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Deliverable D5.1

Moving Block System Specification

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1.0	18/04/2019	First Release	First Release for review by TMT
2.0	05/07/2019	Second Release	Final Version
3.0	31/10/2019	Third Release	After JU Expert Review

Executive Summary

This System Specification is one of a group of documents produced by WP5 Moving Block in the Shift2Rail project X2Rail-1, in accordance with the X2Rail-1 Grant Agreement:

- **D5.1 Moving Block System Specification** (this document) which defines the System Requirements for ETCS Level 3 Moving Block
- **D5.2 Moving Block Operational and Engineering Rules** which defines additional Operational and Engineering Rules required for an ETCS Level 3 Moving Block system
- **D5.3 Moving Block Preliminary Safety Analysis** which describes hazards identified as a result of operating an ETCS Level 3 Moving Block system, and also describes the mitigation of those hazards
- **D5.4 Moving Block Application Analysis** which describes the application of ETCS L3 Moving Block systems to different railway types.

These documents are Deliverables from X2Rail-1, with further work intended in both X2Rail-3 and X2Rail-5. This document is intended to be used as follows:

1) For the creation of ETCS Level 3 Moving Block Technical Demonstrators in X2Rail-3
2) As a basis for further requirements analysis within X2Rail-3
3) As information for consideration during the work to update the CCS TSI.

The group of documents assume ETCS Level 2 [BL3 R2] as a baseline. The work has aimed to minimise the changes required beyond ETCS Level 2. Anything which is unchanged from ETCS Level 2 is not described, except where some description is required to provide context.

This group of documents covers different ETCS Level 3 Moving Block system types. A high-level description of these different system types can be found in section 4. The specifications are written with the intention that a mixture of different systems types could be used.

Some subsystems of the ETCS Level 3 Moving Block System are being addressed by other Technical Demonstrators within Shift2Rail, and will be integrated in later phases. Section 3 Scope defines the scope of the WP5 deliverables and provides some assumptions about other system components.

As a result of the work within X2Rail-1 WP5, there are some proposed enhancements beyond ETCS Baseline 3 Release 2 and Change Request 940. These are described in section 7 Changes in Current Specifications. However, this document cannot be used as the only source for definition of ETCS Level 3 Moving Block Functionality, for inclusion in a future TSI.

As originally planned, the work is not finished in X2Rail-1. Further work is proposed to be carried out within the follow-on project X2Rail-3, and later X2Rail-5. The topics for further work in X2Rail-3 are listed in section 8 Future Work.

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1 Objective

The objective of this document is to define the System Requirements for an ETCS Level 3 Moving Block System based on ETCS Baseline 3, Release 2 [BL3 R2] and the proposed solution to Change Request 940 [CR940].

The objective is to define a single set of System Requirements which are applicable across different railway types.

The objective is to define only those requirements which are beyond current systems for ETCS Level 2.

2 Background

2.1 Shift2Rail Background

This document has been produced within Shift2Rail IP2 "Advanced Traffic Management and Control Systems". The work is part of the work on Technical Demonstrator TD2.3 Moving Block.

The document has been produced within the X2Rail-1 Work Package 5: Moving Block.

2.2 NGTC Background

The work in X2Rail-1 WP5 Moving Block has taken notice of the results of the "Next Generation of Train Control systems" (NGTC) project. The approach using analysis of scenarios follows from the work in the NGTC project [NGTCD51]. The principal difference is that the work in X2Rail-1 WP5 Moving Block has explicitly addressed the implementation of Moving Block using ETCS Level 3.

2.3 ETCS Reference

The work in X2Rail-1 WP5 Moving Block addresses the implementation of Moving Block signalling using ETCS Level 3. The term "ETCS Level 3 Moving Block" is used to mean a signalling system where Moving Block is implemented using ETCS Level 3.

The work in X2Rail-1 WP5 Moving Block has taken notice of the following objective from the introduction to the Description of Work in Annex 1 of the X2Rail-1 Grant Agreement:

> *To ensure the backward compatibility of ERTMS/ETCS technologies, notwithstanding the required functional enrichment of the future signalling and control systems.*

The specifications in this document have used the ETCS Baseline 3 Release 2 [BL3 R2] as a starting point. In addition, the solution to Change Request 940 [CR940], as published by ERA [Article10-2017], has been considered when preparing this document. Of the solutions published by ERA [Article10-2017], 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. As the solution to Change Request 940 [CR940] has not yet been incorporated into a formal update of the TSI, it is possible that there will be modifications to the agreed solution.

In accordance with the above stated X2Rail-1 objective, the impact on the ETCS Baseline [BL3 R2] has been kept to a minimum.

The potential modifications of the ETCS specifications [BL3 R2] identified by this deliverable will be processed through the ERTMS Change Control Management process run by ERA [CRProcess].

2.4 Architecture Assumptions

In accordance with minimising the impact on the ETCS specifications [BL3 R2], the work in X2Rail-1 WP5 has assumed that the system architecture for ETCS implementations remains unchanged. This architecture is summarised in Figure 1:

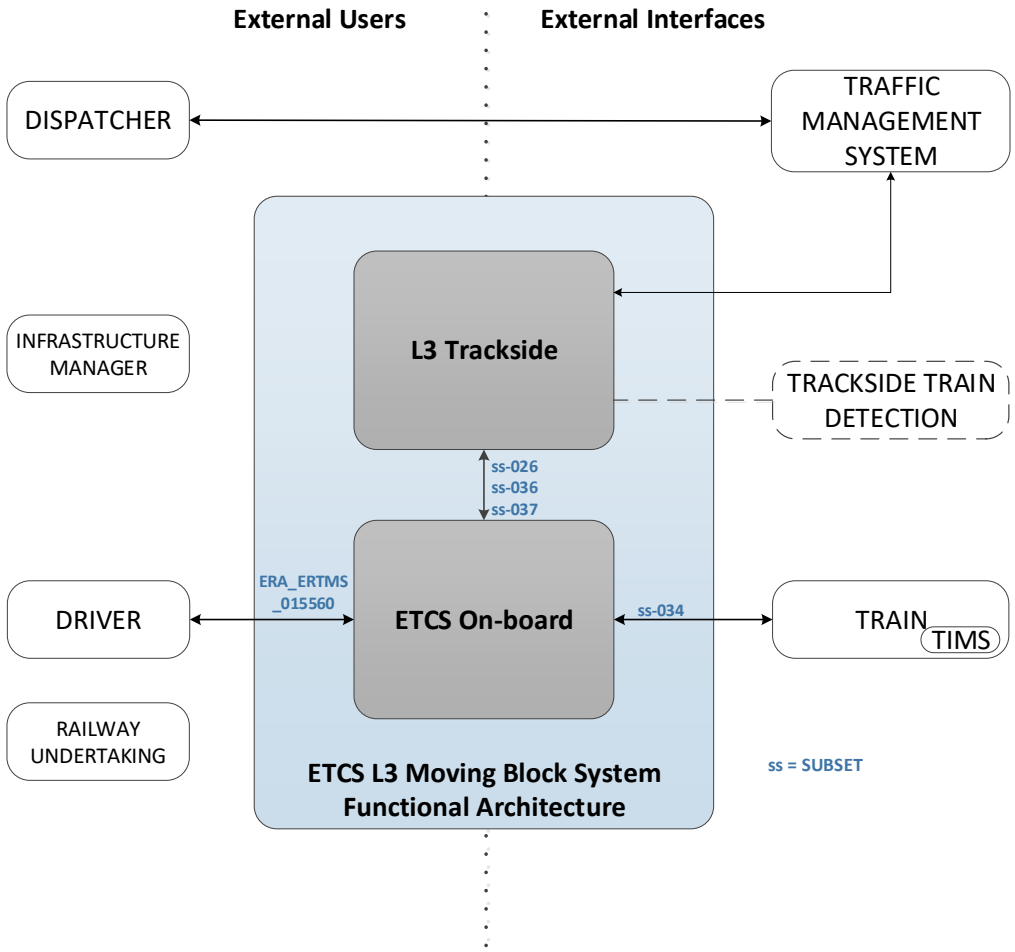

Figure 1 - Generic ETCS Level 3 Moving Block System Functional Architecture

From Figure 1 the key external actors in this system are:

- Dispatcher – the operator of the Traffic Management System
- Infrastructure Manager – the body responsible for the operation of the Railway and maintenance of infrastructure
- Driver – the operator of the train
- Railway Undertaking – Operator of passenger/freight train service.

In this document, the L3 Trackside includes functionality traditionally considered part of the interlocking as well as the RBC functionality. The System Architecture in the ETCS Specifications [BL3 R2] does not consider the interlocking as part of the ETCS system. In an ETCS Level 2 system, although there is no defined interface between RBC and Interlocking, the separation of functions is clearer. In an ETCS Level 3 Moving Block system, Track Status is derived primarily from Train Position Reports, rather than Trackside Train Detection, and therefore the Track Status function is required to be in scope. This is shown in Figure 2 below. Throughout this document, the term "L3 Trackside" is used, which encompasses the Track Status Management function.

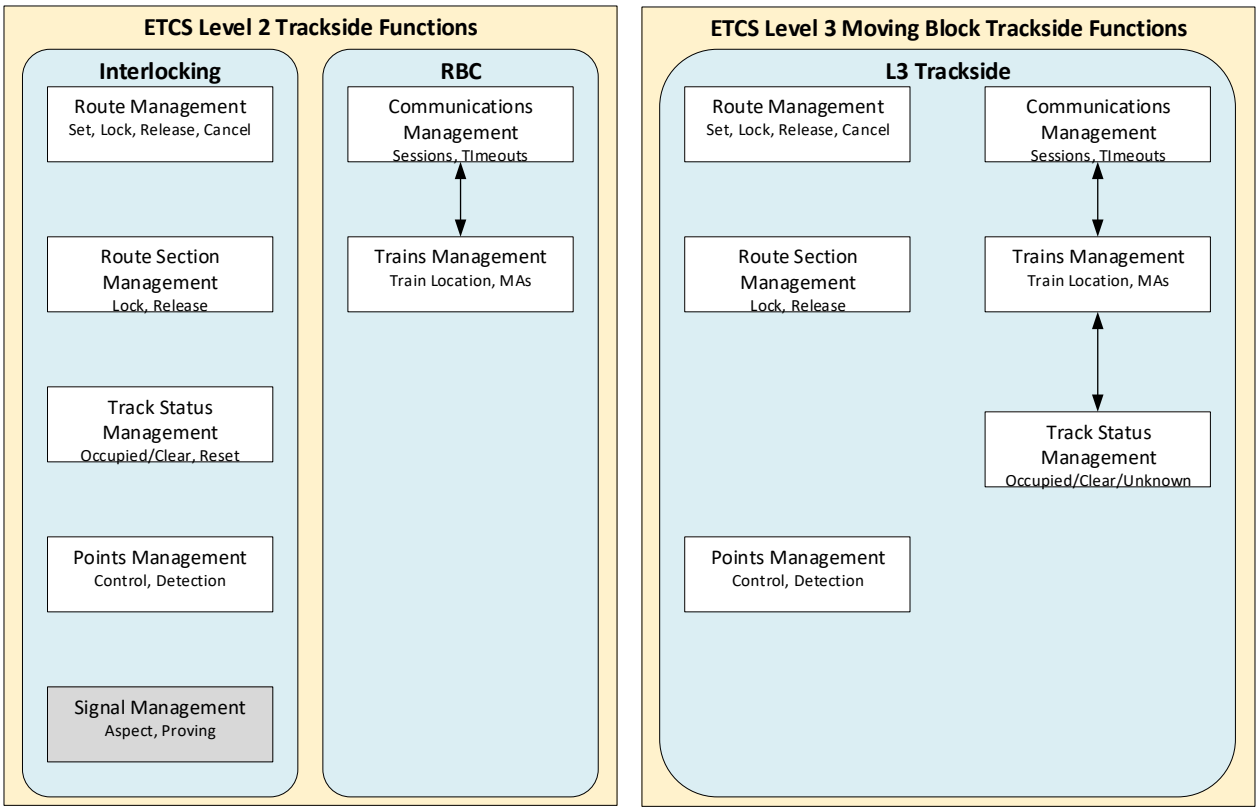

Figure 2 – Comparison of Functional Architectures for ETCS Level 2 and ETCS Level 3 Moving Block

The Traffic Management System shown in Figure 1 can be implemented in different ways, up to an automated Traffic Management System (TMS). The requirements for the interface between the L3 Trackside and TMS are summarised in section 6.27 .

Note that this architecture is aligned with that developed by X2Rail-1 WP2: Technical coordination and System Coherence [D2.1].

This system specification aims to define functional requirements for L3 Trackside and ETCS On-board.

3 Scope

3.1 Document Scope

The System Requirements within this document are only those which are beyond the System Requirements for ETCS Level 2. There are no documented System Requirements for ETCS Level 2 Trackside, so this means that the requirements in this document are those perceived by the WP5 experts to be those beyond ETCS Level 2 as implemented today.

There are companion documents for other aspects of ETCS Level 3 Moving Block Systems. The following table summarises the set of documents:

X2Rail-1 Deliverable	Title	Notes
D5.1	Moving Block System Specification	Defines System Requirements for an ETCS Level 3 Moving Block System, where those requirements are beyond what is required for an ETCS Level 2 system.
D5.2	Moving Block Operational and Engineering Rules	Defines Operational and Engineering Rules for an ETCS Level 3 Moving Block System, where those rules are beyond what is required for an ETCS Level 2 system.
D5.3	Moving Block Preliminary Safety Analysis	Contains hazard analysis of an ETCS Level 3 Moving Block System. This is a proposed input to the update of SUBSET-91 [SS091].
D5.4	Moving Block Application Report	Analysis of applying the ETCS Level 3 Moving Block system to different railway types (Urban/Suburban, High Speed, Overlay and Low Traffic/Freight).

Requirements (D5.1, this document) related to Rules (D5.2) and Hazards (D5.3) are traced between these documents, as shown in Figure 3:

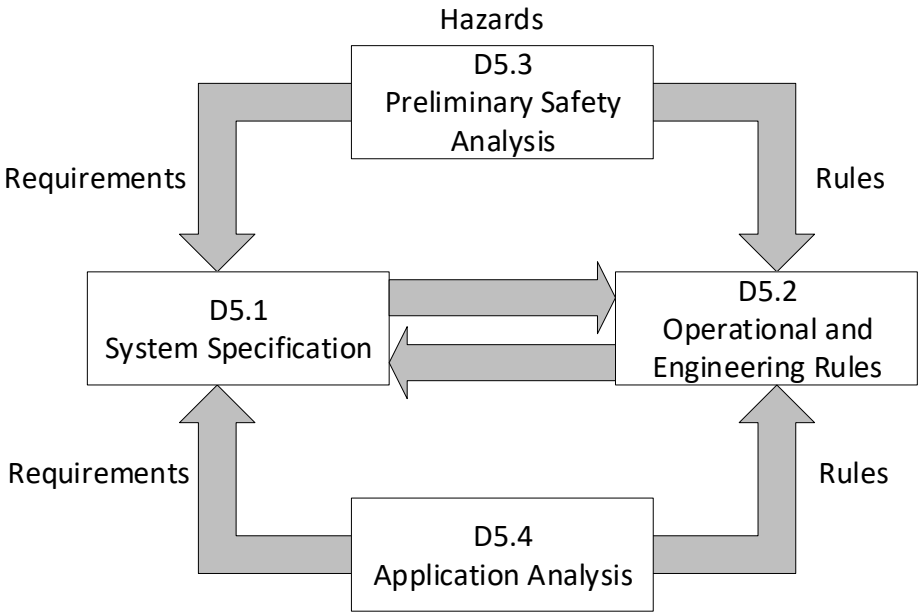

Figure 3 – Traceability between Deliverables

D5.4 contains analysis of the Requirements (D5.1) and Rules (D5.2) as applied to different railway types.

3.2 Application Scope

3.2.1 Railway Types

This system specification defines system requirements for an ETCS Level 3 Moving Block system which can be applied to different railway types.

Within the Grant Agreement, the following types of railway are explicitly listed for WP5 Moving Block:

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

It is the intent that these can all be handled by the same generic system – as defined in this specification. However, there will be differences in the way the system is applied to different types of railway. These differences are identified and analysed in D5.4.

3.2.2 Grade of Automation

The ETCS architecture shown in Figure 1 includes a Driver. The work on this system specification has assumed that there will be a driver present. Therefore, this system is specified to be able to support Grades of Automation up to GoA2. It is not intended to cover systems without a driver, GoA3/4 – these types of systems are out of scope of Technical Demonstrator 2.3.

3.3 System Scope, Assumptions & Constraints

The ETCS Level 3 Moving Block system is part of a larger railway control system. The following are within the scope of this document:

- L3 Trackside
- ETCS On-board.

The following sections describe assumptions about topics which are covered elsewhere within the X2Rail projects.

The co-ordination between the different work packages is being addressed by WP2, which is or will be present in all X2Rail projects.

