



X2Rail-5

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Deliverable D4.1

Moving Block Specification

Part 1 – Introduction

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Authors & Version Management

The Authors and Contributors below cover all the separate parts of Deliverable D4. 1.

Authors	Siemens (SMO)
Contributors	Thales (TD)
	Alstom (ALS)
	Hitachi (STS)
	AZD (AZD)
	Bombardier (BTSE)
	CAF Signalling (CAFS)
	Deutsche Bahn (DB)
	DLR (DLR)
	MERMEC (MERMEC)
	Network Rail (NR)
	SNFC (SNCF)
	Trafikverket (TRV)
	ERTMS Users Group (EUG)

The Version history below refers to Part 1 of Deliverable D4. 1.

Version Management		
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02	30-Apr-21	Final changes from X2Rail-3
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05	02-Sep-22	Updated for "Simple" X2R5 Open Points
06	02-Nov-22	Updated for remaining X2R5 Open Points
07	18-Nov-22	Updated following first WP4 Review
08	25-Nov-22	Updated for TMT/SC review
09	25-Nov-22	Clean version for TMT/SC review
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Executive Summary

This document is Deliverable D4.1 “Moving Block Specifications” from the Project titled “Completion of activities for Adaptable Communication, Moving Block, Fail Safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security” (Project Acronym: X2Rail-5; Grant Agreement No 101014250).

This Deliverable contains Requirements, Operational Rules, Engineering Rules and Hazard Analysis for an ETCS L3 Moving Block System, in accordance with the X2Rail-5 Grant Agreement.

This Deliverable is based on Deliverable D4.2 “Moving Block Specification” from X2Rail-3 [X2R3-D4.2]. This in turn was based on Deliverable D5.1 “Moving Block System Specification” [X2R1-D5.1], D5.2 Moving Block Operational and Engineering Rules [X2R1-D5.2] and D5.3 Moving Block Preliminary Safety Analysis [X2R1-D5.3] from X2Rail-1.

This Deliverable assumes ETCS Level 2 [BL3 R2] together with the Change Request associated with Train Integrity, CR940 [CR940], as a baseline. The work has aimed to minimise the changes required to the ETCS specifications beyond ETCS Baseline 3 Release 2 and Change Request 940. Anything which is unchanged from ETCS Level 2 is not described, except where some description is required to provide context.

The requirements in this specification cover the four ETCS Level 3 system types originally identified within X2Rail-1 WP5 Moving Block:

- 1) Full Moving Block, without Trackside Train Detection
- 2) Full Moving Block, with Trackside Train Detection
- 3) Fixed Virtual Blocks, without Trackside Train Detection
- 4) Fixed Virtual Blocks, with Trackside Train Detection

A description of these different system types can be found in Part 2 System Definition.

The requirements in this specification define the behaviour of the L3 Trackside, including the concepts of Train Location, Track Status, Reserved Status, which can be implemented to realise a system based on any of the above Moving Block System Types, but also a system with any mixture of those System Types.

Some subsystems of the ETCS Level 3 system have been addressed by other Technical Demonstrators within Shift2Rail. Part 2 System Definition defines the scope of this Deliverable, and provides some assumptions about other system components.

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Glossary of Terms and Abbreviations

The following Terms and Abbreviations apply to all Parts of D4.1.

