQ-MA-4		TC-MA-1
REQ-MA-5		TC-MA-1
REQ-MA-6		TC-MA-1
REQ-MA-7		TC-MA-1
REQ-MA-8		TC-MA-1
REQ-MA-9	TSTENV-TMS-3	TC-MA-1, TC-MA-3
REQ-EoAExclusionArea-1		TC-EoAExclusionArea-1
REQ-EoAExclusionArea-2		TC-EoAExclusionArea-1
REQ-StartTrain-1		n/a
REQ-StartTrain-2		n/a
REQ-StartTrain-3		n/a
REQ-StartTrain-4		n/a
REQ-StartTrain-5		n/a
REQ-StartTrain-6		n/a
REQ-StartTrain-7		n/a
REQ-StartTrain-8		n/a
REQ-MovSR-1		n/a
REQ-MovSR-2		n/a
REQ-MovSR-3		n/a
REQ-FirstMA-1		TC-FirstMA-1
REQ-FirstMA-2		TC-FirstMA-2
REQ-LossComms-1	TSTENV-OBU-4	TC-TIMER-1
	TSTENV-DATA-1	
REQ-LossComms-2	TSTENV-OBU-4	TC-TIMER-1
	TSTENV-DATA-1	

Report on Testing of Moving Block Signalling Systems

D5-1 Requirement	Test Environment requirement	Data Test
REQ-LossComms-3	TSTENV-OBU-4	TC-TIMER-1
	TSTENV-DATA-1	n/a
REQ-LossComms-4	TSTENV-OBU-4	TC-TIMER-1
	TSTENV-DATA-1	n/a
REQ-RecoveryMgmt-1		n/a
REQ-RecoveryMgmt-2	TSTENV-OBU-3	n/a
REQ-RecoveryMgmt-3		TC-TIMER-1
REQ-RecoveryMgmt-4		TC-TIMER-1
REQ-RadioHole-1	TSTENV-TMS-4	TC-RadioHole-1
REQ-RadioHole-2		TC-RadioHole-1
REQ-RadioHole-3		TC-TIMER-1
REQ-RadioHole-4		TC-TIMER-1
REQ-RadioHole-5		n/a
REQ-Rev-1		TC-Rev-1
REQ-Rev-2		n/a
REQ-Rev-3		n/a
REQ-EoM-1		n/a
REQ-EoM-2		n/a
REQ-EoM-3		n/a
REQ-EoM-4		n/a
REQ-EoM-5		n/a
REQ-EoM-6		n/a
REQ-LossTI-1		n/a
REQ-LossTI-2		n/a
REQ-LossTI-3		n/a
REQ-LossTI-4	TSTENV-DATA-1	application specific
REQ-LossTI-5	TSTENV-DATA-1	TC-TIMER-1
REQ-LossTI-6		n/a
REQ-LossTI-7		n/a
REQ-LossTI-8		n/a
REQ-LossTI-9	TSTENV-DATA-1	TC-LossTI-1
REQ-LossTI-10	TSTENV-DATA-1	application specific
REQ-LossTI-11		n/a
REQ-LevelTrans-1		n/a
REQ-TrackInit-1		n/a
REQ-TrackInit-2		n/a
REQ-TrackInit-3		n/a
REQ-TrackInit-4		n/a

D5-1 Requirement	Test Environment requirement	Data Test
REQ-TrackInit-5		n/a
REQ-HO-1		TC-HO-1
REQ-HO-2		TC-HO-1
REQ-HO-3		TC-HO-1
REQ-SH-1		TC-SH-1
REQ-SH-2	TSTENV-TMS-5	TC-SH-1
REQ-SH-3		TC-SH-3
REQ-Join-1		n/a
REQ-Join-2		n/a
REQ-Join-3		n/a
REQ-Split-1		n/a
REQ-TMS-1		n/a

Table 6-1: Test and Test Environment Coverage

6.3 Format of Test Cases

6.3.1 Test Cases

This chapter describes the Test Cases required. Each Test Case may require a number of different tests to be performed in order to satisfy all of the possible outcomes.