3.3.1 Train Integrity

Train Integrity is being addressed by Shift2Rail TD2.5 in X2Rail-2 WP4 and X2Rail-4.

Assumptions:

> **ASM-Integrity-1**: Train Integrity is an input to the ETCS On-board from a TIMS device external to the ETCS On-board, with an interface consistent with Change Request 940 [CR940]
>
> **ASM-Integrity-2**: Train Integrity information is processed by the ETCS On-board in accordance with the behaviour specified in the solution to Change Request 940 [CR940].

For Train Integrity, additional assumptions are made for the short term, in agreement with the work in TD2.5. Here “short term” means systems based on the ETCS Specifications [BL3 R2] and Change Request 940 [CR940], as defined in Section 2.2, and before implementation of the changes proposed in Section 7.

Additional Short-Term Assumptions:

ASM-Integrity-3: The status of the TIMS will be visible to the Driver.
This is the status of the TIMS equipment itself, regardless of the state of Train Integrity. This could be directly from the TIMS equipment, or via the Technical and Diagnostic display within the train. This is the maintenance status (Ok/faulty). For example, this permits the Driver to determine whether the TIMS is operational at Start of Mission.

ASM-Integrity-4: The Driver is able to reset or restart the TIMS if it has failed.
For example, the Driver can request the TIMS to be restarted if it is detected as failed at Start of Mission. This could be by operating a power switch.

ASM-Integrity-5: The status of Train Integrity determined by the TIMS will be visible to the Driver.
This is the status of the Train Integrity, assuming that the status of the TIMS equipment is OK. This could be directly from the TIMS equipment, or via the Technical and Diagnostic display within the train. For example, this permits the Driver to determine whether or not train integrity is confirmed at Start of Mission.

ASM-Integrity-6: The frequency of reporting of train integrity confirmed or lost by the TIMS is sufficiently high that it reduces the impact on availability and performance of the L3 railway.

For example, an estimate of the acceptable reporting period is deemed to be at least every 5 seconds.
The frequency of reporting of train integrity influences the performance of the railway, by determining how often the rear train position is updated in the L3 Trackside.

ASM-Integrity-7: The frequency of reporting of train integrity confirmed or lost by the TIMS is sufficiently high that it is not necessary for a Driver to wait before closing the desk at End of Mission.

It could occur that at the time when the Driver performs End of Mission, the CRE of the train is far behind its Rear End (as Train Integrity has not been confirmed recently). In a station area this could result in alternative routes and infrastructure in rear of the train remaining locked due to the Occupied area of track. An alternative to a frequent confirmation of integrity would be for the driver to wait until a position report is sent with "TI Confirmed", however this is considered infeasible. For example, an acceptable reporting period is deemed to be at least every 5 seconds.

In the medium or long term, it is expected that there will be changes to the interface between the Train Interface and TIMS, to enable some TIMS devices to provide train length data. In the short

term, a wired solution is expected to be able to detect loss of integrity of a stationary train, whilst wireless detection is not expected to be available until the medium/long term.

3.3.2 Traffic Management

Traffic Management System is being addressed by Shift2Rail TD2.9 in X2Rail-2 WP6 and X2Rail-4.

Assumptions:

ASM-TMS-1: There will be an interface between the L3 Trackside and the Traffic Management System

ASM-TMS-2: The TMS will require information about all registered trains.

ASM-TMS-3: It is acceptable for System Requirements in this document to request inputs from the Traffic Management System to the L3 Trackside.
There are System Requirements included below which are for inputs from the Traffic Management to the L3 Trackside.

ASM-TMS-4: It is acceptable for System Requirements in this document to define outputs from the L3 Trackside to the Traffic Management System.
There are System Requirements included below which are for outputs to the Traffic Management from the L3 Trackside.

A set of exported requirements for the TMS interface are given in section 6.27 Traffic Management System interface.

3.3.3 Train positioning

Train Positioning is being addressed by Shift2Rail TD2.4 in X2Rail-2 WP3 and X2Rail-5.

Assumptions:

ASM-Position-1: Any change to the Train Positioning technology will not have an impact on the operation of the L3 Trackside, or the ETCS On-board.

3.3.4 ATO over ETCS

ATO over ETCS is being addressed by Shift2Rail TD2.2 in X2Rail-1 WP4 and X2Rail-4.

Assumptions:

ASM-ATO-1: Use of ATO at Grade of Automation 2 (GoA2) will not have an impact on the operation of the L3 Trackside, or the ETCS On-board.

Use of ATO at GoA levels above GoA2 will have an impact on the ETCS L3 Moving Block System (for example, impact on use of SR mode). See section 3.2.2 Grade of Automation for further details.

3.3.5 Communications

Communications is being addressed by Shift2Rail TD2.1 in X2Rail-1 WP3 and X2Rail-3, X2Rail-5.

Assumptions:

> **ASM-Comms-1:** Changes to the communication technology will not affect the content of the messages defined in the ETCS specifications.
>
> **ASM-Comms-2:** Changes to the communication technology will not increase the transit time of the messages between L3 Trackside and On-Board.

3.3.6 Train Length

Train Length will also be addressed by Shift2Rail TD2.5 in X2Rail-2 WP4 and X2Rail-4.

For Train Length additional assumptions are made for the short term. Here "short term" means systems based on ETCS Specifications [BL3 R2] and Change Request 940 [CR940], as defined in Section 2.2, and before implementation of the changes proposed in Section 7.

Additional Short-Term Assumptions:

> **ASM-Length-1**: The Train Length reported by the train represents the maximal length of the train.
> *This means the length of the train at maximum extension, if the train can stretch and contract. This means without the operator including any additional Safety Margin. This means that the Train Lengths can be used by the L3 Trackside to release track behind the train, and for length calculations during splitting and joining.*

In the medium or long term, it is expected that train length will be available from external devices, for example TIMS.

4 Methodology

In order to establish the Requirements, Operational Rules and Engineering Rules for an ETCS Level 3 Moving Block system, the Work Package considered a series of Scenarios, covering both normal and degraded operation of the railway. These scenarios were working documents, not deliverables, and were used as the basis for establishing the Requirements, Operational and Engineering Rules and for the Preliminary Safety Analysis.

Figure 4 provides an overview of the process followed:

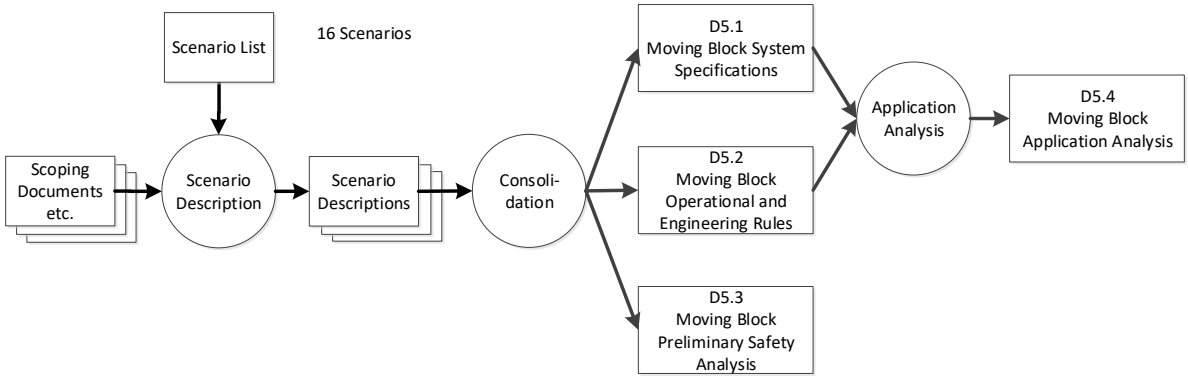

Figure 4 – Process Overview

The following scenarios were analysed:

Scenario
Trackside Initialisation
Start of Train
Normal Train Movement
Transitions
Handover
On Sight Movement
End of Mission
Reversing
Splitting
Joining
Shunting
Mixed Traffic
Communications Failure

Loss of Train Integrity
Recovery of a Failed Train
Override

For each Scenario, the behaviour of the system was examined, with a focus on Track Status. The base System Type in the scenario analysis was ETCS Level 3 Full Moving Block, with no Trackside Train Detection. The analysis also examined the impact of the other three Moving Block system types. The objective was to understand the differences from ETCS Level 2.

After consideration, some topics were not examined by the scenario analysis, as they were determined to be unchanged from ETCS Level 2. For example:

- Temporary Speed Restriction (TSR) management
- Emergency Stop Areas

The argument for the completeness of the analysis is based on the coverage of those aspects of the ETCS Level 3 Moving Block railway which are different from an ETCS Level 2 railway.

5 ETCS Level 3 Moving Block System Types

The work within X2Rail-1 WP5 Moving Block has identified four different Moving Block System Types. These are not mutually exclusive – an ETCS Level 3 Moving Block scheme could be implemented using a mixture of these Moving Block System Types, with adjacent parts of the L3 area utilising a different system subtype. This section describes the four Moving Block System Types.

1) **Full Moving Block, without Trackside Train Detection**

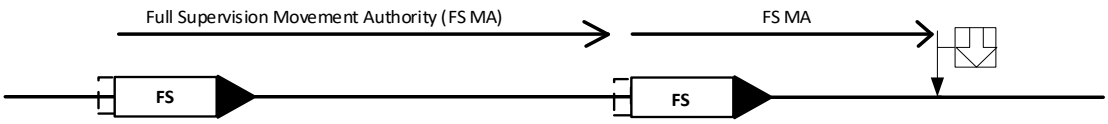

Figure 5 – Overview System Type Full Moving Block without Trackside Train Detection

The system can issue Movement Authorities based on the rear of the preceding train. End of Authority can therefore be an arbitrary location on the railway.

2) **Full Moving Block, with Trackside Train Detection**

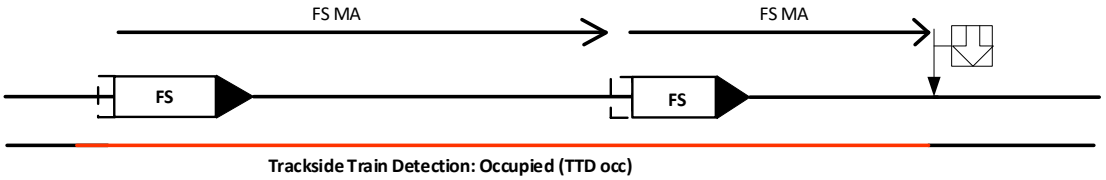

Figure 6 – Overview System Type Full Moving Block with Trackside Train Detection

The system can issue Movement Authorities based on the rear of the preceding train. End of Authority can therefore be an arbitrary location on the railway. In addition, Trackside Train Detection can be used to detect unauthorised train movements, and to improve recovery from degraded situations.

3) **Fixed Virtual Blocks, without Trackside Train Detection**

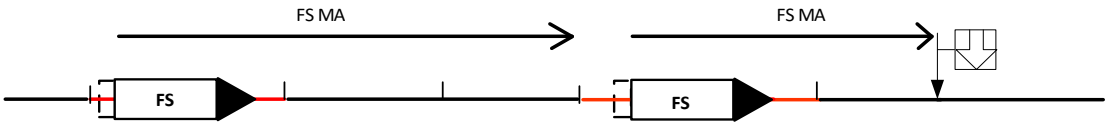

Figure 7 – Overview System Type Fixed Virtual Blocks without Trackside Train Detection

The system can issue Movement Authorities based on virtual block occupancy determined for the preceding train. The End of Authority can therefore only be to fixed predetermined locations on the railway.

4) **Fixed Virtual Blocks, with Trackside Train Detection**

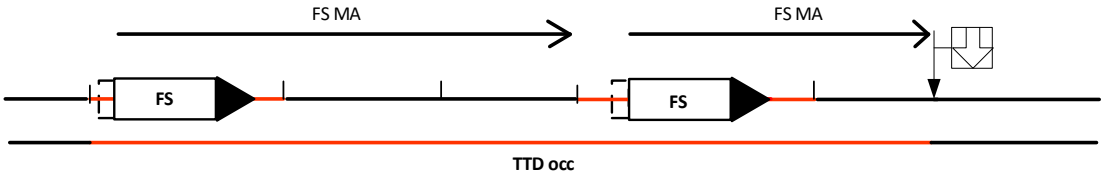

Figure 8 – Overview System Type Fixed Virtual Blocks with Trackside Train Detection

The system can issue Movement Authorities based on virtual block occupancy determined for the preceding train. The End of Authority can therefore only be to fixed predetermined locations on the railway. In addition, Trackside Train Detection can be used to detect unauthorised train movements, and to improve recovery from degraded situations.

During the early stages of the work in X2Rail-1 WP5 Moving Block, it was agreed to include consideration of systems which include Trackside Train Detection. The reason for this is that Work Package members believed that it was likely that some Moving Block systems would be engineered with at least some Trackside Train Detection. Therefore, it was considered important to include requirements relating to Track Status when there are two sources of information: Train Position Reports and Trackside Train Detection.

The base system type considered in this document is ETCS Level 3 Full Moving Block without Trackside Train Detection. The requirements in this document cover all four Moving Block System Types by providing requirements for the base system type, and additional requirements to cover systems with Fixed Virtual Blocks and systems with Trackside Train Detection. This enables the requirements to be used for systems which contain a mixture of the different system types, for example with some areas of Trackside Train Detection. Alternatively, this could result in some sub-system components operating on Fixed Virtual Blocks whilst others utilise Full Moving Block.

It is recognised that the Hybrid L3 specification published by ERTMS Users Group [HL3] is a possible implementation of the system type Fixed Virtual Blocks with Trackside Train Detection.

6 System Requirements Specification

This chapter provides System Requirements for an ETCS Level 3 Moving Block system based on Baseline 3 Release 2 [BL3 R2] with Change Request 940 [CR940], where these requirements are in addition to the requirements for an ETCS Level 2 system.

The chapter is structured into different high-level topics relevant to the operation in ETCS Level 3. The following sub-sections contain an overview of the system functionality and the detailed system requirements.

The first sub-sections contain generic requirements, relevant in all operational scenarios:

Sub-Section	Notes
6.1 Train location	Requirements for the processing of Train Position Reports to determine Train Location
6.2 Track Status	Requirements for the determination of Track Status Occupied / Clear / Unknown
6.3 Reserved Status	Requirements for Reserved status for areas where trains are authorised to run
6.4 Fixed Virtual Blocks	Additional requirements for systems using Fixed Virtual Blocks
6.5 Trackside Train Detection	Additional requirements for systems using Trackside Train Detection

The terms defined in these first sub-sections are then used in the remainder of the document. The X2Rail Integrated Glossary [GLO] contains terms used throughout the X2Rail Work Packages. In addition, the following terms are used within this document:

- Area of Control – the entire area that a single L3 Trackside is responsible for supervision of train movements
- Full Moving Block – A L3 Trackside where the Movement Authority for a train can be issued to the Rear End of the next train
- Fixed Virtual Block – A L3 Trackside where the Movement Authority is issued to fixed, predefined, locations on the railway.

Later sub-sections contain requirements relevant to specific operational scenarios or degraded modes.

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 “REQ” for D5.1
<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 define the system behaviour
- 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.

Requirements which are in blue text like this paragraph are dependent on proposed changes defined in Section 7.

A number of diagrams are used to explain the functionality of the L3 Trackside. Figure 9 gives a key to the symbols used.