Term or Abbreviation	Description
Active Radio Hole	Permanent Radio Hole or an activated Temporary Radio Hole
Active Shunting Area	Permanent Shunting Area or an activated Temporary Shunting Area
Area of Control	The area of railway controlled by an instance of L3 Trackside. At borders, the boundaries of the Area of Control may be different in each direction.
CMD	Cold Movement Detector
Consolidated Track Status	Consolidated Track Status is the combination of all the Track Status Areas, giving a single Track Status for all the track within the Area of Control.
CRE	Confirmed Rear End The position of the rear of a train deduced from the safe train length information received in a position report confirming train integrity. Defined in [CR940].
CSM	Common Safety Method as defined in [CSM-RA]
DP	Danger Point Danger Point is defined in SUBSET-026 part of [BL3 R2]
EoA	End of Authority This is the end of a Movement Authority. End of Authority is defined in SUBSET-026, part of [BL3 R2]
EoM	End of Mission The process for End of Mission is defined in SUBSET-026-5, part of [BL3 R2]
Fixed Virtual Block	A L3 Trackside where the Movement Authority for a train can be issued to fixed, predefined, locations on the railway. Defined in Part 2.
FMB	Full Moving Block
Full Moving Block	A L3 Trackside where the Movement Authority for a train can be issued to the Confirmed Rear End of the preceding train. Defined in Part 2

Term or Abbreviation	Description
FVB	Fixed Virtual Block
Ghost Train	A Ghost Train is a railway vehicle within the Area of Control of the L3 Trackside, which is not known to the L3 Trackside
IM	Infrastructure Manager
L2	Abbreviation for ETCS Level 2
L3	Abbreviation for ETCS Level 3
L3 Margin	The Margin which is used between trains in accordance with Requirements in Part 3.
L3 On-board	The on-board component of the L3 System as defined in Part 2 System Definition
L3 System	The L3 signalling system as defined in Part 2 System Definition
L3 Trackside	The trackside component of the L3 System as defined in Part 2 System Definition.
LRBG	Last Relevant Balise Group. Part of a Train Position Report, as defined in SUBSET-026, part of [BL3 R2]
MSFE	Maximum Safe Front End Defined in SUBSET-026, part of [BL3 R2].
Obstruction	Limit for extension of Full Supervision Movement Authority. In all system types, the end of an authorised path, or the end of the railway In Full Moving Block system types, the boundary of an Occupied or Unknown Track Status Area In Fixed Virtual Block system types, the border of a Fixed Virtual Block which is Occupied or Unknown.
Reserved Status (*)	Reserved Status is the term used when a part of the track is reserved for use by a train. Every part of the track within the Area of Control will be Reserved or Not Reserved. The overall Reserved Status is made up of a number of Reserved Status Areas.

Term or Abbreviation	Description
Reserved Status Area (*)	An individual Reserved Status Area may either be allocated to one specific train, or not allocated to any train.
Shadow Train	A Shadow Train is a Ghost Train which is in the same or an adjacent TTD as a communicating train, and which therefore cannot be detected by TTD occupation. Shadow Trains are a concept in system types with TTD.
SoM	Start of Mission The process for Start of Mission is defined in SUBSET-026, part of [BL3 R2]
Track State (*)	Track State is the term used to refer to Track Status and Reserved Status together
Track Status (*)	Track Status is the term used for track occupancy. Track Status can be Occupied, Unknown or Clear. Track Status is made up of a number of Track Status Areas, which may overlap.
Track Status Area (*)	A Track Status Area is either Occupied or Unknown.
Train Location (*)	a) The location of a train as established within the L3 Trackside, based on Train Position Reports, and adjusted by TTD if present.
Train Position Report	Train Position Report from Train to L3 Trackside, as defined in SUBSET-026, part of [BL3 R2]
TTD	Trackside Train Detection Trackside system for determining whether a section of track is clear or not. TTD covers both Track Circuits and Axle Counters.
TIMS	Train Integrity Monitoring System A system external to ETCS, which provides an input to the ETCS On-Board indicating the train integrity status.
TMS	Traffic Management System

(*) For Track State, Track Status, Track Status Area, Train Location, Reserved Status, Reserved Status Area, please refer to Part 3, where these are described in more detail, together with associated diagrams.

1 Background

1.1 Shift2Rail Background

This document is the first part of Deliverable D4.1 “Moving Block Specifications” from the Project titled “Completion of activities for Adaptable Communication, Moving Block, Fail Safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security” (Project Acronym: X2Rail-5; Grant Agreement No 101014250) [X2R5GA]. The work is part of the work on Technical Demonstrator TD2.3 Moving Block.