6.3.2 Format for the Data Tests Case Descriptions

For each Test Case, the following items are included

- Test Case reference number in the form *<Type> - <Subject Area> – <Number>*
 - *<Type>* is “TC” (Test Case) for D4.1
 - *<Subject Area>* Section for the Test Case
 - *<Number>* to identify various test case in the same subject area
- Data Items covered
- Level of testing
- Requirements are references to requirements from D5.1 and/or engineering or operational rules from D5.2
- Scenario
- Expected results

6.4 Clearance of Points

TC-PTS-1

6.4.1 Data Items

Track topology of points area around the Fouling Points and Point Toe (Release Points) of a set of points

6.4.2 Level of Testing

100% coverage of points, traversed in each possible direction

6.4.3 Requirements

REQ-PTS-1

REQ-PTS-2

6.4.4 Scenario

A set of points that have been locked for a train can only be unlocked and moved by the L3 Trackside once the train has reported a position that ensures that the CRE of the train is clear of the Release Points.

6.4.5 Expected Results

Test includes all sets of points covered by the L3 Trackside and specifically tests that they have been correctly configured. Points cannot be moved by L3 Trackside until traversing train reports a position that confirms that the CRE is clear of the Release Points.

6.5 Position of Radio Holes

TC-RadioHole-1

6.5.1 Data items

The position of pre-defined area of Static or Dynamic Radio Holes. Dynamic Radio Holes will include all GSM-R Nodes to cover failures or outages for maintenance.

6.5.2 Level of Testing

100% coverage of Radio Holes

6.5.3 Requirements

REQ-RadioHole-1

REQ-RadioHole-2

6.5.4 Scenario

Each Radio Hole should have an EoA Exclusion Area associated with it. The test should ensure that the L3 Trackside does not extend an MA until there is an area of clear track status a minimum of the train length beyond the Radio Hole.

6.5.5 Expected results

Test covers all pre-defined Radio Holes. L3 Trackside does not extend MA through any Radio Hole unless there is a train length's worth of Clear track status beyond the Radio Hole.

6.6 Position of Shunting Areas

TC-SH-1

6.6.1 Data items

Configuration data for predefined Permanent and Temporary Shunting Areas.

6.6.2 Level of Testing

100% coverage of Permanent and Temporary Shunting Areas

6.6.3 Requirements

REQ-SH-1

REQ-SH-2

REQ-SH-3

6.6.4 Scenario

Need to confirm the position of all predefined shunting areas and the ability of the L3 Trackside to mark them as Unknown Areas when active.

6.6.5 Expected results

Shunting Area positions are confirmed and Temporary Shunting Areas can be activated and deactivated.

6.7 EoA Exclusion Areas

TC-EoAExclusionArea-1

6.7.1 Data items

All EoA Exclusion Areas that are defined in configuration data. Note that the testing of some EoA Exclusion Areas may be included as part of other Test Cases, e.g. Radio Holes, Points.

6.7.2 Level of Testing

100% coverage of End of Authority Exclusion Areas

6.7.3 Requirements

REQ-EoAExclusionArea-1

REQ-EoAExclusionArea-2

6.7.4 Scenario

When an EoA Exclusion Area is defined, the Level 3 Trackside will ensure that a train is able to completely leave the EoA Exclusion Area before extending the Movement Authority beyond the EoA Exclusion Area. This must consider the length of the train, to ensure its rear end does not infringe the EoA Exclusion area.

6.7.5 Expected results

Test covers all EoA Exclusion Areas. L3 Trackside does not issue or extend an MA until there is sufficient Clear track beyond the EoA Exclusion Area to accommodate the full length of the train.

6.8 Transitions

TC-Trans-1

6.8.1 Data items

All transitions into and out of Level 3 in the L3 Trackside Area of Interest including balise data

6.8.2 Level of Testing

100% coverage of transition boundaries, in each possible direction

6.8.3 Requirements

No D5.1 Requirements

6.8.4 Scenario

All transitions must be tested in all permitted directions.