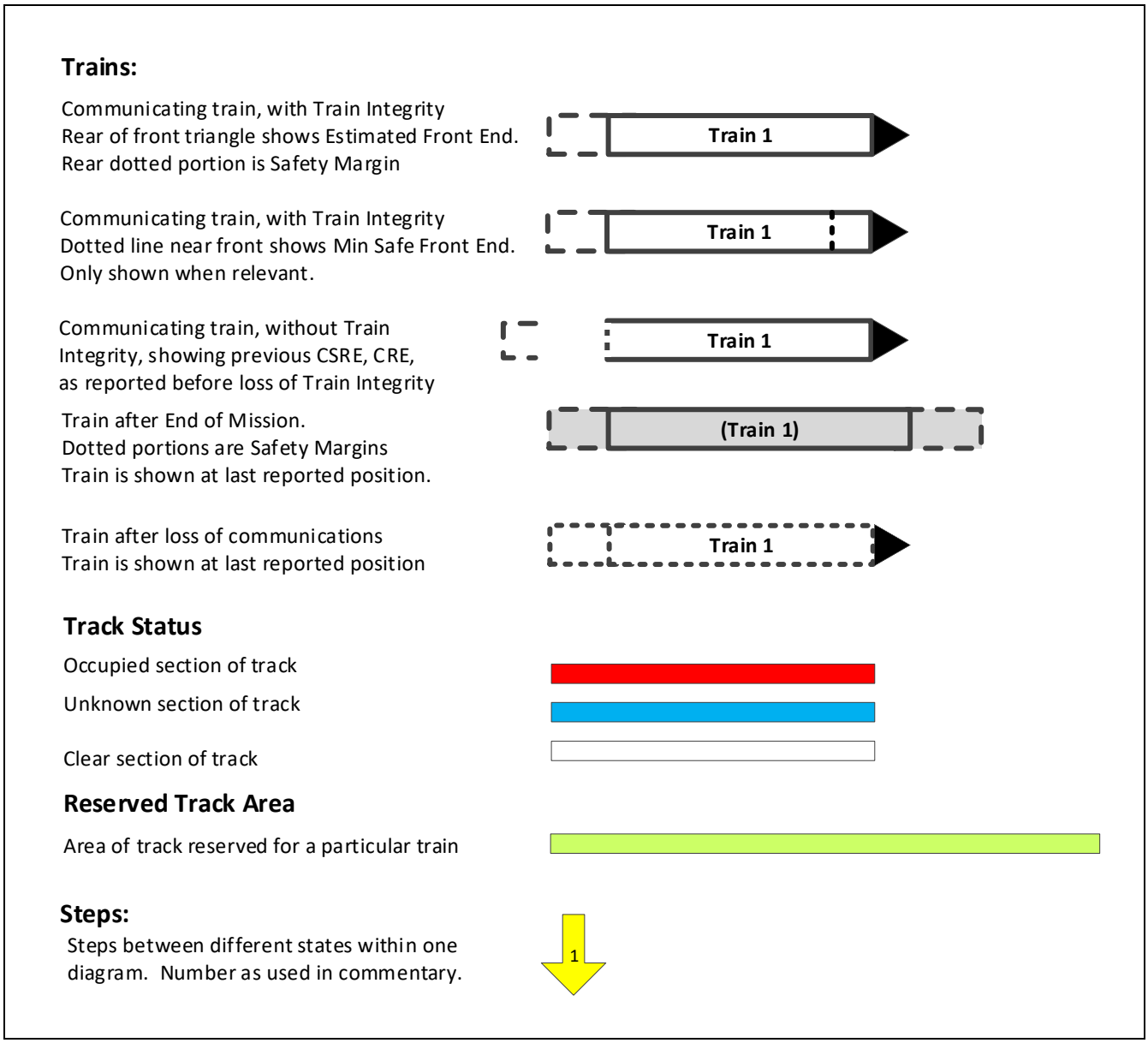

Figure 9: Key to diagrams

6.1 Train location

6.1.1 Introduction

This section contains requirements relating to the processing of Train Position Reports by the L3 Trackside, in order for the L3 Trackside to determine the location of Trains within its Area of Control.

During normal operation trains are located by position reports received by the L3 Trackside. As such, there is a fundamental principle:

The L3 Trackside must be aware of all locations that are potentially occupied by rail vehicles

For the purposes of L3, a Ghost Train is defined as follows:

A Ghost Train is a Railway Vehicle within the Area of Control, which is not known to the L3 Trackside.

The L3 Trackside will be responsible for maintaining knowledge about the location of all Rail Vehicles within the Area of Control. This means:

a) Interpreting Train Position Reports, to determine the area of railway occupied by each train, taking account of the information in the Train Position Report regarding Train Integrity status, and Train Length

b) Maintaining records of locations of trains which perform an End of Mission within the Area of Control, or which otherwise cease to communicate with the L3 Trackside.

The term Valid Location means that the train has reported a valid position, and its location in the L3 Trackside is unambiguous.

6.1.2 Requirements

REQ-TrainLoc-1

The L3 Trackside shall determine and retain the location of all trains within its Area of Control.

Rationale:

It is critical that within a system where the means of locating trains is via Train Position Reports, the Trackside maintains a record of the locations of trains within its Area of Control. This is required in order for the L3 Trackside to be able to set Routes and issue Movement Authorities.

Guidance:

Reporting trains will provide their location through Train Position Reports. This does not prevent other systems providing additional information on train location such as TTD.

This requirement implies the retention of information about trains which have ceased communications within the Area of Control.

In order to meet this requirement, extra considerations will be required at the boundaries of the Area of Control. See section 6.19 Level Transition and section 6.21 Handover.

In order to meet this requirement, extra considerations will be required when trains are joined and split. See section 6.23 Joining and section 6.24 Splitting.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrainLoc-2

The L3 Trackside shall consider the Train Location to be from the Confirmed Rear End of the train to the Max Safe Front End.

Rationale:

This is to determine the Train Location of the train, from the Trackside point of view.

Guidance:

Figure 10 defines Confirmed Rear End and Max Safe Front End based on the parameters within a Train Position Report:

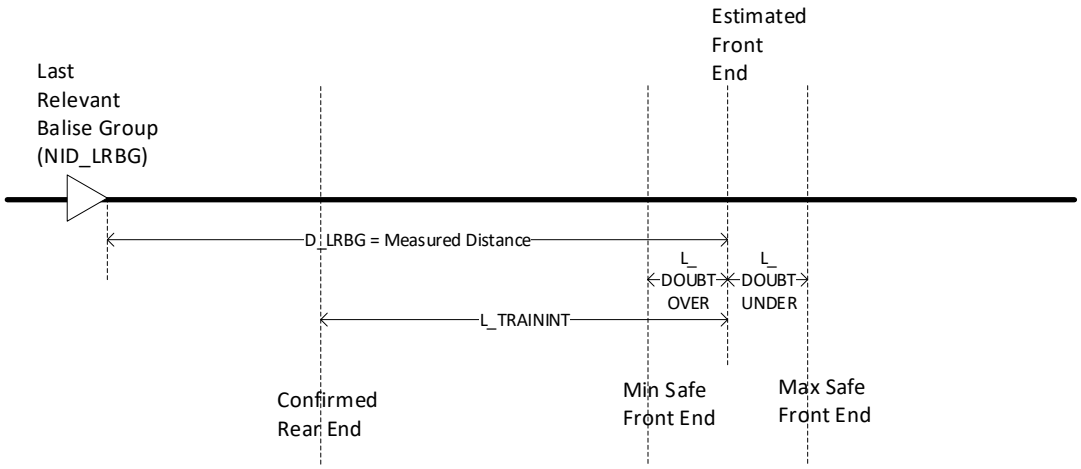

Figure 10: Definition of Confirmed Rear End from Position Report

The Max Safe Front End is derived by the L3 Trackside from Train Position Reports and is updated whether or not train integrity is confirmed.

The Confirmed Rear End is derived by the L3 Trackside from Train Position Reports and is only updated if train integrity is confirmed in a new Train Position Report.

Figure 11 shows how the Train Location is represented in the remainder of this document.

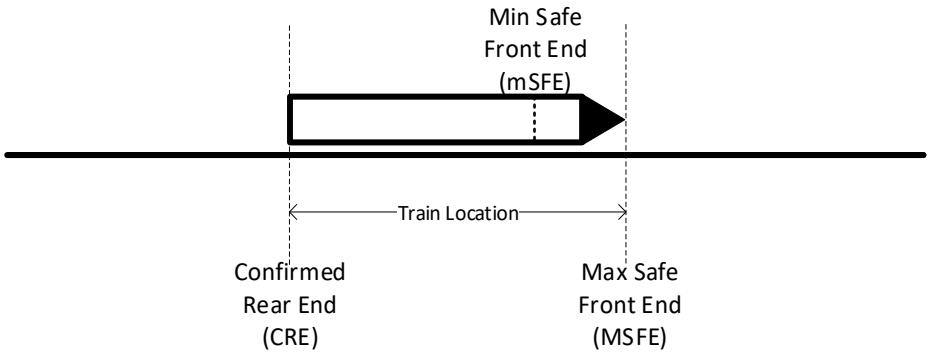

Figure 11: Train Location from L3 Trackside viewpoint

The Min Safe Front End is only shown where required.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrainLoc-3

When necessary, The L3 Trackside shall determine a Safety Margin in rear of the Train Location, which will define the Confirmed Safe Rear End.

Rationale:

This is to allow for possible changes to the train location, for example rolling backwards.

Guidance:

The Safety Margin is a dynamic value added by the Trackside considering the risks of a train moving backwards or errors in train location due to relocation performed when no linking information is available.

The following factors could be considered as part of the Safety Margin:

- The National Value for Reverse Movement (D_NVPOTRP)
- The National Value for Rollback (D_NVROLL)
- The Maximum distance not detected by CMD equipment.

Figure 12 defines the Confirmed Safe Rear End:

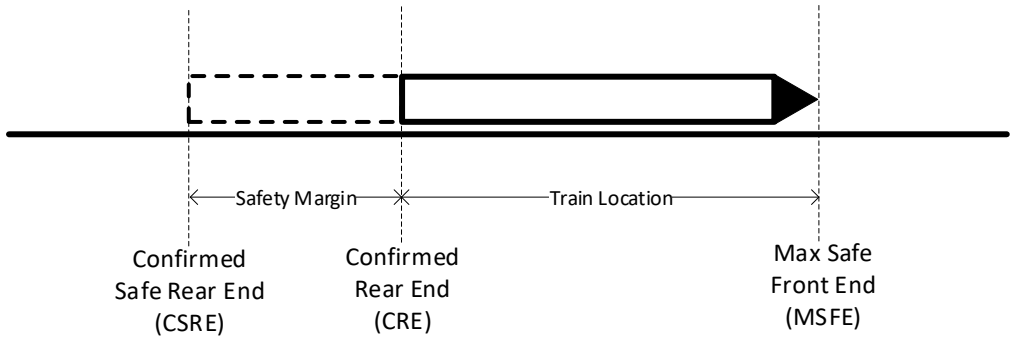

Figure 12: Definition of Confirmed Safe Rear End

During normal operation, when the train is moving, and the risk of rolling backwards is small, the Safety Margin can be zero. The algorithm for Safety Margin should avoid the CSRE moving backwards at End of Mission.

An alternative approach is to use a fixed value for the Safety Margin. This would simplify the L3 Trackside.

At End of Mission, there may be additional factors required to calculate the Safety Margin. See section 6.17.

The derivation of the Safety Margin functionality is considered as part of the future work for the project. See section 8.3.

D5.2 Operational Rule: None

D5.2 Engineering Rules: ENG-Generic-6

REQ-TrainLoc-4

The L3 Trackside shall calculate a Front Safety Margin in advance of the train location.

Rationale:

This is to allow for possible changes to the train location when a train is stationary, for example rolling forward.

Guidance:

When a train is moving forwards, the Front Safety Margin will be zero. At End of Mission, Front Safety Margin is not expected to be zero. See section 6.17.

D5.2 Operational Rules:None

D5.2 Engineering Rules: ENG-Generic-6

REQ-TrainLoc-5

The L3 Trackside shall be able to request the ETCS On-board to report train position as soon as its Confirmed Rear End is in advance of a specified location.

Rationale:

This is to improve performance of the system, for example by enabling release of infrastructure as soon as the CRE is clear of a release point.

Guidance:

If the system allows configuring such value, it could be used by the L3 Trackside to ask the ETCS On-board to inform about when it has passed special locations such as points or level crossing, speeding up the release of these portions of track. The proposal is to modify the variable Q_LGTLOC used in packet 58 'Position Report Parameters' (qualifier that tells the ETCS On-board whether the train has to report its position when the max safe front end or when the min safe rear end has over passed the location defined by D_LOC) in order to allow this reporting based on the Confirmed Rear End of the train. It must be noted that since the Confirmed Rear End of the train does not take into account its Safety Margins, this would have to be considered when engineering D_LOC when required.

This requirement could also be used to trigger disconnection of a train from the Handing Over L3 Trackside during Handover.

This requirement is dependent on a Change Request to the ETCS Baseline. See section 7.1 New train position report when the CRE has passed a specific location

Alternatively, the objective of this requirement can be met without implementation of a Change Request by requesting a Train Position Report when the Min Safe Rear End of the train reaches a point beyond the required location. However, this does not consider the frequency of TIMS reporting and the subsequent impact on the location of the CRE.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrainLoc-6

The ETCS On-board shall be able to send a position report when it passes a specific location with its Confirmed Rear End if requested by Trackside.

Rationale:

This is to improve performance of the system, for example by enabling release of infrastructure as soon as the CRE is clear of a release point.

Guidance:

This requirement is dependent on a Change Request to the ETCS Baseline. See section 7.1 New train position report when the CRE has passed a specific location.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrainLoc-7

The L3 Trackside shall not process Train Position Reports from Non-Leading engines to establish Train Location.

Rationale:

Train Position Reports from Non Leading engines can be expected to occur.

Guidance:

Any ETCS Onboard in Non Leading mode is assumed to be part of another fully protected train.

It is optional whether or not the L3 Trackside maintains the communications session with the Non Leading engine.

Train Position Reports from an ETCS Onboard in Non Leading can be used for representation purposes, in which case they will need to be transmitted from the L3 Trackside to the TMS.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrainLoc-8

The L3 Trackside shall not process Train Position Reports from ETCS On-Board in SB Mode to establish Train Location.

Rationale:

Train Position Reports from ETCS On-Board in SB Mode can be expected to occur.

Guidance:

It is optional whether or not the L3 Trackside maintains the communications session with ETCS On-Board in SB Mode.

Train Position Reports from an ETCS Onboard in SB Mode can be used for representation purposes, in which case they will need to be transmitted from the L3 Trackside to the TMS.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrainLoc-9

The L3 Trackside shall store valid information for all trains within its Area of Control. The following information will be stored:

a) Train id (NID_ENGINE)

b) Train length (L_TRAIN)

c) Most recent Train Position Report

d) Most recent Confirmed Rear End.

Rationale:

This is to enable the L3 Trackside to, for example:

- Clear an Unknown area when a train performs Start of Mission (see section 6.9)
- Recognise a train which has regained communications as the same train which lost communications (see section 6.14).

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-TrackInit-1

REQ-TrainLoc-10

The L3 Trackside shall report the Train Location and status for all trains within its Area of Control to the Traffic Management System.

Rationale:

This is to provide the Traffic Management System with information about the location of trains and their status.

Guidance:

The Status of trains can consist of the following information (though it is application specific the exact parameters exchanged):

- Train Speed
- Mode
- Extent of Movement authority remaining
- Train integrity status.

6.2 Track Status

6.2.1 Introduction

This section contains requirements relating to the processing of Train Locations by the L3 Trackside, in order for the L3 Trackside to determine the Track Status within its Area of Control.

Any part of the track can be:

- **Occupied** The L3 Trackside considers that there is a communicating train with train integrity confirmed present on the track
- **Clear** The L3 Trackside considers that there are no obstacles present on the track
- **Unknown** The L3 Trackside is unsure whether there is a train or obstacle present on the track (neither Occupied nor Clear).

A number of factors may cause an area of track to become unknown. The following non-exhaustive list gives some examples:

a) The system has been initialised

b) The track is within a Shunting Area which has been activated

c) There is a train which has suffered a loss of communications, but which was last reported as occupying this location, or being authorised to move to this location

d) There is a train which has never reported integrity, or suffered a loss of integrity

e) TTD becomes Occupied where no train is known to be located (possibly a Ghost Train)

f) The TMS has defined an area of track to be Unknown

g) There is a splitting or joining procedure, and the checks on train lengths fail to account for all the previous train lengths known to the L3 Trackside

h) A train performs an End of Mission

i) Propagation of an Unknown area due to loss of integrity, EoM or loss of communications.

When an area of track becomes Unknown, it is necessary to record the reason for that area of track becoming Unknown, as this will affect the way in which the Unknown area can be removed. The following non-exhaustive list gives a number of methods for the Unknown status of an area of track to be removed:

a) Use of stored information for Trackside initialisation

b) Recovery of communications with a train which suffered loss of communications

c) Recovery of train integrity for a train which has suffered loss of integrity

d) Determination that an area of track is free based on Trackside Train Detection

e) Removal of an Unknown area by the TMS

f) Matching a train performing Start of Mission with information stored for a train which performed End of Mission

g) Matching two (or more) trains after splitting with the train before splitting

h) Matching a train after joining with two (or more) trains before joining

i) Sweeping of the unknown area.

Sweeping means the removal of Unknown status by the passage of a train which has Train Integrity confirmed. A train with a Movement Authority over an Unknown section of track must proceed in On Sight mode.

Unknown Areas can be considered Sweepable or Non-Sweepable. Non-Sweepable Unknown areas are retained by the L3 Trackside even after the passage of an integer, communicating train through the area. The Non-Sweepable parameter is to protect against hazards on the railway that the Dispatcher/TMS is aware of and wants every train to pass in On Sight. Unknown areas with the Non-Sweepable parameter can only be created and removed by the Dispatcher/TMS. Unknown areas created by the L3 Trackside (such as at EoM) are always with the parameter Sweepable.

The analysis performed by WP5 used three states: Occupied, Clear and Unknown. Particular implementations may choose to subdivide the Unknown state to create additional track states.

This is the approach adopted in the L3 Hybrid specification published by the ERTMS Users Group [HL3], which applies for systems with Fixed Virtual Blocks, with Trackside Train Detection.

6.2.2 Requirements

REQ-TrackStatus-1

The L3 Trackside shall determine the Track Status of the entire track within the Area of Control.