This Deliverable has been prepared during X2Rail-5 based on the previous deliverable D4.2 from X2Rail-3 [X2R3-D4.2]. This in turn was prepared during X2Rail-3 based on the previous deliverables D5.1 [X2R1-D5.1], D5.2 [X2R1-D5.2] and D5.3 [X2R1-D5.3] from X2Rail-1.

1.2 ETCS Reference

The work in X2Rail-5 WP4 Moving Block addresses the implementation of Moving Block signalling using ETCS Level 3.

This Deliverable has used ETCS Baseline 3 Release 2 [BL3 R2] as a starting point. In addition, the solution to Change Request 940 [CR940], as published by ERA, has been considered when preparing this Deliverable. Of the solutions published by ERA, only Change Request 940 [CR940] has been judged to have a clear and obvious impact on the train integrity reporting and therefore also on the required behaviour of the L3 Trackside.

1.3 Scope of Deliverable D4.1

The Deliverable defines an ETCS Level 3 system which can be applied to different railway types:

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

Mixed Traffic Lines for example may include passenger and freight trains.

The requirements in this specification cover the four ETCS Level 3 system types originally identified within X2Rail-1 WP5 Moving Block:

- 1) Full Moving Block, without Trackside Train Detection
- 2) Full Moving Block, with Trackside Train Detection
- 3) Fixed Virtual Blocks, without Trackside Train Detection
- 4) Fixed Virtual Blocks, with Trackside Train Detection

The requirements in this specification define the behaviour of the L3 Trackside, including the concepts of Train Location, Track Status, Reserved Status, which can be implemented to realise a system based on any of the above Moving Block System Types, but also a system with any mixture of those System Types.

The technical scope of Deliverable D4.1 is given in Part 2 System Definition.

1.4 Structure of D4.1

This deliverable is made up of several different parts:

Part Number	Title	Notes
1	Introduction	This part defines the structure of this Deliverable, and contains Glossary of Terms and Abbreviations, and References applicable to the complete Deliverable.
2	System Definition	This part defines the L3 System. It includes assumptions, for example about Train Integrity, Communications, Train Length.
3	System Specification	This part contains requirements for the L3 system beyond L2. These are mostly requirements for the L3 Trackside.
4	Operational Rules	This part contains Operational Rules for L3 beyond those required for L2.
5	Engineering Rules	This part contains Engineering Rules for L3 beyond those required for L2.
6	Safety Analysis	This part contains a Hazard Analysis of the L3 System defined in Part 2, with references to mitigations provided by Requirements and Rules in Parts 3, 4 and 5.

Table 1: D4.1 Structure

2 Methodology

The work in X2Rail-5 WP4 Moving Block has taken as its starting point the Deliverable from X2Rail-3 WP4 Moving Block:

D4.2 Moving Block System Specification [X2R3-D4.2]

This in turn was based on the deliverables from X2Rail-1 WP5 Moving Block.

Figure 1 below shows the overall flow of the work within TD2.3 Moving Block in X2Rail-1 WP5, X2Rail-3 WP4 and X2Rail-5 WP4.