6.8.5 Expected results

Trains approaching boundary of the L3 Trackside Area in Level 2/1/0/NTC that connect and report position as the configuration was designed will transition into Level 3 successfully. All trains that approach the boundary departing the L3 Trackside Area transition out of Level 3 to Level 2/1/0/NTC successfully.

6.9 Handover

TC-HO-1

6.9.1 Data Items

The data defining all boundaries where one L3 Trackside system hands over trains to an accepting L3 Trackside system.

6.9.2 Level of Testing

100% coverage of Handover Boundaries, in each possible direction

6.9.3 Requirements

REQ-HO-1

REQ-HO-2

REQ-HO-3

6.9.4 Scenario

When acting as an Accepting L3 Trackside, the L3 Trackside shall consider the area sent as part of a Route Related Information message to an adjacent L3 Trackside as Reserved. When the Handing Over L3 Trackside receives a position report and detects that the Confirmed Rear End of the train has crossed the border, it shall send a session termination order to the ETCS On-Board equipment.

6.9.5 Expected Results

Handover is achieved at the correct locations in all instances.

6.10 Timers

TC-TIMER-1

6.10.1 Data Items

There are a number of timers contained within the L3 Trackside dataset. Some are optional. All configured timers must be tested. The timers include:

- Session Timer
- Mute Timer (optional)
- Latency Timer (TTD)
- Integrity Timer
- Radio Hole Timer (optional)

6.10.2 Level of Testing

100% coverage. Each configured Timer value should be tested

6.10.3 Requirements

Session Timer	REQ-LossComms-4 REQ-RecoveryMgmt-3	REQ-RecoverMgmt-2 REQ-RecoveryMgmt-4
Mute Timer	REQ-LossComms-1 REQ-RecoveryMgmt-3	REQ-LossComms-2 REQ-RecoveryMgmt-4
Latency Timer	REQ-TTD-1	ENG-Generic-8
Train Integrity Timer	REQ-LossTI-5	
Radio Hole Timer	REQ-RadioHole-3 REQ-RadioHole-4	ENG-LossComms-2

6.10.4 Scenario

Each of these timers that are configured in the data needs to be tested to ensure that the L3 Trackside responds as expected at the desired time.

6.10.5 Expected Results

L3 Trackside reacts with the required reaction at the required time.

6.11 Loss of Train Integrity

TC-LossTI-1

6.11.1 Data Items

Configuration whether the 'train integrity confirmed by driver' (Q_LENGTH = 2) is accepted by the L3 Trackside.

6.11.2 Level of Testing

100% coverage. One test to check that Train Integrity Confirmed by Driver is handled as configured

6.11.3 Requirements

REQ-LossTI-9

6.11.4 Scenario

A train performs Start of Mission, for example at a station. TIMS is not working, therefore, the Driver confirms Train Integrity. The train then travels in FS, but without Train Integrity confirmed, to a second station. At the second station, the Driver again confirms train integrity.

6.11.5 Expected Results

If the L3 Trackside is configured to accept Train integrity confirmation by the driver:

- After start of mission, the L3 Trackside considers the Track Status of the area between the CRE and the MSFE as Occupied.
 - This Occupied area is extended with each subsequent position report from the train until the train enters the second station and the driver confirms the train integrity again.
- When the train stops at the second station and afterwards the L3 Trackside receives the train integrity confirmation by the driver, then the L3 Trackside considers the Track Status of the area between the previous CRE and current SRE as Clear and the Track Status of the area between the current CRE and the current MSFE as Occupied.

If the L3 trackside is not configured to accept Train Integrity Information by the driver then:

- After start of mission: L3 Trackside will not issue MA to train.

6.12 Reversing

TC-Rev-1

6.12.1 Data Items

Definition of Reversing Areas

6.12.2 Level of Testing

100% coverage of Reversing Areas

6.12.3 Requirements

REC-Rev-1

6.12.4 Scenario

A reversing route is set for a train.