Rationale:

It is critical that within a system where the means of locating trains is via Train Position Reports, the Trackside maintains an up to date record of the Track Status within its Area of Control.

Guidance:

Every area of track within the Area of Control will be Occupied, Unknown or Clear.

The Track Status will need to be updated, for example if:

a) A new Train Position Report is received

b) There is a loss of communications with a train

c) There is a loss of Train Integrity for a train.

These and other situations are covered by further requirements.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackStatus-2

The L3 trackside shall establish an Occupied area of track for each communicating train with Train Integrity confirmed, based on its Train Location and Safety Margin.

Rationale:

This is required in order for the L3 Trackside to maintain the Track Status within its Area of Control.

Guidance:

Figure 13 shows the relationship between Train Location and Occupied Track Status for an individual train in a track which is otherwise Clear:

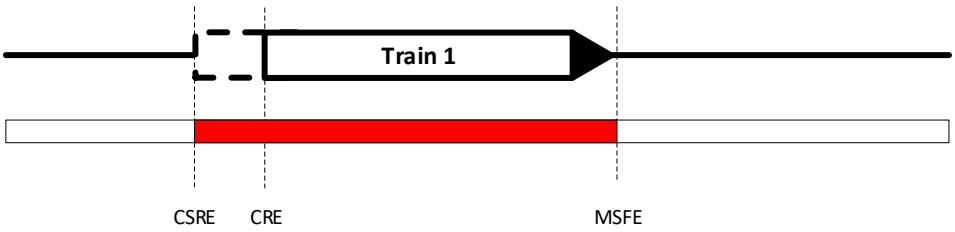

Figure 13: Track Status from Train Location

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackStatus-3

The L3 Trackside shall update the Occupied area of track for a communicating train with Train Integrity confirmed, when a new Train Position Report is received, regardless of the previous Track Status in the new train location.

Rationale:

This is required in order for the L3 Trackside to maintain the Track Status within its Area of Control.

Guidance:

Figure 14 shows the relationship between Train Location and Occupied Track Status for an individual train in a track which is otherwise Clear:

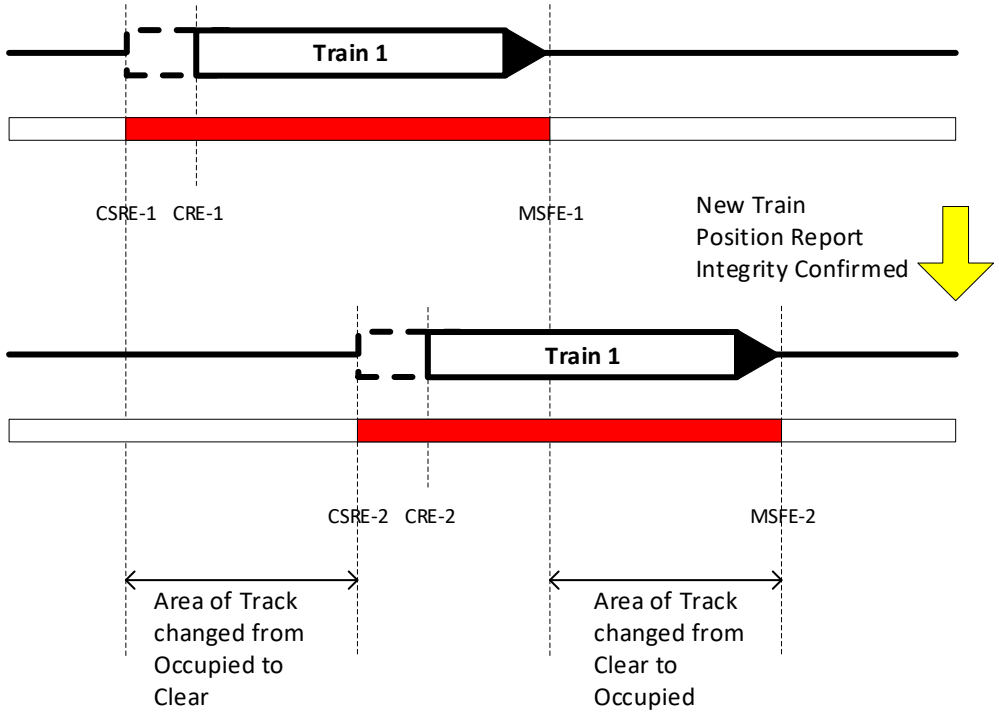

Figure 14: Track status update with new Train Position Report

The diagram above shows that the area of track in front of the old Train Location is changed from Clear to Occupied, and the area of track behind the new Train Location is changed from Occupied to Clear.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackStatus-4

If a communicating train with Train Integrity confirmed issues a new Train Position Report, and the train is moving into an area of Unknown which is Sweepable, then the L3 Trackside shall use the Min Safe Front End of the train to reduce the area of Unknown.

Rationale:

Sweeping is performed by the Min Safe Front End (mSFE) of a train, as it cannot be guaranteed that there is no obstruction between the mSFE and front of the Occupied area of track, which is the Max Safe Front End (MSFE).

Guidance:

Figure 15 shows the relationship between Train Location and Occupied Track Status for an individual train in a track which was previously Unknown ahead of the train:

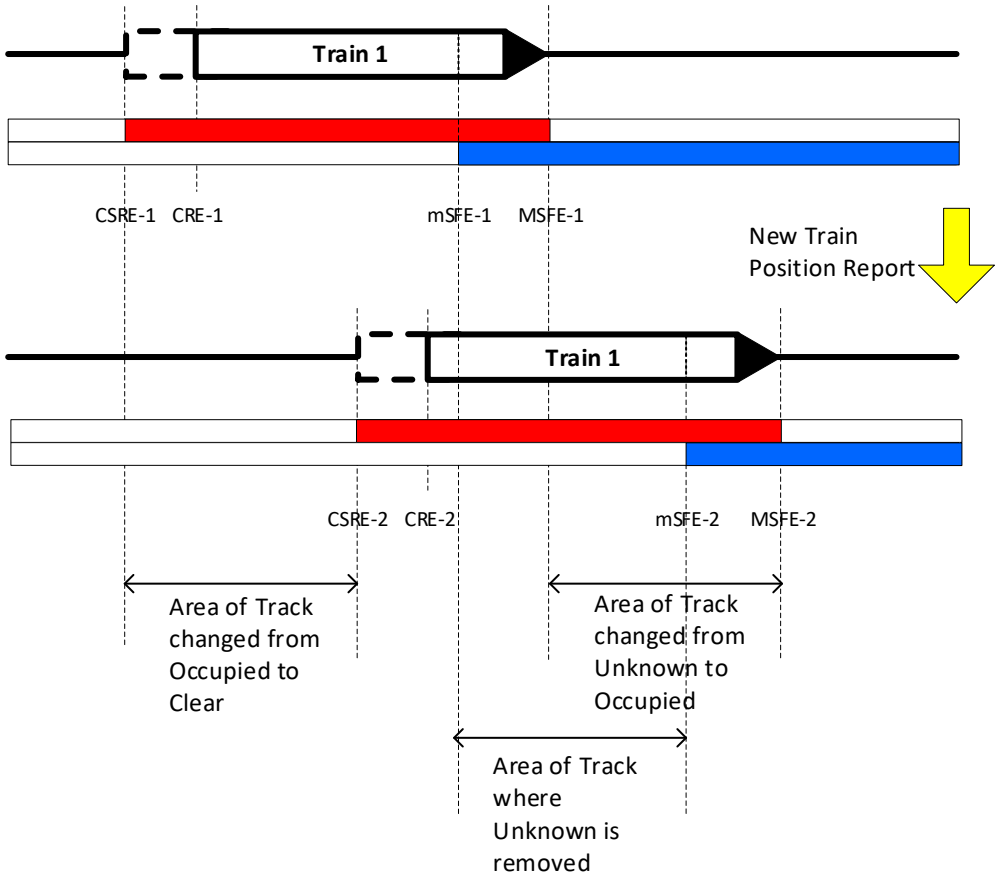

Figure 15: Track status update: Train entering an Unknown area

The passage of a train with Train Integrity confirmed through an area with Track Status Unknown represents sweeping of that area.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackStatus-5

The L3 Trackside shall be able to set areas of track with Track Status Clear to Unknown when requested by the Traffic Management System.

Rationale:

This is to allow the L3 Trackside to have all relevant information concerning obstructions, as some may only be detected by external systems.

Guidance:

For example, external systems may detect fallen objects, or landslides.

This can be also used in the degraded situation of a non-communicating train. A train without communications must be moved inside an area with state Unknown so that the L3 Trackside is aware that this area is protected for a specific train.

The Unknown area may be created automatically by the TMS, or via dispatcher interaction with the TMS.

The Unknown area must be longer than the configurable minimum length for removal of Unknown, defined in REQ-TrackStatus-11.

Any area of track with Track Status Occupied within the new Unknown area will remain in the state Occupied.

D5.2 Operational Rules:OPE-TrackInit-2; OPE-Generic-6

D5.2 Engineering Rules:ENG-StartTrain-2

REQ-TrackStatus-6

When the TMS creates an Unknown area it shall flag it as Sweepable or Non-Sweepable.

Rationale:

When the TMS creates an Unknown area it may be for a reason that would make it unsuitable to be swept e.g. a known permanent obstacle on the line.

Guidance:

Non-Sweepable areas of Unknown will only be cleared at the request of the TMS.

D5.2 Operational Rules:OPE-Generic-6

D5.2 Engineering Rules:None

REQ-TrackStatus-7

For an Unknown Area created by the TMS and flagged as Non-Sweepable, the L3 Trackside shall retain the Unknown area after traversal by a train which has confirmed train integrity.

Rationale:

Non-Sweepable Unknown areas must be retained. As such, an Integer Train passing through such an area will briefly transition it to Occupied, but the Unknown will remain after the train has passed through.

Guidance:

Non-Sweepable areas of Unknown will only be cleared at the request of the TMS.

D5.2 Operational Rules:OPE-Generic-6

D5.2 Engineering Rules:None

REQ-TrackStatus-8

The L3 Trackside shall be able to set areas of track with Track Status Unknown to Clear when requested by the Traffic Management System.

Rationale:

L3 Trackside allows the Traffic Management System to clear areas of the track based on the result of operational procedures.

Guidance:

For example, some Infrastructure Managers may permit a track to be cleared based on the observations of a Driver sweeping on an adjacent line.

The Dispatcher, via the Traffic Management System, will input the extent of each area of track to be set to Clear.

Robust operational procedures are required in order to permit the Dispatcher, via the Traffic Management System, to clear Unknown areas.

D5.2 Operational Rules: OPE-Generic-1, OPE-OS-3

D5.2 Engineering Rules:None

REQ-TrackStatus-9

The L3 Trackside shall define a configurable Propagation timer for areas with Track Status Unknown.

Rationale:

The expiry of the Propagation timer is the trigger for the L3 Trackside to start propagating an Unknown area.

Guidance:

It is application specific whether the timer is implemented as a single global value across the L3 Area, or whether it is different according to the different triggers for starting the timer, or for different areas of the track.

Note that the topic of Propagation is one considered for further work. Further details can be found in Section 8.5 Development of Propagation Functionality.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LossTI-2

REQ-TrackStatus-10

After expiry of the propagation timer, the L3 Trackside shall be able to apply propagation of the Unknown state.

Rationale:

This propagation functionality is needed to protect the track from unsupervised train movements.

Guidance:

The configuration of the propagation algorithm is application specific. The following situations may be considered in application of the propagation function:

a) Loss of Integrity: after expiry of the propagation timer the L3 Trackside could propagate the Unknown area rearwards to protect against a loose wagon rolling backwards and exiting the Unknown area

b) End of Mission: After a train has performed End of Mission, the L3 Trackside may propagate the Unknown in front and rear of the train's last location.

When implementing the propagation functionality, it is important to consider the boundaries of the propagation. If the system uses TTD this could form the boundaries. In addition, points and crossings and the boundary of Occupied areas of track could also form the extent of propagation. See section 8.5 on further work to be carried out on this topic.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackStatus-11

The L3 Trackside shall automatically clear isolated Unknown areas that are shorter than a configurable minimum length.

Rationale:

This is to avoid having small areas of track with status Unknown that have to be swept when it is known that there cannot be a vehicle inside them.

Guidance:

Small areas of track with status Unknown could arise from splitting and joining procedures, or from sweeping.

For example, this requirement could apply to cross-over areas, as given in Figure 16:

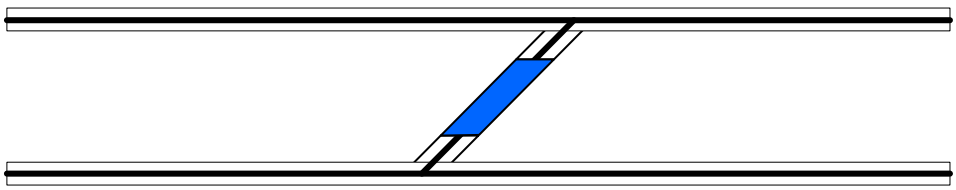

Figure 16: Short unknown area at crossover

The configurable minimum length could be related to the length of the shortest vehicle that could be running on the line.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-StartTrain-2

REQ-TrackStatus-12

The L3 Trackside shall report the Track Status for all track within its Area of Control to the Traffic Management System.

Rationale:

This is to provide the Traffic Management System with information about the Track Status.

Guidance:

This information can be used by the Traffic Management System during normal operation, and also to manage degraded situations.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackStatus-13

The L3 Trackside shall store the Track status for all track within its Area of Control.

Rationale:

Stored information will be used by recovery mechanisms, for example SoM, recovery after loss of integrity etc.

Guidance:

For the information stored to be useful, it needs to be stored with the associated Train data (REQ-TrainLoc-7). For example, when a train performs an EoM the ID of the train and its length is related to the Track Status transition.

Stored information and the associated Track Status can be used in the following situations:

a) Joining/Splitting: The Length of trains involved in Splitting and Joining is recorded, and the L3 Trackside ensures that the full length is accounted for before and after the procedure

b) SoM: Comparing the new train length to the stored length for that area of track and removing the Unknown area if the lengths match

c) Recovery after loss of Communications (new session): New train length received is compared with that stored to check that it is the same train reconnecting.

D5.2 Operational Rules: None

D5.2 Engineering Rules: None

REQ-TrackStatus-14

The L3 Trackside shall manage the overlap of multiple Unknown areas and only clear them when it is safe to do so.

Rationale:

Unknown areas may be created due to a number of actions: degraded situations (Loss of Integrity, Loss of Communications), TMS intervention, Shunting etc. It is critical that the L3 Trackside manages the overlap of these different areas and only clears them when their own conditions for clearance are fulfilled.

Guidance:

Some clearance mechanisms (for example Sweeping) may apply to multiple overlapping Unknown areas.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

The situation may arise where a “Non-Sweepable” Unknown area is overlapped with a “Sweepable” Unknown area. In the event of a sweeping train traversing this combined area, the L3 Trackside will ensure only the Sweepable Area is cleared.

REQ-TrackStatus-15

If an area of Unknown is created that is in conflict with other train movements, the L3 Trackside shall react to transition the system to a safe state.

Rationale:

A new area of Unknown within an area reserved for a train may require urgent action from the L3 Trackside in order to avoid a hazard.

Guidance:

The specific reaction applied will depend on the scenario and application specific requirements. Possible reactions include: shortening of the Movement Authority for another train, sending an Unconditional Emergency Stop to one or multiples trains etc.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackStatus-16

Where the L3 Trackside determines there is an overlap of areas with Occupied and Unknown state, the L3 Trackside shall consider the overlapped area to have a state of Occupied.

Rationale:

The state of Occupied is considered to have precedence over Unknown, as it is more restrictive. Occupied areas can only be entered in On Sight with authorisation from the TMS.

Guidance:

Overlap of Occupied and Unknown areas may occur when sweeping is performed by an integer train, or when splitting and joining movements are undertaken.

This requirement is also applicable in the derivation of the status of Fixed Virtual Blocks.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.3 Reserved Status

6.3.1 Introduction

This section contains requirements relating to the reserving of track for the movement of trains by the L3 Trackside.

An area of track must be Reserved before the L3 Trackside authorises a particular train to move through that area. The Reserved state is separate to the states defined for Track Status.

An area of the track is Reserved if:

- The L3 Trackside has sent a Movement Authority to a train for that area of track
- The L3 Trackside has authorised a SR movement
- The L3 Trackside has sent Route Related Information as part of handover to an adjacent L3 Trackside.

An area of track remains Reserved in rear of a train if the L3 Trackside has authorised a RV movement.

6.3.2 Requirements

REQ-Reserved-1

The L3 Trackside shall establish Reserved status for the area of track where a train will be authorised to run.

Rationale:

This is to avoid points movement or other potential conflict with other trains.

The Reserved area is established within the L3 Trackside before a Movement Authority or SR Distance is issued to a train.