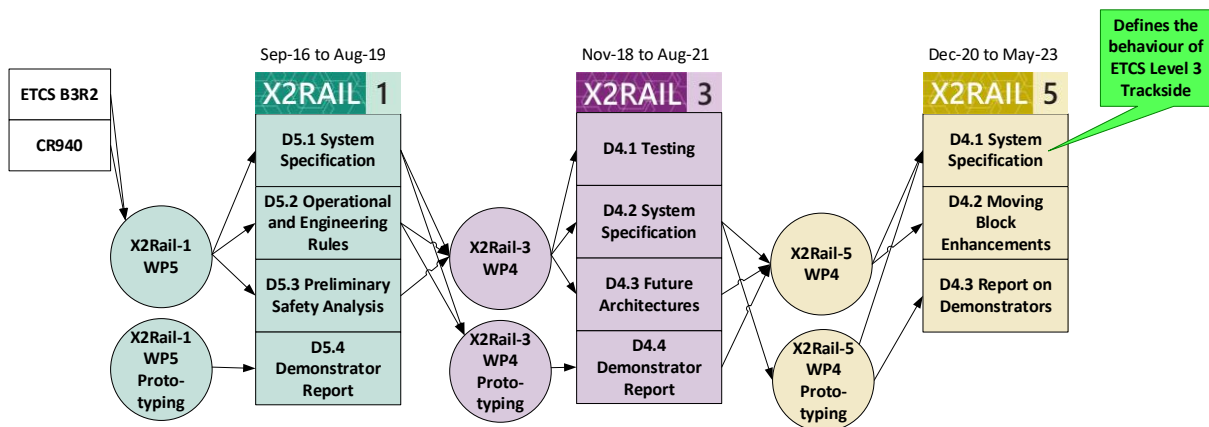


Figure 1: Overview of TD2.3 Moving Block in X2Rail-1, X2Rail-3 and X2Rail-5

An important point to note is that the current ETCS Baseline [BL3 R2] does not define in detail the behaviour of the ETCS Trackside. Much of the work has been to define the required behaviour of the ETCS Trackside in a Level 3 system. In particular, this work has focussed on the concepts of Train Location, Track Status and Reserved Status within the L3 Trackside. This is described in Part 3.

There are sections below summarising the work in the different projects.

2.1 X2Rail-1 Work on Moving Block

The work in X2Rail-1 was divided into two phases:

- 1) Work to define the Scope, and approach to be taken.
- 2) Work based on Scenario descriptions, to derive Requirements, Operational and Engineering Rules, and to perform Preliminary Hazard Analysis.

Figure 2 shows a summary of the work in X2Rail-1 WP5.

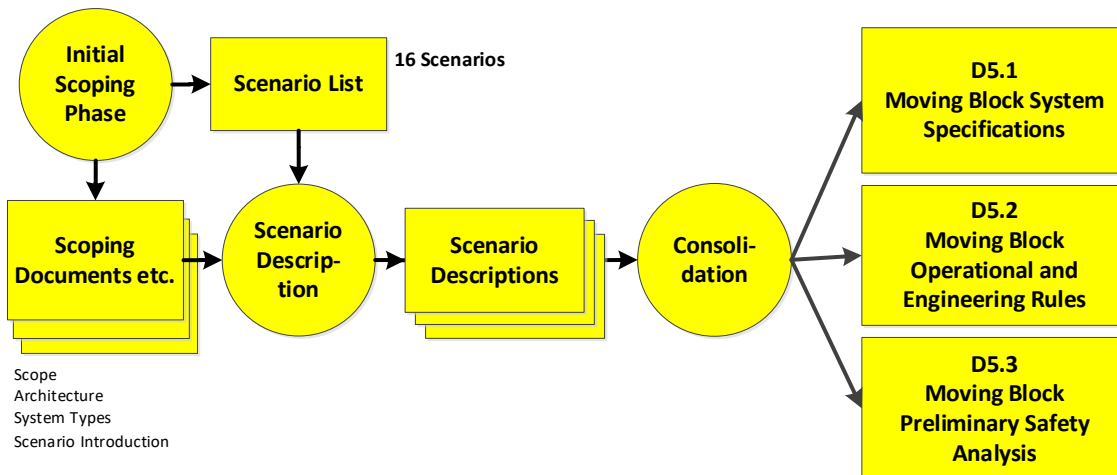


Figure 2: Overview of Moving Block in X2Rail-1

During X2Rail-1, the following key items were considered:

- The Architecture is based on ETCS.
- The work includes systems with Trackside Train Detection (TTD), as well as systems without TTD.
- The four “Moving Block System Types” (see Part 2) were developed.
- The list of sixteen Scenarios was determined, which would be used to derive the Requirements, Operational and Engineering Rules.