6.12.5 Expected Results

Check that the L3 Trackside retains the Reversing Area at the expected location until the train has passed through the Reversing Area.

Check that the reversing information sent to the train covers the expected area.

6.13 Configurable Minimum Unknown

TC-TrackStatus-1

6.13.1 Data Items

Configurable minimum train length

6.13.2 Level of Testing

100% coverage. One test to check that the Configurable Minimum Unknown is as expected.

6.13.3 Requirements

REQ-TrackStatus-11

6.13.4 Scenario

A route is set for a train and within this route there is an Unknown Area. The Unknown Area is sweepable. The L3 Trackside has issued an MA with a mode profile On Sight over the Unknown area.

6.13.5 Expected Results

When the distance from mSFE to the end of the Unknown Area > Configurable Minimum Unknown then the Unknown Area remains.

When the distance from mSFE to the end of the Unknown Area <= Configurable Minimum Unknown then the Unknown Area is cleared.

6.14 First Movement Authority without Train Integrity

TC-FirstMA-2

6.14.1 Data Items

Configuration whether a first movement authority is issued if there is no confirmed train integrity or the train integrity is confirmed by the driver.

6.14.2 Level of Testing

100% coverage. One test to check that First Movement Authority without Train Integrity is handled as configured.

6.14.3 Requirements

REQ-FirstMA-2

6.14.4 Scenario

A train performs Start of Mission, for example at a station. TIMS is not working, The L3 Trackside is requested to issue a first MA for this train.

6.14.5 Expected Results

When the L3 Trackside is configured to provide a first MA for a train even if there is no confirmed train integrity or the integrity is confirmed by the driver, then the L3 Trackside shall issue a first MA to this train.

If the L3 Trackside is not configured to provide a first MA for a train if there is no confirmed train integrity or the integrity is confirmed by the driver, then the L3 Trackside does not issue a first MA to this train until the train integrity is confirmed.

6.15 Automatic Extension of MA into Unknown Area

TC-MA-3

6.15.1 Data Items

Configuration whether it is allowed to automatically extend an MA into an Unknown area.

6.15.2 Level of Testing

100% coverage. One test to check that extension of MA into an Unknown Area is handled as configured.

6.15.3 Requirements

REQ-MA-9

6.15.4 Scenario

A route is set for a train and within this route there is an area of Unknown.

6.15.5 Expected Results

If the L3 Trackside is configured to automatically extend a Movement Authority into Unknown areas, then the L3 Trackside extends the Movement Authority over the area with Track Status Unknown with a mode profile On Sight.

Otherwise the L3 Trackside requests the confirmation from the TMS before extending the Movement Authority into the Unknown area.

6.16 Movement Authorities

TC-MA-1

6.16.1 Data Items

The data necessary to issue a valid Movement Authority to a train, up to the next obstruction, which can be a fixed or dynamic.

6.16.2 Level of Testing

Sample only. The sample should include at least one pass through all main routes with one train following another train as a minimum sample. The sample might also include MAs in FS Mode and OS Mode across some or all of the main routes.

6.16.3 Requirements

REQ-MA-1

REQ-MA-2

REQ-MA-3, D5.2 Operational Rules: OPE-OS-4

REQ-MA-4

REQ-MA-5

REQ-MA-6, D5.2 Engineering Rules: ENG-Generic-6

REQ-MA-7

REQ-MA-8

REQ-MA-9, D5.2 Engineering Rules: ENG-REC-1

6.16.4 Scenario

A L3 Trackside is able to issue a Movement Authority to a train up to the next obstruction or up to the configured maximum permitted length of MA. The MA is also sent to the TMS where one is used. The obstruction could be the train ahead of this train.

6.16.5 Expected Results

The train moves to the EoA. The resultant MAs can be checked on the TMS where one is used.

6.17 First Movement Authority

TC-FirstMA-1

6.17.1 Data Items

The data necessary to issue a valid first FS Movement Authority to a train anywhere on the Area of Control.