Guidance:

This includes:

a) Movement Authority, including up to any Danger Point, and any Overlap

b) Staff Responsible distance if issued via the L3 Trackside

c) Reversing distance.

Except in the case of authorised reversing, a train is not permitted to move backwards, and so the track behind the train is not Reserved except in this case. See section 6.16 Reverse movement.

Figure 17 shows an Area of Track with Reserved status ahead of a train:

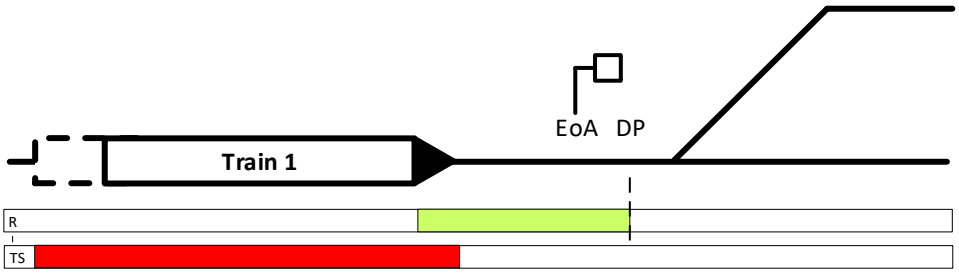

Figure 17: Reserved Area for a single train

The Reserved status is separate from the Route locking, if the L3 Trackside permits more than one train within a single route, as shown in Figure 18:

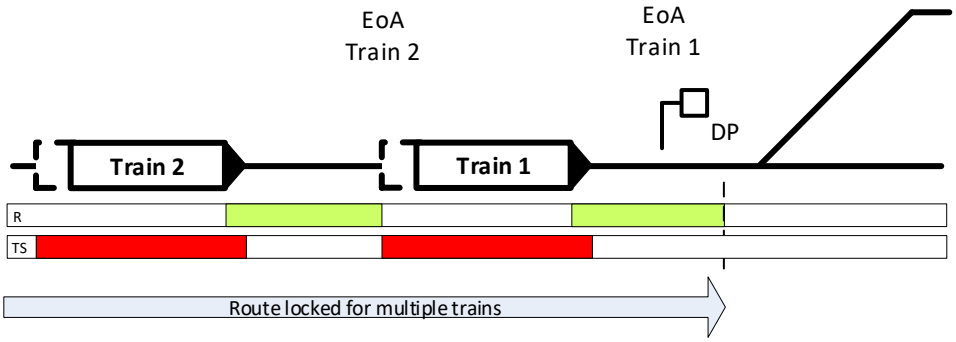

Figure 18: Reserved Areas for two trains following one another

D5.2 Operational Rules:OPE-MovSR-1

D5.2 Engineering Rules:ENG-MovSR-1

REQ-Reserved-2

The L3 Trackside shall report the Reserved Status for all track within its Area of Control to the Traffic Management System.

Rationale:

This is to enable the Traffic Management System to represent for the Dispatcher the Reserved area for the movement of every train in the Area of Control.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-Reserved-3

The L3 Trackside shall update the Reserved area of track for a communicating train when a new Train Position Report is received.

Rationale:

This is required in order for the L3 Trackside to maintain the Reserved Status within its Area of Control.

Guidance:

Figure 19 shows the Reserved Status update for an individual train:

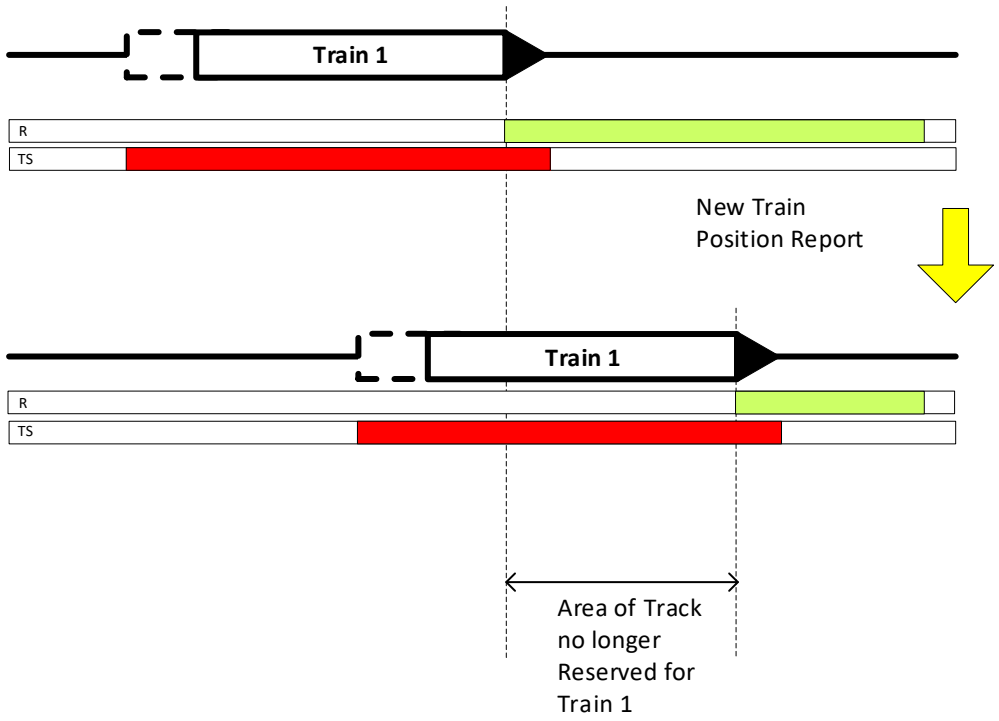

Figure 19: Reserved Status update with new Train Position Report

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.4 Fixed Virtual Blocks

6.4.1 Introduction

This section contains requirements relating to ETCS Level 3 Moving Block systems which are configured to use Fixed Virtual Blocks.

Fixed Virtual Blocks may be used to provide both:

a) Predefined areas of track, each with Track Status Occupied / Clear / Unknown

and:

b) Predefined locations for the end of Movement Authorities.

In a system with Fixed Virtual Blocks, it is necessary to engineer the Fixed Virtual Blocks.

It is assumed that infrastructure elements such as point ends (between the point toe and fouling points) and diamond crossings (between fouling points) are entirely within a single Fixed Virtual Block. For further information, see section 6.6 Points Control.

All requirements specific to systems using Fixed Virtual Block start with the wording:

"For a system using Fixed Virtual Blocks…"

6.4.2 Requirements

REQ-FVB-1

For a system using Fixed Virtual Blocks, the L3 trackside shall determine the Track Status of all the Fixed Virtual Blocks within the Area of Control by applying the following algorithm:

If there is any part of an area of track with Track Status Occupied within the FVB:
Then
The FVB has status Occupied
Elseif there is any part of an area of track with Track Status Unknown within the FVB
the FVB has status Unknown
Else
the FVB has status Clear
Endif

Rationale:

In a system using Fixed Virtual Blocks, Track Status must be determined at the level of Fixed Virtual Blocks. This is required in order for the L3 Trackside to set Routes and issue Movement Authorities.

Guidance:

Every Fixed Virtual Block will be Occupied, Unknown or Clear. The algorithm can be considered to be a projection of the Track Status derived through Moving Block principles onto the Fixed Virtual Blocks.

The following diagrams illustrate the application of the algorithm. Figure 20 illustrates the derivation for an area of Track Status Occupied:

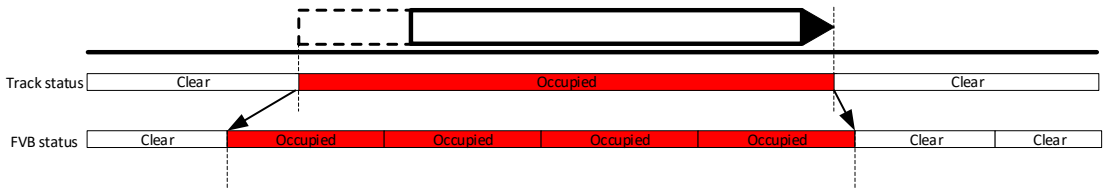

Figure 20: Train location mapped to Fixed Virtual Blocks

This also means that a Fixed Virtual Block which has all or part of two different areas of Track Status Occupied will have status Occupied, as given in Figure 21:

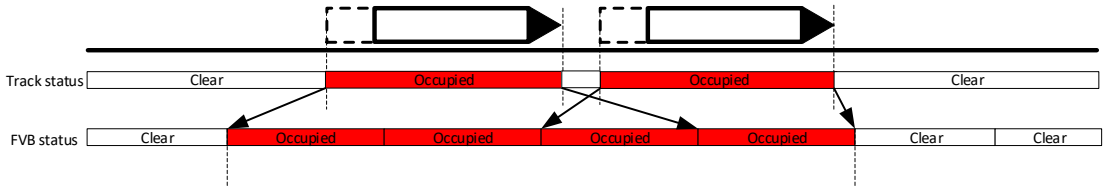

Figure 21: FVB Track Status with multiple trains

Figure 22 illustrates the derivation of the FVB status for an area of Track Status Unknown:

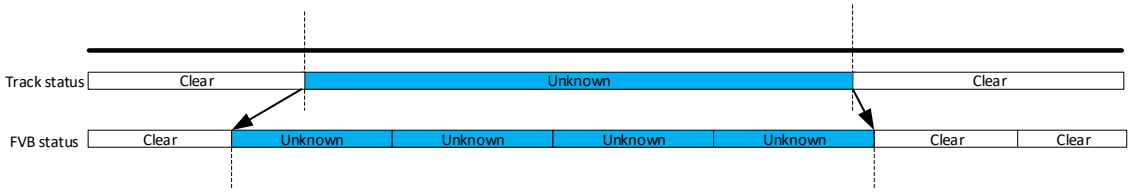

Figure 22: FVB Track status with Unknown area

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-7

6.5 Trackside Train Detection

6.5.1 Introduction

This section contains requirements relating to ETCS Level 3 Moving Block systems which are engineered to use Trackside Train Detection.

The L3 Trackside can operate without Trackside Train Detection. However, some systems may use Trackside Train Detection, and so the L3 Trackside is also defined so that it can support this. The system could be equipped with Trackside Train Detection only in specific locations, or throughout the Area of Control. Section 4 describes different ETCS Level 3 Moving Block System Types, with and without Trackside Train Detection.

Trackside Train Detection may be used for the following:

- To detect and permit movement of trains not equipped with TIMS, in a Mixed Traffic scheme

- To reduce the performance impact of trains operating without integrity in the L3 area (either due to loss of integrity or a lack of TIMS equipment being fitted)
- To detect the entry of unfitted trains (trains without ETCS On-board) or other non-communicating railway vehicles at the boundaries of the Area of Control
- To detect occupation of the track in a shunting area, or in other areas where trains are joined, split, perform End of Mission or where vehicles are parked without performing End of Mission
- To achieve faster release of points and crossings, level crossings etc.
- To assist with faster recovery from degraded situations, to avoid the need for "sweeping" a section of the railway in On Sight mode.

Depending on TTD state, Occupied or Clear, L3 Trackside will adjust the Track Status of the area of track covered by the TTD section, as summarised in the table below. Note that a TTD section reported as "Faulty" will be treated as Occupied by the L3 Trackside.

Old Track Status	**Event: New TTD State**	**New Track Status**	**Notes**
Occupied	Clear → Occupied	Occupied (No change)	
Clear	Clear → Occupied	Track Status changed to Unknown after latency timer [REQ-TTD-1]	Could be a Ghost Train
Unknown	Clear → Occupied	Occupied (No change)	
Occupied	Occupied → Clear	Track Status changed to Clear [REQ-TTD-2]	Need to ensure that complete train is not removed from L3 Trackside Need to consider overhang.
Clear	Occupied → Clear	Clear (No change)	
Unknown	Occupied → Clear	Track Status changes to Clear [REQ-TTD-3]	

Infrastructure elements such as points and diamond crossings must be entirely within a single Trackside Train Detection section, as in the railway today.

For ETCS Level 3 Moving Block systems using Fixed Virtual Blocks, the TTD boundaries must also be Fixed Virtual Block boundaries, as shown in Figure 23.

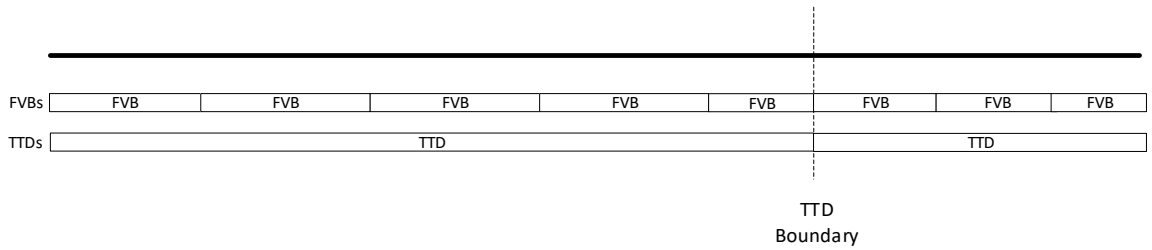

Figure 23: Fixed Virtual Blocks with TTD

All requirements specific to systems using Trackside Train Detection start with the wording:

"For a system using Trackside Train Detection…"

6.5.2 Requirements

REQ-TTD-1

For a system using Trackside Train Detection, after expiry of a Latency timer, the L3 Trackside shall consider as Unknown the area covered by an occupied TTD when there are no parts of any Train Locations from Train Position Reports within the TTD section.

Rationale:

This is to identify possible obstructions in the line when the system knows that the area is not occupied by a communicating train.

Guidance:

Due to the latency of Train Position Reports, it is possible that a train occupies a TTD section before a Train Position Report within the TTD section is received by the L3 Trackside. To distinguish between the latency in normal operation and unexpected TTD occupation, the Latency timer has been defined.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-8

REQ-TTD-2

For a system using Trackside Train Detection, the L3 Trackside shall be able to change Track Status Occupied to Clear for areas of track corresponding to a TTD section which is Clear.

Rationale:

TTD information can be used to improve performance of the system.

Guidance:

This could be used to release points and level crossings faster.

Care must be taken with the application of this requirement, to ensure that a train is not completely removed from the Track Status view of the Area of Control. This could occur due to latency between TTD operation and Train Position Reports.

Care must be taken to allow for the overhang of vehicles at the boundary between and occupied and clear TTD.

Full Moving Block, Clear TTD in front of Train

A clear Trackside Train Detection (TTD) section in front of a train can shorten the occupied part of the Track Status at the front of the train, as shown in Figure 24:

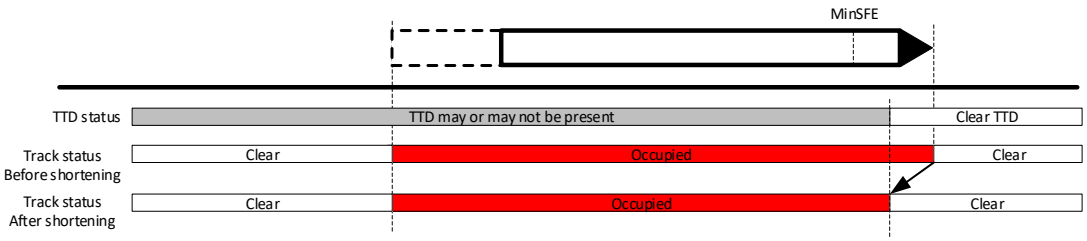

Figure 24: Shortening of front of Track Occupancy due to clear TTD (FMB)

In order to avoid a train being completely removed, this shortening is only applied up to the Min Safe Front End.

The following figure shows the situation where the Min Safe Front End is reported as within the Clear TTD, as shown in Figure 25:

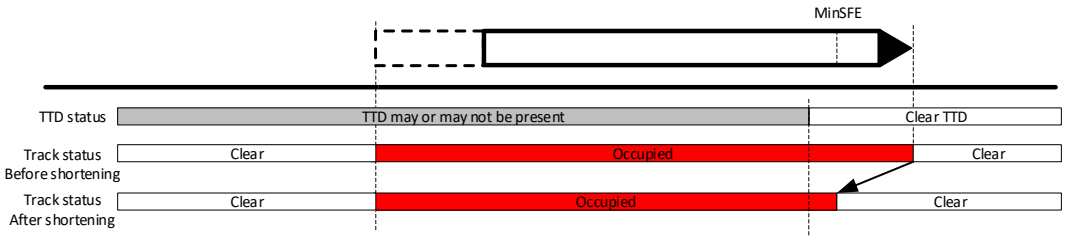

Figure 25: Track Occupied in clear TTD due to position report

Full Moving Block, Clear TTD in rear of Train

A clear Trackside Train Detection (TTD) section in rear of a train shortens the occupied part of the Track Status at the rear of the train:

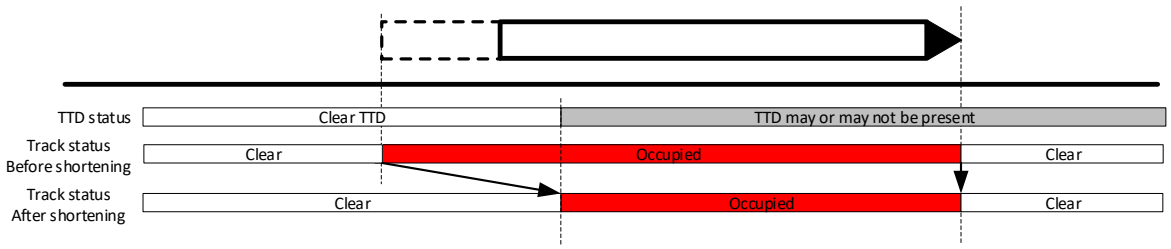

Figure 26: Shortening of rear of Track Occupancy due to clear TTD (FMB)

The Safety Margin may be reduced, or even removed, as shown above.