This list of Scenarios used in X2Rail-1 is in Table 2.

X2Rail-1 Scenarios	
Initialisation Trackside	Splitting
Start of Train	Joining
Normal Train Movement	Shunting
Transitions	Mixed Traffic
Handover	Communications Failure
On Sight Movement	Loss of Train Integrity
End of Mission	Recovery
Reversing	Override

Table 2: X2Rail-1 Scenario List

The work to prepare the Scenario Descriptions was distributed between the participants. The process also included a set of Workshops, which were attended by representatives of the separate safety team, in order to carry out the Preliminary Hazard Analysis, also based on the same set of Scenarios.

2.2 X2Rail-3 Work on Moving Block

The work in X2Rail-3 WP4 Moving Block took as its starting point the Deliverables from X2Rail-1 WP5 Moving Block:

- D5.1 Moving Block System Specification [X2R1-D5.1]
- D5.2 Moving Block Operational and Engineering Rules [X2R1-D5.2]
- D5.3 Moving Block Preliminary Safety Analysis [X2R1-D5.3]

The work in X2Rail-3 WP4 Moving Block was to validate the results from X2Rail-1 WP5 Moving Block, by working on a number of Use Cases, as listed in Table 3.

X2Rail-3 Use Cases	
End of Mission / Start of Mission	Radio Holes
Handover	Release of Points
Joining	Reversing
Level Transitions	Shunting
Loss of Communications	Splitting
Loss of Integrity	Sweeping
Movement in Staff Responsible	Trackside Initialisation

Table 3: Table of X2Rail-3 Use Cases

Each Use Case resulted in a number of Open Points. Most of these Open Points were analysed, resulting in changes to the Requirements, Operational Rules, Engineering Rules and Hazards from the X2Rail-1 WP5 Deliverables. These changes were implemented as part of creating the X2Rail-3 deliverable [X2R3-D4.2]. Some Open Points remained open at the end of X2Rail-3.

In addition, there were a number of topics listed in X2Rail-1 D5.1 [X2R1-D5.1] as “Future Work”. These were addressed within X2Rail-3 WP4 via a series of workshops as listed in Table 4. The workshops also resulted in changes to the Requirements, Operational Rules, Engineering Rules and Hazards from the X2Rail-1 WP5 Deliverables. These changes were implemented as part of creating the X2Rail-3 deliverable [X2R3-D4.2].

X2Rail-3 Workshop Topics
Safety Margin
Propagation
Track State
Stored Data

Table 4: Table of X2Rail-3 Workshop Topics

Figure 3 below summarises the methodology described above:

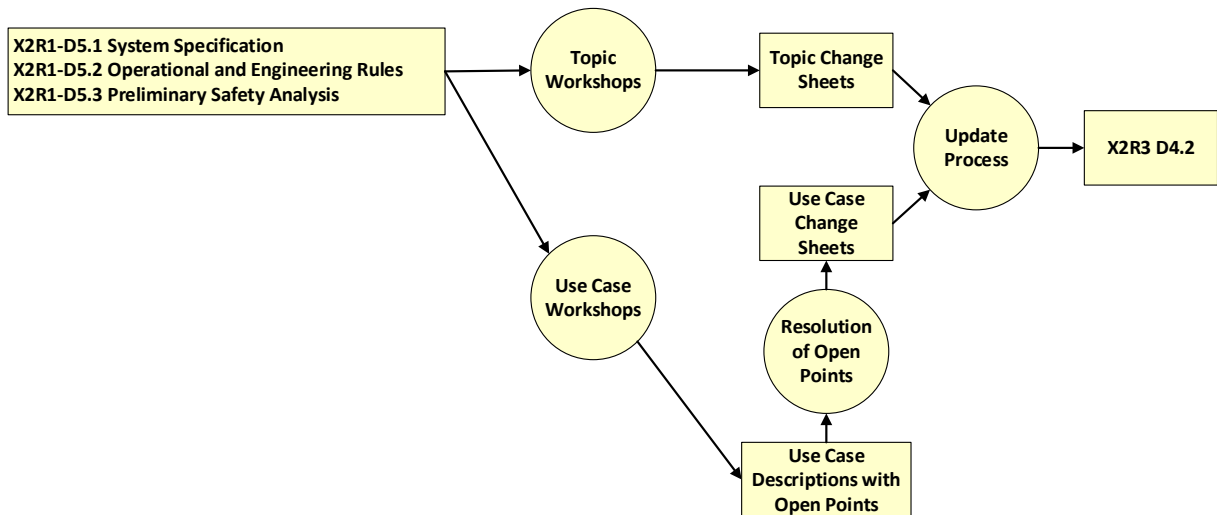


Figure 3: Methodology used for X2Rail-3 D4.2

2.3 X2Rail-5 Work on Moving Block

The work in X2Rail-5 WP4 Moving Block has been to solve all the remaining Open Points from X2Rail-3 WP4 Moving Block, by working on a number of Use Cases, as listed in Table 5. This is the same list as for X2Rail-3, with the addition of one more Use Case for the Use of Reserved.

X2Rail-5 Use Cases		
End of Mission / Start of Mission	Loss of Integrity	Shunting
Handover	Movement in Staff Responsible	Splitting
Joining	Radio Holes	Sweeping
Level Transitions	Release of Points	Trackside Initialisation
Loss of Communications	Reversing	Use of Reserved

Table 5: Table of X2Rail-5 Use Cases

During X2Rail-3, each Use Case had resulted in a number of Open Points, which were not all resolved before the completion of the work in X2Rail-3. These Open Points have been further analysed and solved within X2Rail-5, resulting in changes to the Requirements, Operational Rules, Engineering Rules and Hazards from the X2Rail-3 WP4 Deliverable. These changes have been implemented to create this X2Rail-5 deliverable.

The overall result of the methodology described is that the work in X2Rail-5 has further enhanced the quality of the results from X2Rail-3, giving a much more robust set of Requirements, Operational Rules, Engineering Rules and Hazard Analysis.

3 Conclusions

The aim of this Deliverable is to define the System Requirements, Operational Rules and Engineering Rules, supported by a Preliminary Hazard Analysis, for the ETCS Level 3 system, relative to an ETCS Level 2 system.

The baseline of ETCS used is:

- a) The CCS TSI which defines ETCS Baseline 3 Release 2, as defined in TSI Commission regulation (EU) 2016/919, of 27 May 2016 [BL3 R2]
- b) The solution to Change Request 940, as published by ERA [CR940]

As with X2Rail-3 WP4 Moving Block, the work has aimed to minimise the changes to Baseline 3 Release 2.

The requirements in this specification cover the four ETCS Level 3 system types originally identified within X2Rail-1 WP5 Moving Block:

- 1) Full Moving Block, without Trackside Train Detection
- 2) Full Moving Block, with Trackside Train Detection
- 3) Fixed Virtual Blocks, without Trackside Train Detection
- 4) Fixed Virtual Blocks, with Trackside Train Detection

The requirements in this specification define the behaviour of the L3 Trackside, including the concepts of Train Location, Track Status, Reserved Status, which can be implemented to realise a system based on any of the above Moving Block System Types, but also a system with any mixture of those System Types.

4 References

The following references apply to all Parts of D4.1.

- [BL3 R2] Set of specifications # 3 (ETCS Baseline 3 Release 2 and GSM-R Baseline 1) according to Annex A of Commission Implementing Regulation (EU) 2019/776 of 16 May 2019. It is publicly available:
<https://www.era.europa.eu/content/set-specifications-3-etcs-b3-r2-gsm-r-b1>
- [CRProcess] Change Control Management process ERA_ERTMS_0001_v.2.0
ERA document
- [CR940] The Change Request is held within the ERA Change Request database, together with the proposed solution.