6.17.2 Level of Testing

Sample only. All locations/directions where first MA is likely during normal operation, where Start of Mission will occur should be included in the sample together with a sample of other locations.

6.17.3 Requirements

REQ-FirstMA-1

6.17.4 Scenario

The L3 Trackside shall be able to send a first FS Movement Authority to a train anywhere in the Area of Control, so long as the conditions for sending a Movement Authority are fulfilled.

6.17.5 Expected Results

Train can receive a first MA when starting off anywhere within the Area of Control as long as the relevant conditions are satisfied.

7 Requirements to Test Environment for testing the L3 Trackside

This chapter proposes a suite of requirements to a Test Environment to test the functionality and data for the L3 Trackside of an ETCS Level 3 system based on the requirements contained in [D5.1] and Baseline 3 Release 2 [BL3 R2] with Change Request 940 [CR940]. These new requirements are in addition to those of a test environment for an ETCS Level 2 system.

The requirements to the Test Environment have been derived from [D5.1].

This chapter is structured into different subchapters whereas each subchapter represents either a subsystem or a high-level aspect of the test environment.

Sub-Section	Notes
7.1 ETCS Trains	Requirements to the test environment related to the ETCS trains, especially to the OBUs.
7.2 Trackside Train Detection	Requirements to the test environment related to the Trackside Train Detection.
7.37.3 Non-ETCS trains	Requirements to the test environment related to the non-ETCS trains.
7.4 TMS	Requirements to the test environment related to the TMS functionality.
7.5 Data	Data that needs to be known by the test environment.
7.6 Optional requirements	Optional requirements to the test environment

Each requirement has been structured in four different parts:

- ID: each item is given a Unique Id, structured as follows:
 <Type>-<Section>-<Number>
 where:
 <Type> is "TSTENV" for D4.2
 <Section> is an abbreviation within the document for a section of requirements
 <Number> is a number unique to the document section
- Requirement: this is the text of the requirement to subsystem / aspect of the test environment.
- Rationale:
 this is the reasoning explaining why and in which situations this requirement is needed
- Guidance:
 this is a proposal for the requirement implementation or other aspects to be considered during its implementation.

References to requirements starting with REQ- are related to [D5.1].

7.1 ETCS trains

7.1.1 Introduction

This section contains requirements to the test environment related to the ETCS trains.

7.1.2 Requirements

TSTENV-OBU-1

The test environment shall consist of OBUs that are implemented according [BL3R2] and [CR940].

Rationale:

CR940 covers the reporting of Train Integrity which is crucial for an ETCS Level 3 system.

Note: This requirement does not imply that all OBUs of the test environment have to be implemented according [BL3R2] and [CR940]. For a system using Trackside Train Detection there might be some trains that are already equipped with a TIMS. The OBUs of these trains have to implement [CR940]. But there might be also other trains that are not equipped with a TIMS (yet).

Please note that other CRs (as e.g. requested due to chapter “Changes in Current Specifications” ([D5.1.]), are not in scope of the test environment.

Guidance:

None.

TSTENV-OBU-2

It shall be possible to trigger a certain train integrity status (Q_LENGTH) at a given time from the ETCS Trains to the L3 trackside.

Rationale:

A certain train integrity status (e.g. ‘Train integrity lost’) is required to trigger some specific behaviours of the L3 trackside as e.g. specified in

- REQ-LossTI-1: To verify this requirement, it shall be possible to trigger the train integrity status ‘Train integrity lost’.
- REQ-LossTI-5: To verify this requirement, it shall be possible to trigger the reporting of the train integrity status ‘No integrity information available’ for a configurable time.

Additionally for a system with Trackside Train Detection this requirement supports the mixed traffic of trains with a TIMS and trains without a TIMS.

Guidance:

None.

TSTENV-OBU-3

It shall be possible to manipulate the train length (L_TRAIN, L_TRAININT) of the ETCS trains in the test environment.