In order to avoid a train being completely removed, this shortening is only applied up to the Min Safe Rear End.

Fixed Virtual Blocks, Clear TTD in front of Train

A clear Trackside Train Detection (TTD) section in front of a train results in a Clear FVB, even if that FVB is partially or completely within the Train Location:

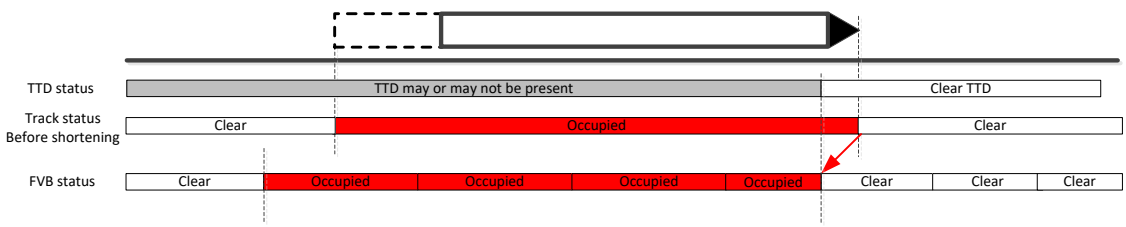

Figure 27: Shortening of front of Track Occupancy due to clear TTD (FVB)

It is proposed that this shortening is only applied up to the Min Safe Front End from the most recent Train Position Report.

Fixed Virtual Blocks, Clear TTD in rear of Train

A clear L3 Trackside Train Detection (TTD) section in rear of a train results in a Clear FVB, even if that FVB is partially or completely within the Train Location or the Safety Margin:

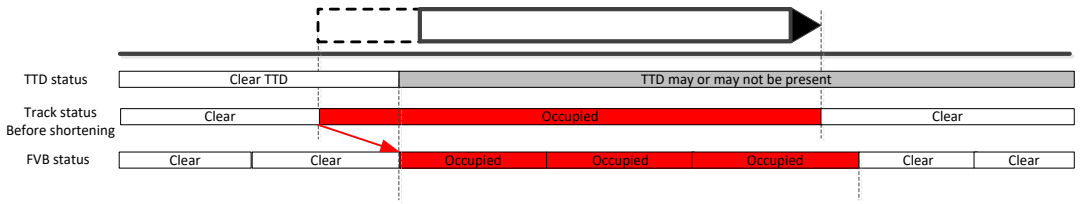

Figure 28: Shortening of rear of Track Occupancy due to clear TTD (FVB)

Note that the Safety Margin may be reduced, as shown above, or even removed.

In order to avoid a train being completely removed, this shortening is only applied up to the Min Safe Rear End.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TTD-3

For a system using Trackside Train Detection, the L3 Trackside shall be able to change Track Status Unknown to Clear for areas of track corresponding to a TTD section which is Clear. The following situations will act as exceptions to this mechanism:

a) the Unknown area has been created at the request of the TMS and marked as Non-Sweepable

b) the Unknown area is due to an active Shunting Area

Rationale:

TTD information can be used to clear the line under degraded situations.

Guidance:

With TTD, there is no need for sweeping to clear Unknown areas of track as this can be used as an alternative.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TTD-4

The L3 Trackside shall be able to consider an Unknown area caused by a faulty TTD as Clear, if it can be sure that no train is located over it and the TMS has authorised the operation.

Rationale:

In L3 operation, when all train movements are supervised by ETCS On-board with position reporting, a faulty TTD can be detected; dependent on the states of the neighbouring TTD's and position reports of other trains.

Guidance:

This function could be used to improve the reliability of the system and overrule false occupation reported by TTD (e.g. malfunctioning axle counters). This function will not be possible if the TTD is used to detect non-communicating trains, for example at interlocking borders and in mixed traffic areas. The function could be used to alert other systems (e.g. TMS, maintenance etc.) of a faulty TTD.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-9

6.6 Points Control

6.6.1 Introduction

This section contains requirements relating to the movement of points or other moveable infrastructure.

Points will be controlled by the L3 Trackside in the normal way, for example by the setting of Routes. This section only contains additional requirements for L3 relating to the locking of points, and the override procedure to move points if they are locked.

Points are locked by Track Status if any part of the area defined by the Fouling Points and the Point Toe has status Unknown or Occupied. This area is defined by rail topology and is individual for each set of points.

Points are locked by Reserved Status if any part of the area defined by the associated Release Points has status Reserved. This area is defined by design, and can cover several sets of points, and can also cover diamond crossings.

6.6.2 Requirements

REQ-PTS-1

The L3 Trackside shall prevent movement of points within an area of track with Track Status Unknown, Occupied or Reserved, unless using an operational procedure.

Rationale:

To avoid a point movement while there is a train over it or about to pass over it.

Guidance:

All points in an area which is Unknown or Occupied must remain locked, unless they are moved under an operational procedure.

Points are within an area of track with Track Status Unknown or Occupied if any part of the track between the Fouling Points and the Point Toe has Track Status Unknown or Occupied

Figure 29 below shows the area between Fouling Points and the Point Toe:

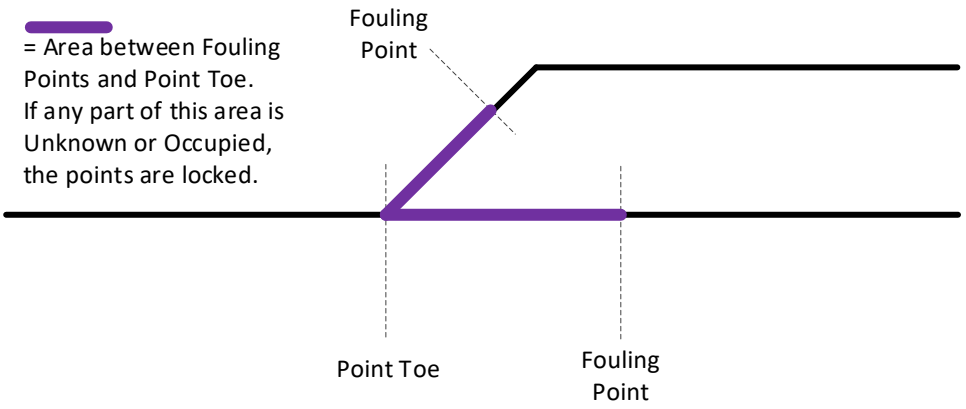

Figure 29: Area where Track Status Unknown or Occupied locks Points

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-PTS-2

The L3 Trackside shall Release Points to enable Points to be moved when the area of track containing the Points has Track Status Clear and Reserved Status Not Reserved.

Rationale:

This requirement enables movement of points when they are no longer locked for train movements.

Guidance:

In order to meet this requirement, it is necessary to define the area of track containing the points.

This can be done by defining Release Points, as shown in Figure 30 below for a single set of points.

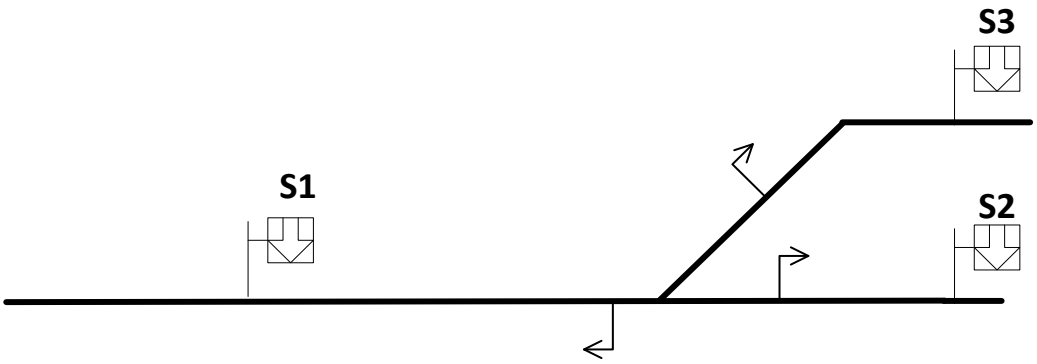

Figure 30: Release Points at a simple junction

Release Points are engineered and can cover more than one set of points. They can also cover diamond crossings. Figure 31 below shows a double junction, with Release Points for the complete junction.

Release Points after divergences must be at or beyond the Fouling Point. Release Points after convergences must be at or beyond the toe of the point.

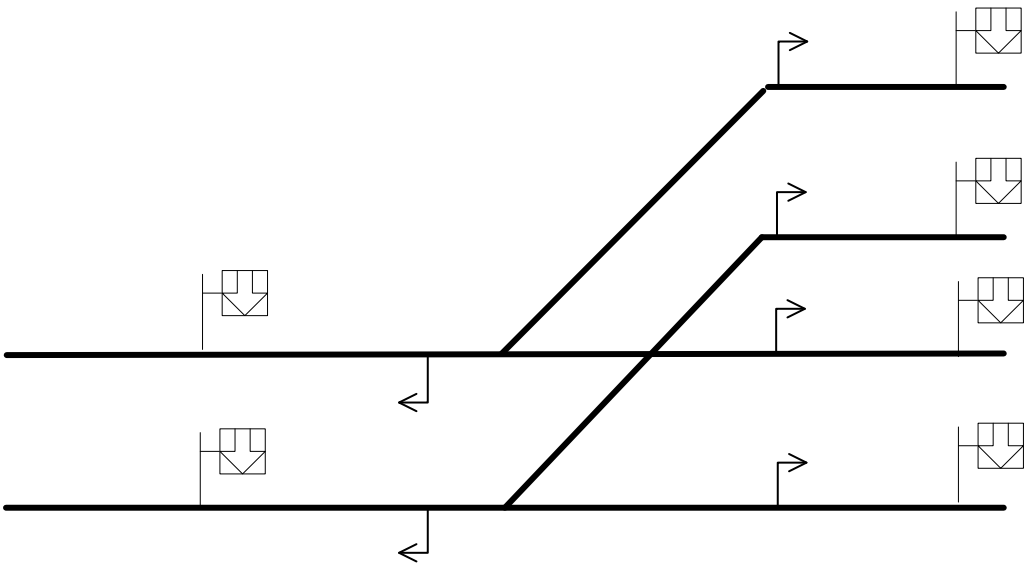

Figure 31: Release Points at a double junction

It is a design decision whether or not to include further Release Points, for example between the top point and the diamond.

When the Confirmed Safe Rear End of a train passes the Release Point, the points can be released for movement.

For a system with Fixed Virtual Blocks, the Release Points must be at Fixed Virtual Block boundaries.

For a system with Trackside Train Detection, the Release Points could be at Trackside Train Detection boundaries. In this case, they must be at or beyond the Clearance Points.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-3

REQ-PTS-3

The L3 Trackside shall provide a mechanism so that points entirely within an area of track with Track Status Unknown can be moved by the Traffic Management System under an operational procedure.

Rationale:

In order to allow the Traffic Management System to move a train to a different location in degraded situation, it may be necessary to move points which are locked by Track Status Unknown.

Guidance:

If Trackside Train Detection is present at the points, then this may be used to determine if the area over the points is free from railway vehicles.

Note that the phrase "Entirely within an area of track with status Unknown" means that the points area up to each Fouling Point is Unknown, as illustrated in Figure 32. If the Area is not already Unknown, the TMS may have to extend the Unknown area.

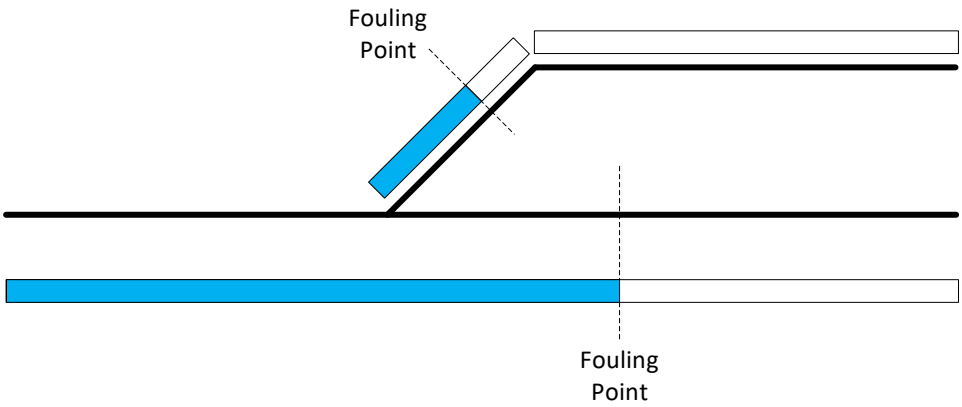

Figure 32: Points Area with status Unknown

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-PTS-4

When a Train is sweeping a set of points, the L3 Trackside shall consider Clear the alternate leg of the points as far as the Fouling Point in addition to the path the train takes.

Rationale:

When a train traverses a set of points, it occupies the alternate leg as far as the Fouling Point (due to overhang of the bodyshell from the bogies). As such the L3 Trackside can consider the area up to the Fouling Point swept if the sweeping train successfully traverse it.

Guidance:

Figure 33 illustrates the passage of a Sweeping train through set of point in an Unknown area.

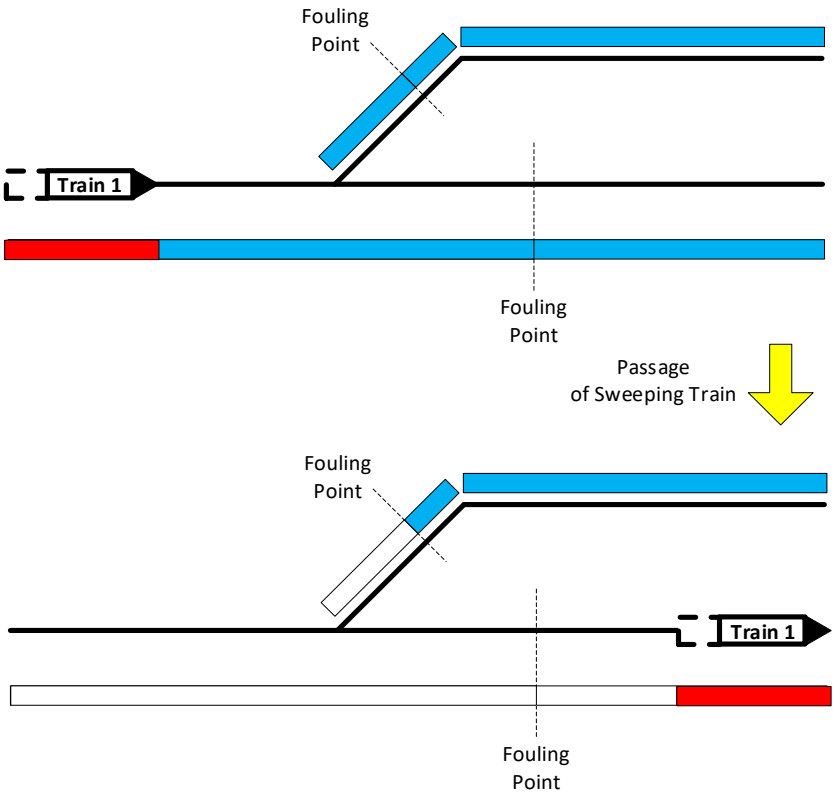

Figure 33: Passage of Sweeping train across Points inside Unknown area

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.7 Movement Authorities

6.7.1 Introduction

This section uses the concept of a Route, which is a path through the railway which is authorised for the passage of one or more trains.

The L3 Trackside can issue a Movement Authority to a train, up to the next obstruction, which can be a fixed or dynamic location.

For an ETCS Level 3 system using Full Moving Block, Movement Authorities can be to an arbitrary location, for example determined by the rear of a preceding train.

For an ETCS Level 3 system using Fixed Virtual Blocks the Movement Authorities will be to fixed pre-determined locations, at the boundaries of the fixed blocks.

A Movement Authority can be extended to the next obstruction, which can include:

- The end of the authorised route
- The end of the track (special case of first bullet)
- For an ETCS Level 3 system using Full Moving Block, the location determined from the rear of a preceding train
- For an ETCS Level 3 system using Fixed Virtual Blocks, the border of a Fixed Virtual Block
- The boundary of an area of track with status Unknown, unless continuing with OS mode profile
- The limits of area of track with status Reserved, for example associated with a Reversing Area
- The boundary of an End of Authority Exclusion area, depending on conditions.