The solution is publicly available within Opinion ERA/OPI/2020-2:
<https://www.era.europa.eu/library/opinions-and-technical-advice/en>
The description of CR940 is available in Annex 3 of the above.

The solution has subsequently been updated in the ETCS CCM process, but without impact on our work.
- [CSM-RA] Commission implementing Regulation (EU) 2015/1136 of 13 July 2015 amending implementing Regulation (EU) No 402/2013 on the common safety method for risk evaluation and assessment
- [DEU-RS] Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety.
- [EN50121-1] EN 50121-1:2017 Railway applications. Electromagnetic compatibility. General
- [EN50121-2] EN 50121-2:2017 Railway applications. Electromagnetic compatibility. Emission of the whole railway system to the outside world
- [EN50121-3-1] EN 50121-3-1:2017+A1:2019 Railway applications. Electromagnetic compatibility. Rolling stock. Train and complete vehicle
- [EN50121-3-2] EN 50121-3-2:2016+A1:2019 Railway applications. Electromagnetic compatibility. Rolling stock. Apparatus
- [EN50121-4] EN 50121-4:2016+A1:2019 Railway applications. Electromagnetic compatibility. Emission and immunity of the signalling and telecommunications apparatus

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- [EN50121-5] N 50121-5:2017+A1:2019 Railway applications. Electromagnetic compatibility. Emission and immunity of fixed power supply installations and apparatus
- [EN50125-1] EN 50125-1:2014. Railway applications. Environmental conditions for equipment. Rolling stock and on-board equipment
- [EN50125-2] EN 50125-2:2002. Railway applications. Environmental conditions for equipment. Fixed electrical installations
- [EN50125-3] EN 50125-3:2003. Railway applications. Environmental conditions for equipment. Equipment for signalling and telecommunications
- [EN50126] EN 50126-1:2017: Railway Applications -The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
- [HL3] Hybrid ERTMS/ETCS Level 3
ERTMS Users Group document
EUG Reference: 16E042
Version: 1D 15/10/2020
- [OPE TSI] The TSI for Operation and Traffic Management is available here:
https://www.era.europa.eu/activities/technical-specifications-interoperability_en
- [RiskWShop] Minutes X2Rail-3 WP4 Risk Analysis Workshop
4&5-Nov-19
Internal X2Rail-3 document
Reference: X2R3-T4_4-B-SMD-010-01
- [X2R1-D5.1] X2Rail-1 Deliverable D5.1
Moving Block System Specification
Published on Shift2Rail Web Site:
https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-1
- [X2R1-D5.2] X2Rail-1 Deliverable D5.2
Moving Block Operational and Engineering Rules
Published on Shift2Rail Web Site:
https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-1
- [X2R1-D5.3] X2Rail-1 Deliverable D5.3
Moving Block Preliminary Safety Analysis
Published on Shift2Rail Web Site:
https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-1

- [X2R3-D4.2] X2Rail-3 Deliverable D4.2
Moving Block Specifications
Published on Shift2Rail Web Site:
https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-3
- [X2R3-D4.3] X2Rail-3 Deliverable D4.3
Future Moving Block Architectures
Published on Shift2Rail Web Site:
https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-3
- [X2R3-D4.4] X2Rail-3 Deliverable D4.4
Report on Technology Demonstrators
Published on Shift2Rail Web Site:
https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-3
- [X2R5GA] X2Rail-5 Grant Agreement
Full project title: “Completion of activities for Adaptable
Communication, Moving Block, Fail Safe Train Localisation (including
satellite), Zero on site Testing, Formal Methods and Cyber Security”
Grant Agreement No 101014250

Appendix A: Ownership of results

The following Table 6 lists the ownership of results for this deliverable.

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

Table 6: Ownership of results

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