Rationale:

In deviation to an L2 trackside, the train length (L_TRAIN, L_TRAININT) is more important to an L3 trackside, especially for determining the train location (REQ-TrainLoc-1), for the recovery management (REQ-RecoveryMgmt-2) and operational situations such as loss of train integrity, joining and splitting.

Guidance:

None.

TSTENV-OBU-4

It shall be possible to suppress any application message from the OBUs to the L3 Trackside for a configurable time.

Rationale:

Suppressing the application message from the OBUs to L3 Trackside is necessary to verify the reaction of the L3 Trackside when the mute timer has expired as specified in REQ-LossComms-1 to REQ-LossComms-4.

Guidance:

Suppressing the application messages from the OBUs to the L3 Trackside must not be realised by terminating the safe connection / communication session from the OBU to the L3 trackside.

TSTENV-OBU-5

It shall be possible to manipulate the confidence interval of the OBUs of the test environment.

Rationale:

In deviation to an ETCS L2 system, the performance of an ETCS L3 system is more dependent on the extent of the confidence interval reported by the OBUs.

Manipulating the confidence interval of the OBUs is necessary to:

- Test whether the performance of the ETCS L3 system fulfils the requirements of the infrastructure managers dependent on the confidence interval
- Test whether the system behaves correctly dependent of the extent of the confidence interval.

Guidance:

This can be realised e.g. by configuring the extent of the confidence interval in percentage (e.g. 2%) as in [Subset-41].

7.2 Trackside Train Detection

7.2.1 Introduction

This section contains requirements to the test environment related to the Trackside Train Detection.

7.2.2 Requirements

TSTENV-TTD-1

For a system using Trackside Train Detection, the test environment shall be able to manipulate the latency between Trackside Train Detection and latency of the Train Position Reports

Rationale:

This is necessary to verify the requirements related to the Train Location and the Track Status, especially REQ-TTD-2.

Guidance:

The idea is to configure a latency timer to

1. Delay the forwarding of a TTD status in case the test environment detects an occupancy or clearance and
2. Delay the forwarding of train position reports.

Additionally the test environment may support a TTD failure simulation.

7.3 Non-ETCS trains

7.3.1 Introduction

This section contains requirements to the test environment that are related to non-ETCS trains.

7.3.2 Requirements

TSTENV-NONETCS-1

For a system using Trackside Train Detection, the test environment shall support non-ETCS trains, i.e. non-communicating trains.

Rationale:

Supporting non-communicating trains is necessary to verify the system behaviour for systems with mixed traffic of communicating trains (with a TMS) and non-communicating trains.

Especially requirements such as REQ-TTD-1 can be only verified when this requirement is fulfilled.

Guidance:

None.

7.4 TMS

7.4.1 Introduction

This section contains requirements to the test environment that are related to the TMS functionality.

7.4.2 Requirements

TSTENV-TMS-1

The test environment shall be able to set areas from Unknown to Clear and Clear to Unknown.

Rationale:

Setting areas from Clear to Unknown is necessary to provide all relevant information concerning obstructions to the L3 trackside, cp. REQ-TrackStatus-5.

Setting areas from Unknown to Clear is necessary to clear areas based on the result of operational procedures, cp. REQ-TrackStatus-8. Especially in a system without Trackside Train Detection, the L3 Trackside starts in the most restrictive state (Unknown) after (re-) starting the L3 trackside. To avoid that trains have to sweep all Unknown areas, the L3 trackside can set areas from Unknown to Clear.

Rationale:

When setting an area from Clear to Unknown, the test environment shall be also able to set the areas to Sweepable or Non-Sweepable, cp. REQ-TrackStatus-6.

TSTENV-TMS-2

The test environment shall be able to provide a location of a train, which is reporting an invalid or unknown position, to the L3 trackside.

Rationale:

When e.g. a train starts up, then it is possible that the train location is invalid or unknown. With an invalid or unknown position, the L3 trackside won't issue a Movement Authority to this train until the train has reported a valid position. This avoids executing specific tests. Therefore there needs to be a possibility to provide a location of a train which is reporting an unknown or invalid position, to the L3 trackside.