The extent of the Movement Authority will also be limited by Engineering Rules, as in L2.

For an ETCS Level 3 system using Full Moving Block, given that the Movement Authority can extend to the rear of the preceding train, there is the potential for the Movement Authority to be regularly updated for a train where the one in advance is moving away from it. This situation could cause the Movement Authority of the train in rear to be frequently updated by only a few meters at a time. To avoid the nuisance to the driver of frequent Movement Authority update, the L3 Trackside is able to limit the updates to those that are meaningful to operation of the railway.

The TIMS refresh rate could have an impact on performance in terms of how often the CRE is updated. This is not only relevant for a quick update of Mas but also to provide a quick release of points or to minimise the areas considered as Unknown after an End of Mission (due to the CRE being located far behind the actual train location)

6.7.2 Requirements

REQ-MA-1

The L3 Trackside shall only issue Movement Authorities to trains which have a valid location.

Rationale:

The L3 Trackside must know the location of trains before it can issue them with a Movement Authority. This requirement is similar to that for a L2 System, however in the case of a L3 System without TTD it is more critical due to the complete reliance on Train Position Reports.

Guidance:

The term valid location is from the L3 Trackside point of view, as defined in section 6.1 Train location.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-MA-2

The L3 Trackside shall be able to issue a Movement Authority for a train up to the next obstruction.

Rationale:

This is to enable the maximum possible Movement Authority to be issued.

Guidance:

A Route must be locked and the area Reserved before the Movement Authority is extended.

The end of the locked Route is an obstruction for all ETCS Level 3 system types. For a Full Moving Block system, the Confirmed Safe Rear End of the preceding train is an obstruction, as given in Figure 34.

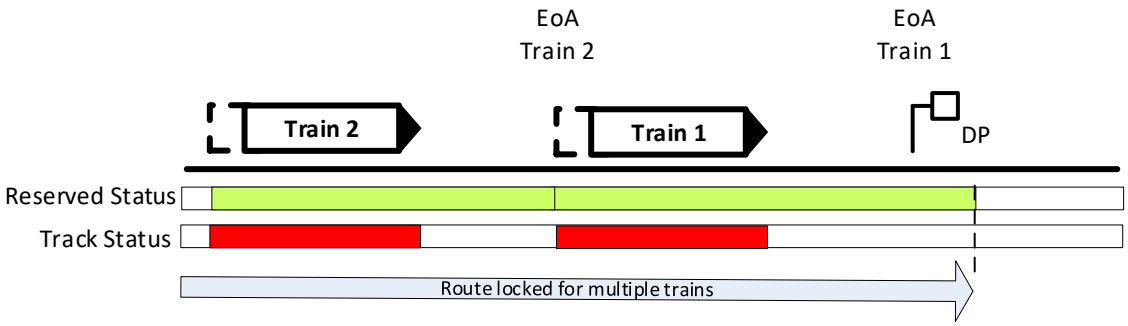

Figure 34: Two trains in the same route (FMB)

For a Fixed Virtual Block system, the rear of the Fixed Virtual Block occupied by the Confirmed Safe Rear End of the preceding train is an obstruction, as given in Figure 35.

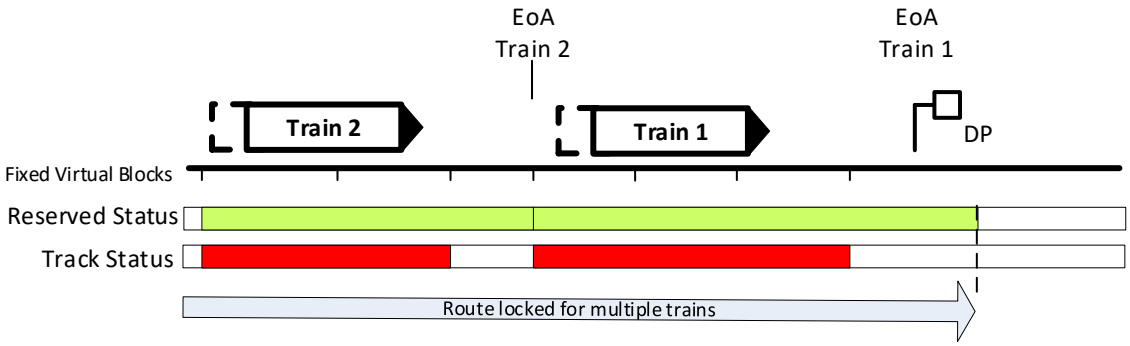

Figure 35: Two trains in the same route (FVB)

The Movement Authority will be subject to Engineering Rules, as in Level 2, and may not necessarily reach the next obstruction.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-MA-3

The L3 Trackside shall be able to issue Movement Authorities with mode profile On Sight over areas of track which have Track Status Unknown or Occupied.

Rationale:

Areas of track with Track Status Unknown may contain railway vehicles or other obstructions, so it is necessary for trains to proceed in On Sight mode.

Areas of track with Track Status Occupied will contain at least one train, so it is necessary for trains to proceed in On Sight mode.

Guidance:

Passage of a train in On Sight mode, over an area of track with Track Status Unknown, results in sweeping the track. The track will become Clear after the passage of a train with Train Integrity confirmed.

Extension of a Movement Authority in On Sight mode over an area of track with Track Status Occupied may be required in order to perform joining of trains.

D5.2 Operational Rules:OPE-OS-4

D5.2 Engineering Rules:None

REQ-MA-4

The L3 Trackside shall be able to issue a FS Movement Authority for a train to enter a route where there is already another train.

Rationale:

This is to allow multiple trains into the same route, thus facilitating railway operation for several trains travelling in the same direction one after another.

Guidance:

The same Route could be requested by the Traffic Management System. Subsequent trains will be allowed to enter the route when conditions are fulfilled and, in this way, follow the train in front in the moment it clears part of the track.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-MA-5

For a system using Trackside Train Detection, the L3 Trackside shall allow multiple trains to enter in the same Trackside Train Detection section.

Rationale:

This is to facilitate railway operation, for example increasing the capacity of the line, or reducing the amount of Trackside Train Detection equipment required for a given capacity.

Guidance:

This requirement applies to both Full Moving Block and Fixed Virtual Block systems.

Figure 36 illustrates this for a system with Fixed Virtual Blocks

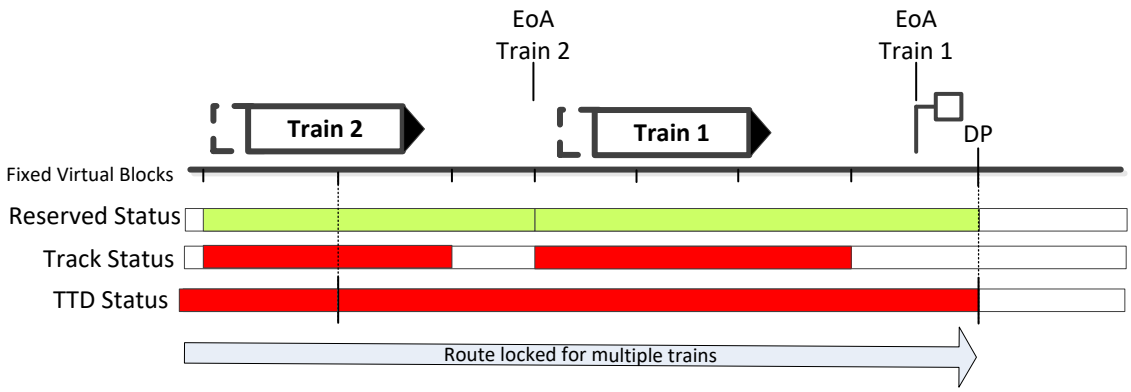

Figure 36: Two trains in the same route (FVB with TTD)

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-MA-6

The L3 Trackside shall be configurable to only issue Movement Authority updates relevant for operation of the railway.

Rationale:

Changes to the Movement Authority issued to a train cause recalculation of the speed supervision on board, and the results are displayed in the planning area. Frequent changes to the Movement Authority can therefore lead to distraction of the Driver. In accordance with 7.4.1.1 of ERA_ERTMS_015560, v3.60 [15560], if the train is in Target Speed Monitoring for the EoA then a sound is played each time the Most Restrictive Displayed Target is updated. The configuration should allow the Infrastructure Manager to prevent changes in the extent/content of Movement Authorities until a period of time has elapsed or the change in the extent of the MA has exceeded the predefined threshold.

Guidance:

A threshold, based on time or distance, could be established such that only MA updates that exceed these limits are issued. The Infrastructure Manager should select the time and distance criteria for sending updates of MA. The distance should be selected to reflect the type of railway and would be shorter for a frequent service. Exceptions to the time and distance selected may be required to allow for short MA extensions to be sent to allow a train to complete a mission.

In implementing such limits on the MA update, it will be important to bear in mind the potential impact this may have on ATO operation (if fitted). Limiting the MA update may result in degrading the service due to suboptimal speed curves being followed. Careful analysis therefore needs to take place to ensure the impact is minimised. An alternative, that would require a change to the current ETCS baseline [BL3 R2], would be to decouple the update of the MA from the alerts that the Driver receives.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-6

REQ-MA-7

The L3 Trackside shall report the Movement Authorities issued to trains to the Traffic Management System.

Rationale:

This is so that the Traffic Management System has information on the Movement Authorities issued.

Guidance:

The report to the TMS will include the complete information about Movement Authorities.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-MA-8

Where possible, the L3 Trackside shall include Linking Information in Movement Authorities issued to trains.

Rationale:

Linking information improves the accuracy of position reports received from a train. Given the reliance on Train Position Reports in ETCS Level 3 Moving Block, it is critical that, where possible, Linking Information is included.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-MA-9

If there is an area of Unknown within a Route set for a train, then the L3 Trackside shall be configured to either:

a) automatically extend a Movement Authority into Unknown areas or
b) require confirmation via the Traffic Management System before extending a Movement Authority into Unknown areas.

Rationale:

A Sweeping train can be automatically authorised by L3 Trackside or after Dispatcher confirmation, depending on specific application requirements.

Guidance:

The portion of the Movement Authority which is over the area of Unknown will have an OS Mode Profile.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-REC-1

6.8 EoA Exclusion area

6.8.1 Introduction

There may be areas of the railway where it is desirable that trains are not stopped by the authorisations from the L3 Trackside.

For example, consider:

- Non-powered sections
- Level crossings
- Some tunnels or viaducts
- Switches.

By default, a Movement Authority can be extended to any location in the railway, and so a mechanism is required to ensure that a Movement Authority is not permitted to extend part way into an area where trains are not to be stopped.

This is called an “End of Authority (EoA) Exclusion Area”. 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.

Note that EoA Exclusion Areas are a separate concept to Non Stopping Areas as already defined in the ETCS specifications (SUBSET 026 3.12.1.3 [BL3 R2]). Non Stopping Areas are a type of track condition and, once transmitted to the ETCS On-Board, are handled by the train. By contrast, an EoA Exclusion area is a L3 Trackside concept and the train will not be aware of it being imposed.

It may be beneficial to define concurrent Non Stopping Areas so that the ETCS On-can display the Non-Stopping areas to the Driver. The End of Authority Exclusion Area is then used by the L3 Trackside to ensure that any MA issued permits the train to proceed beyond the area, and the Non-Stopping area is used by the On-Board on the display to the Driver.

6.8.2 Requirements

REQ-EoAExclusionArea-1

The L3 Trackside shall be able to use End of Authority Exclusion areas defined in configuration data.

Rationale:

This is to avoid blocking points or level crossings with a train at standstill, preventing electric trains from stopping at powerless sections and any other operational issues resulting from stopping the train in certain areas of the track.

Guidance:

EoA Exclusion Areas needs to be configured depending on the scenario. In addition, EoA Exclusion Areas could impact the performance of the line by over impeding the update of Movement Authorities and hence, at its extreme, impacting the service headway. Therefore, detailed analysis is required when configuring these areas.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-2

REQ-EoAExclusionArea-2

For a train approaching an EoA Exclusion Area, the L3 Trackside shall only issue an MA such that the train can proceed beyond the EoA Exclusion Area and stop with its rear end clear of the area, taking into account the length of the train and any Safety Margin.

Rationale:

This is to avoid the train having an MA finishing with any part of the train in an EoA Exclusion area.

Guidance:

With ETCS Level 3 Full Moving Block, the L3 Trackside can potentially issue a Movement Authority to any location on the track. At certain locations it may not be suitable for a train to stop here. EoA Exclusion areas enable these areas to be defined in the L3 Trackside and managed so that no part of a train stops in the area. Examples of where these areas may be defined are:

a) Tunnels and viaducts

b) Powerless sections

c) Switches and Crossings (in particular at entry/exit of a station).

Figure 37 illustrates an example of an EoA Exclusion Area in operation.

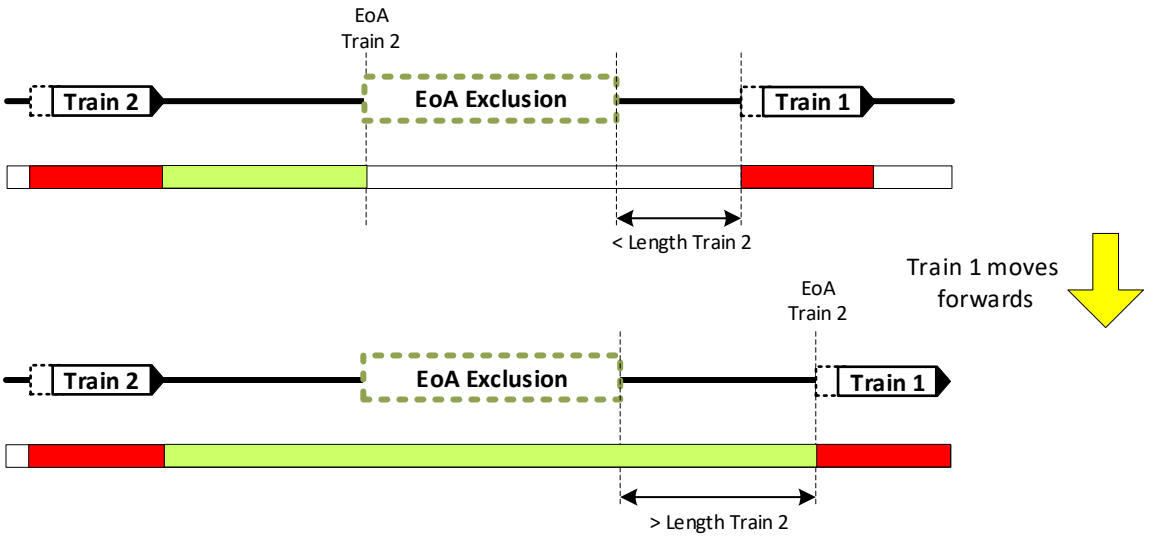

Figure 37: Example of an EoA Exclusion Area

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.9 Start of Train

6.9.1 Introduction

The Start of Mission for a train in the L3 Area is similar to the procedure for a L2 area. However, there are differences due to trains only being detected when they send position reports.

When a train establishes a communication session with the L3 Trackside in the L3 Area, the L3 Trackside compares the information from the train to its history of that location of the track. If the received data matches that which has been previously stored, and the data stored is still valid, the L3 Trackside will decide that the train is the same and the previously Unknown part of track is changed to Occupied.

If the received data does not match, then only that part of the track corresponding to the newly received train data will become Occupied, and any remaining areas of track with status Unknown will remain with status Unknown.

The efficiency of Start of Mission of a train which has entered 'No Power' mode within the area of control can be increased by using Cold Movement Detection.

The L3 Trackside must be able to manage trains that are reporting Unknown or Invalid position during the Start of Mission.

6.9.2 Requirements

REQ-StartTrain-1

The L3 Trackside shall always accept a train during Start of Mission.

Rationale:

Regardless of if a train has an invalid/unknown position, the L3 Trackside shall accept and maintain a connection. For a train reporting a valid position, the L3 Trackside can determine whether or not this is within the Area of Control of the L3 Trackside. This requirement is to avoid hazards such as having a ghost train moving in the L3 area.

Guidance:

It could be configured to eventually disconnect the train after a timeout. Alternatively, the TMS could request the L3 Trackside to disconnect the communication if the train is not within its area of control.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-StartTrain-2

The L3 Trackside shall maintain the communication session with a train that was last known to be located inside the L3 area and reported a position from a LRBG which is not known to the L3 Trackside until it is determined by the L3 Trackside that it is safe to disconnect the train.

Rationale:

This is to avoid the hazard of having a ghost train moving on the tracks. This could occur during a Level Transition out of the L3 Area or a Handover when the train reports a position from an unknown LRBG but the CRE is still inside the L3 area or the Handing Over L3 Trackside area.