Guidance:

None.

TSTENV-TMS-3

The test environment shall be able to confirm to the L3 trackside whether an MA can be extended into Unknown areas within a route set for a train.

Rationale:

Cp. also REQ-MA-9.

Guidance:

This requirement needs to be only fulfilled, if the L3 trackside is configured so. If the L3 trackside is configured to automatically extend an MA into Unknown areas, then there is no need to fulfill this requirement.

TSTENV-TMS-4

The test environment shall include functionality to activate or deactivate predefined dynamic Radio Holes.

Rationale:

Cp. also REQ-RadioHole-1. To consider the requirements related to Radio Hole in the tests for the L3 trackside, this requirement needs to be supported.

Guidance:

None.

TSTENV-TMS-5

The test environment shall include functionality to enable or disable Temporary Shunting Areas.

Rationale:

Cp. also REQ-SH-2. To consider the requirements related to Shunting Areas in the tests for the L3 trackside, this requirement needs to be supported.

Guidance:

None.

7.5 Data

7.5.1 Introduction

This section contains requirements for a test environment related to new engineering data that is necessary to test a L3 trackside. In addition to the L3 trackside, the test environment needs to be configurable with the following engineering data to enable the behaviour of the L3 trackside.

7.5.2 Requirements

TSTENV-DATA -1

The test environment shall know the following engineering data.

- Configurable minimum length for removal of Unknown
 - o Cp. REQ-TrackStatus-11
- Configurable time (mute timer) after which the L3 trackside will consider the communication with the train as lost
 - o Cp. REQ-LossComms-1,2,3,4
- Configurable Trackside reaction to a reported loss of TI
 - o Cp. REQ-LossTI-4
- Configurable time after which the L3 Trackside considers the train integrity as lost when no integrity info is reported longer than this configurable time
 - o Cp. REQ-LossTI-5
- Configuration whether to accept confirmation of integrity by driver.
 - o Cp. REQ-Loss-TI-9
- Configuration whether an authorisation of an MA is required for a train that has lost train integrity.
 - o Cp. REQ-Loss-TI-10
- TTD Latency timer
 - o REQ-TTD-1

Rationale:

See above.

Guidance:

7.6 Optional requirements

7.6.1 Introduction

This section contains optional requirements to the test environment.

7.6.2 Requirements

TSTENV-OPT-1

The test environment should provide a data analysis tool. This data analysis shall collect all variable data as output from the L3 trackside, especially e.g.

- Train Location
- Track Status
- Movement Authorities
- etc.

Rationale:

This data analysis tool can be used to evaluate whether the L3 trackside behaves according to specific invariants, e.g.

- The L3 trackside never issues an FS-MA to a following train with an EoA beyond the CRE of a preceding train.
- The L3 trackside never issues an FS-MA into an Unknown area.
- etc.

Guidance:

None.

TSTENV-OPT-2

The test environment should be able to automatically check variable data as output from the L3 trackside, especially, e.g.

- Train Location
- Track Status
- Movement Authorities
- etc.

Rationale:

This automatic check can be used to reveal when the L3 trackside does not behave according to a specific invariant.

Guidance:

None.

8 Future Work

The coverage of these test cases and test environment requirements cannot be considered complete as work is still progressing on X2Rail-3 WP4 Task 4.3 deliverable D4.2 Moving Block System Specification. Also two additional areas are highlighted.

8.1 Test Scenarios

Development of these scenarios has tracked development in X2Rail-3 D4.2 as far as is possible during their preparation. However this document has been completed before the finish of X2Rail-3 WP4 Task 4.3 and the production of D4.2 so a further check of the completeness of these test scenarios will be needed to ensure that the data required for all of the requirements, engineering and operational rules are included.

8.2 Derived Requirements

The production of these test scenarios has highlighted a number of areas where the tests derived do not have requirements that address all of the possible outcomes of the scenarios. Work is therefore required to assess and complete the requirements and/or operational or engineering rules to cover these areas.

8.3 ETCS Level 2 Test Scenarios/Test Cases

This task was explicitly required to cover only those test cases that are original or changed from those already being used to assess ETCS Level 2 systems. Despite a lot of research no definitive specification of what test cases are included in the testing of ETCS Level 2 Trackside Systems were identified. [Subset-076 contains tests for the ETCS OBU for testing compliance with Subset-026.] None of the Infrastructure Managers involved in Work Package was able to specify a benchmark test set that was used to certify an ETCS Level 2 Trackside System as fit for purpose. To ensure that all areas had been addressed for the testing of a L3 Trackside system it is required to pass both the ETCS Level 2 trackside test cases that are not superseded by Level 3 functionality and the test cases defined in this document for a L3 Trackside so the ETCS Level 2 test cases that are assumed to be unchanged for a Level 3 system should be documented.

9 Conclusions

The purpose of this deliverable has been to propose a set of new test scenarios that can be applied to test L3 Trackside data to ensure that it operates correctly. This deliverable also provides proposals for a set of requirements needed for a test environment in order to be able to perform these tests.

The main input to this task deliverable has been the outputs from X2Rail-1 WP5. In addition, developments during the production of X2Rail-3 D4.2 have been tracked and incorporated as far as possible during the production of this document. It should be noted that the D4.2 work had not been concluded at the time this document was produced. This deliverable will be subject to ongoing review and update during X2Rail-5.

10 References

- [BL3 R2] TSI Commission regulation (EU) 2016/919, of 27 May 2016, on the technical specification for interoperability relating to the 'control-command and signalling' subsystems of the rail system in the European Union
Set of specifications # 3 (ETCS baseline 3 and GSM-R baseline 1)
- This set of specifications is colloquially referred to as "Baseline 3 Release 2"
- [CR940] Opinion ERA/OPI/2017-2
(https://www.era.europa.eu/sites/default/files/library/docs/opinion-advice/opinion_era-opi-2017-2_en.pdf)
- This opinion contains Change Request 940, which covers the reporting of Train Integrity.
- [Subset-026] Control, Command and Signalling Commission Regulation (EU) 2016/919 of 27/05/2016 on the Technical Specification of Interoperability relating to the 'Control Command and Signalling' subsystems of the rail system in the European Union (plus corrigendum and amended by Commission Implementing Regulation (EU) 2019/776 of 16th May 2019)
- This set of specifications is colloquially referred to as "Baseline 2 Release 3.0.d" or BL2.3.0.d
- [Subset-076] ERA ERTMS/ETCS Subset-076-5-2 Test Cases for Feature
ERA ERTMS/ETCS Subset-076-6-3 Test Sequences
ERA ERTMS/ETCS Subset-076-7 Scope of the Test Specifications
- [Subset 110] UNISIG Interoperability Test – Guidelines Subset-110
- [Subset 111} UNISIG Interoperability Test – Guidelines Subset-111
- Subset 112] UNISIG Interoperability Test – Guidelines Subset-112
- [D5.1] Deliverable D5.1 Moving Block System Specification
Version 3.0 31/10/2019.
- [D5.2] Deliverable D5.2 Moving Block Operational and Engineering
Rules Version 4.0 19/11/2019

[D5.3] Deliverable D5.3 Moving Block Preliminary Safety Analysis
Version 3.0 07/11/2019

[Subset-041] to be added.

Appendix A: Ownership of results

The following Table 10-1 lists the ownership of results for this deliverable.

Ownership of results				
Company	Percentage	Short Description of share/ of delivered input	Concrete (where applicable)	Result
SIE				
ALS				
STS				
BTSE				
CAF				
NR				
TD				
TRV				
AZD				
DB				
MERMEC				
DLR				
SNCF-R				

Table 10-1: Ownership of results

This deliverable is jointly owned by the companies listed above. The last three columns in the table are intentionally left empty.