Guidance:

Having enough Balise Groups known by L3 Trackside in these areas could mitigate the issue. Furthermore, the presence of TTD at the L3 Area boundary could be used as a mitigation. If the problem persists, each specific application has to decide when it is considered safe to disconnect the train taking into account the possible Unknown area that has to be established.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-StartTrain-3 [REQ-StartTrain-124]

The L3 Trackside shall alert the TMS of a train that is reporting an invalid or unknown position.

Rationale:

A train reporting an invalid or unknown location may need to be located manually by the Traffic Management System. As such it needs to be made aware of this.

Guidance:

If the L3 Trackside is able to locate the train by some other means, then the TMS will not need to be notified.

D5.2 Operational Rules:OPE-StartTrain-4; OPE-Generic-3

D5.2 Engineering Rules:None

REQ-StartTrain-4

The L3 Trackside shall be able to accept from the TMS a location for a train which is reporting an invalid or unknown position.

Rationale:

This is to allow the TMS to locate the train on the track when the train location is otherwise not available.

Guidance:

The TMS will need to be able to provide the Dispatcher with facilities to enter the location of a train which is reporting an invalid or unknown position. This could be done by assigning a position for the front or rear end of the train. The estimate location entered would need to include additional margins for safety at the front and rear.

The area of track occupied by the train location defined by the TMS will have Track Status Unknown. For a system with TTD, this may help the system locate the train.

D5.2 Operational Rules:OPE-StartTrain-5

D5.2 Engineering Rules:None

REQ-StartTrain-5

The L3 Trackside shall compare the new train location information reported by a train performing Start of Mission against the information stored for the same location for a previous train.

Rationale:

This is to determine whether the train performing Start of Mission is the same train which performed End of Mission, and if so, whether the train has moved since it reported End of Mission.

Guidance:

The mechanism should be designed so that comparison when a train has changed direction results in a match, so long as the length is matched.

The reactions to the result of this comparison are specified in the next requirements.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-StartTrain-6

If the L3 Trackside determines that the first train position report received containing confirmation of train integrity, from a train performing Start of Mission, matches a train which performed End of Mission at that location, then the L3 Trackside shall remove the Unknown area of track corresponding to the train when it performed End of Mission, and the area of track corresponding to the new train location becomes Occupied.

Rationale:

This enables the L3 Trackside to replace the Unknown area from End of Mission with an Occupied area after Start of Mission.

Guidance:

The Start of Mission train position report will not include confirmation of train integrity and, depending on the onboard systems, it may take several position reports before one is received containing confirmation of train integrity. Until such time the Train Location will be considered Unknown.

Figure 38 below shows an example where the train location information matches, and the area of Unknown is completely removed as a result.

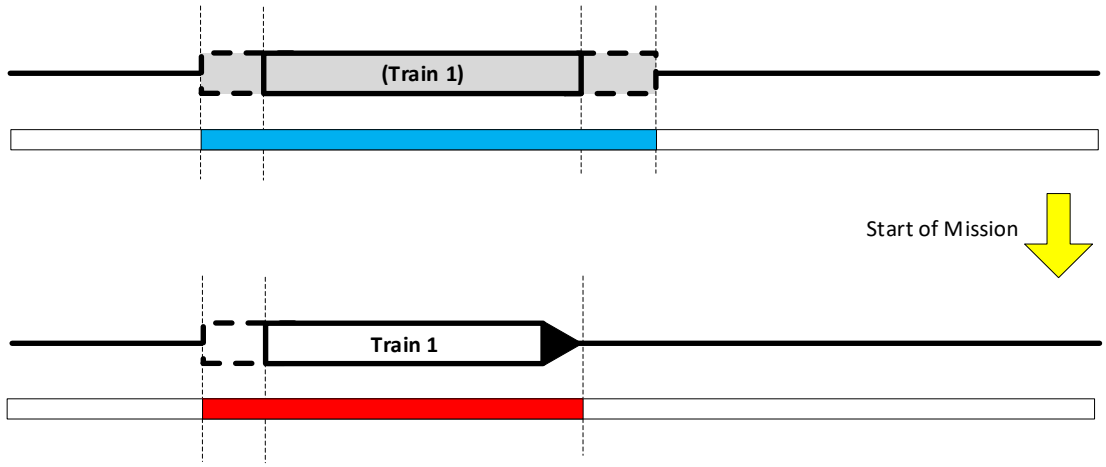

Figure 38: Start of Mission with matching Train Location

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-StartTrain-7

If the L3 Trackside determines that the train location information from a train performing Start of Mission does not match a train which performed End of Mission, then the L3 Trackside shall retain the Unknown area of track corresponding to the train when it performed End of Mission, and the area of track corresponding to the new train location becomes Occupied.

Rationale:

This is to ensure that any areas where there are remaining railway vehicles are protected by an area of track with status Unknown.

Guidance:

Figure 39 below shows an example where the train location information does not match, and the area of Unknown is retained, except where it becomes Occupied.

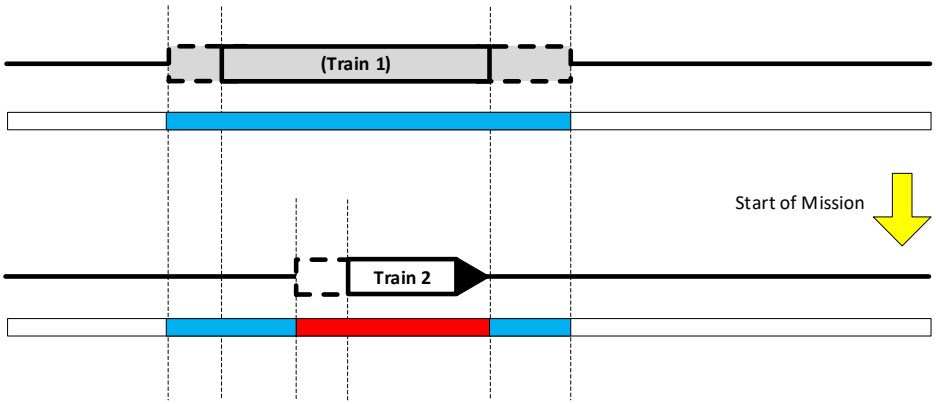

Figure 39: Start of Mission with Train Location which does not match

It is possible that the new area of track which becomes Occupied can completely remove the area of Unknown.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-StartTrain-8

If a train reports a position that is unexpected or in conflict with other train movements, the L3 Trackside shall react to transition the system to a safe state.

Rationale:

There are several scenarios where a position report from a train may require urgent action from the L3 Trackside in order to avoid a hazard:

- A train performing Start of Mission in an area previously considered clear
- A train reporting a position in a location with status Reserved for another train.

Guidance:

The specific reaction applied will depend on the scenario and application specific requirements. Possible reactions include: shortening of the Movement Authority for another train, sending an Unconditional Emergency Stop to one or multiples trains etc.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.10SR Movement

6.10.1 Introduction

Staff Responsible (SR) mode is the primary means of moving non-communicating trains or communicating trains without a valid location. Authorisation to move in SR mode must therefore follow a defined procedure which is out of the scope of this document.

The Use of Staff Responsible can be categorised into three scenarios:

1) **Train without connection to the L3 Trackside:** In this scenario, the Driver must use the Override function to enter SR, as it cannot be authorised by the L3 Trackside. The Dispatcher may be able to establish an approximate location for the train from the Driver and create an Unknown area to protect the train and its subsequent movement. No additional functionality is required from the L3 Trackside.
2) **Train has a connection to the L3 Trackside but cannot be located due to invalid/unknown position**: In this scenario, the Dispatcher must enter an estimate for the train location to the L3 Trackside and protect the path the train will take with an Unknown area. The L3 Trackside can then authorise the train for movement in SR with an SR distance to the end of the Unknown area. The objective of this operation is to permit the train to move such that it can establish a valid location.

3) **Train has a connection to the L3 Trackside and can be located, but it is not possible to issue an MA**: In this scenario, the L3 Trackside can calculate the SR distance and a list of Balises that can be passed before authorising the train for movement in SR.

In the third scenario, there is the possibility that the L3 Trackside is still not able to authorise SR movement (due to an obstruction for example). In this case, the driver must still use the override functionality following operational procedures.

6.10.2 Requirements

REQ-MovSR-1

For a train without a valid location, the L3 Trackside shall be able to provide SR Authorisation to a train, based on the approximate location of the train, and the extent of an Unknown area created by the TMS.

Rationale:

This is to enable a train to be moved to a location where it can establish a valid location.

Guidance:

The SR Authorisation will be from the approximate location of the train entered by the Dispatcher.

A possible sequence is:

a) The Dispatcher enters an approximate location via the TMS for a train without a valid location

b) The TMS creates an Unknown area from the location of the train to a location in the track where it will be possible for the train to establish a valid location

c) The L3 Trackside provides SR Authorisation to the train, in accordance with this requirement

d) The train moves in SR mode until it reaches a location where it is able to establish a valid location

D5.2 Operational Rules: OPE-StartTrain-3, OPE-StartTrain-4, OPE-StartTrain-5

D5.2 Engineering Rules:None

REQ-MovSR-2

For a train with a valid location, the L3 Trackside shall be able to provide SR Authorisation to a train, based on the location of the train, and an area Reserved for the train.

Rationale:

This is to enable a train to be moved to a location where it can be issued with a Movement Authority.

Guidance:

The SR Authorisation will start from the reported train location.

A possible sequence is:

a) The L3 Trackside Reserves the area ahead of the train, up to a location where the train will be able to receive a Movement Authority.

b) The L3 Trackside provides SR Authorisation to the train, in accordance with this requirement

c) The train moves in SR mode until it reaches a location where it can be given a Movement Authority.

In some situations, the L3 Trackside may be unable to provide the authority for SR Movement. In this scenario, the Driver would have to use the Override functionality.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-MovSR-3

For a train with a valid location, the L3 Trackside shall maintain the previous CSRE of a train in SR mode from when the train reports in SR until the train transitions out of SR to FS/OS mode and reports with Train Integrity confirmed.

Rationale:

When the train is in SR mode, Balise Linking information is not available. As a result, the CSRE is not updated until the train transitions to FS.

There is a risk that the CSRE is updated incorrectly due to the train relocation function.

Guidance:

For trains with a valid location, but which have not confirmed train integrity, there will be no CSRE. In this case the Track Status will be Unknown, and the previous boundary of the Unknown area should be maintained, as described by the functionality in section 6.18 Loss of Train Integrity.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.11First MA

6.11.1 Introduction

This section includes requirements which are specific to the first Movement Authority issued to a train after Start of Mission.

6.11.2 Requirements

REQ-FirstMA-1

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.

Rationale:

The first FS Movement Authority can be sent with the train located anywhere in the line since L3 Trackside knows the Track Status of the Area of Control.

Guidance:

The conditions for sending a Movement Authority are defined in section 6.7.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-FirstMA-2

The L3 Trackside shall be able to, if configured, provide the first MA for a train even if there is no integrity information or the integrity is confirmed by driver.

Rationale:

This is to enable trains without integrity to still be moved under the supervision of ETCS. This may be to move them into a siding so that the impact to operations is minimised. However, this could have impact on a following train in case integrity remains unconfirmed.

Guidance:

The Infrastructure Manager may wish to configure the L3 Trackside such that the Traffic Management System must first authorise the Movement Authority, having been notified of the train requesting a Movement Authority without confirmation of train integrity.

Confirmation may also be required if the train integrity is confirmed by the Driver, rather than by TIMS.

D5.2 Operational Rules:OPE-REC-1

D5.2 Engineering Rules:ENG-StartTrain1; ENG-LossTI-3; ENG-LossTI-4

6.12Loss of Communication

6.12.1 Introduction

Following Loss of Communications, the area of track in front of the train is considered unknown, as the train may be anywhere between the last Confirmed Safe Rear End of the train and the most recent End of Authority.

If the communication session is restored, then the track status will be recovered, after checks that the new communications are for the same train, same length – as explained in section 6.9.

If the communication session is not restored, or communication is restored but the train is not recognised as the same train, then the track will remain unknown, and it will need to be cleared by some other method.

6.12.2 Requirements

REQ-LossComms-1

The L3 Trackside shall be able to define a configurable time (mute timer) after which it will consider the communication with the train as lost.

Rationale:

This is to enable the L3 Trackside to react faster to the potential loss of communication with an ETCS On-board than the timeout in the ETCS specifications. The ETCS specification timer of 5 minutes might be considered too long for some ETCS Level 3 Moving Block systems.

Guidance:

This is an optional functionality to be defined at application level based on the needs of the system. T_NVCONTACT plus a margin could be considered as a value for guidance.

The starting condition for the configurable timer is the reception of every application message and ending condition is the disconnection of the train or the reception of a new message from this train.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LossComms-1

REQ-LossComms-2

The L3 Trackside will maintain the communication session with ETCS On-board as active even when the mute timer has expired until the maximum time to maintain a communication session as specified in SUBSET-026 [BL3 R2] has elapsed.

Rationale:

Between the expiry of the Mute timer and the expiry of the session timer, the L3 Trackside will treat the train as having lost communications. However, it will maintain the session during this period in case the train regains communications.

Guidance:

This requirement is already part of the ETCS specifications [BL3 R2]. However, it important to reiterate this behaviour of the L3 Trackside due to the new Mute timer functionality introduced.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossComms-3

When the mute timer expires, the L3 Trackside shall set the Track Status Unknown for the area from the CSRE until the end of the area Reserved for that train.

Rationale:

This is the area where the non-communicating train could be located, and as such needs to be protected.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossComms-4

If the Mute timer is not considered for use on a particular application, the L3 Trackside shall react when the session timer expires by setting the Track Status Unknown for the area from the CSRE until the end of the area Reserved for that train.

Rationale:

This is so that, even for applications not utilising the mute timer functionality, the Trackside is protected when communications with a train expire according to the existing session expiry timer in the ETCS specifications [BL3 R2].

Guidance:

Whether or not to use the Mute timer will depend on whether it is required to detect loss of communications before expiry of the session timer. This in turn will depend on traffic density and the typical speed of trains.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.13Movement of a non-communicating train

6.13.1 Introduction

In order to move a train with failed communications, the path through which the affected train will move must be protected for that train by the Traffic Management System.

Section 6.2 Track Status contains requirements that enable the Traffic Management System to be able to create areas of track with Track Status Unknown.

The train can then be moved by manual procedures, for example using Override.

6.13.2 Requirements

None additional to a Level 2 system.

6.14Recovery management after loss of communication

6.14.1 Introduction

Fast recovery of the railway state after a train has lost communication is key to ensuring availability of the ETCS Level 3 Moving Block system. After a train reconnects following loss of communications, the track state can be recovered from Unknown to enable continuation of normal railway operation. The use of stored information can enable track previously considered 'Unknown' to be cleared.

The method based on stored information depends upon the train reconnecting being recognised as identical to the one that originally lost communications.

In recovery from a loss of communications two scenarios can occur:

- reconnection within the same session
- reconnection after session expiry.

Reconnection after session expiry is in principle the same as a train performing Start of Mission (described in section 6.9 Start of Train). However, the L3 Trackside considers this scenario differently due to the following:

- The Unknown area could be large, as it extends from the previous CSRE to the End of Authority
- The session expired rather than being terminated.

If the train reconnecting cannot be confirmed as the same train as the one that lost communications, for example due to a difference in the train data, then the track must be recovered using different procedures, such as running a train in On Sight to sweep the Unknown area.

6.14.2 Requirements

REQ-RecoveryMgmt-1

The L3 Trackside shall consider a train which starts communicating with the L3 Trackside within the same communications session as previously used for the train as the same train, so long as no change in train data has occurred.

Rationale:

The L3 Trackside is certain that this is the same train, as it is using the same communication session. The affected area can be normalised and the train can continue to run – facilitating a quick recovery.

Guidance:

This situation will occur after expiry of the mute timer in REQ-LossComms-1, but before expiry of the communications session.

The changes in Track Status following recovery of communications are provided in requirements REQ-RecoveryMgmt-3 and REQ-RecoveryMgmt-4 below.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-RecoveryMgmt-2

The L3 Trackside shall consider a train reconnecting with a new communications session as the same train as before losing communications after passing the following checks:

a) the train has the same ID (NID_ENGINE) AND

b) the train is the same length (L_TRAIN).

Rationale:

If the L3 Trackside is certain that this is the same train, the affected area can be normalised and the train can continue to run – facilitating a quick recovery.

Guidance:

This situation will occur after expiry of the session timer referred to in REQ-LossComms-2, or if the ETCS Onboard closes the connection and redials the L3 Trackside.

This situation is similar to Start of Train.

The changes in Track Status following recovery of communications are provided in requirements REQ-RecoveryMgmt-3 and REQ-RecoveryMgmt-4 below.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-RecoveryMgmt-3

If the L3 Trackside establishes that the same train has reconnected, the L3 Trackside shall change the parts of the Unknown area of track now known not to be occupied by the train to Clear.

Rationale:

If the L3 Trackside is certain that this is the same train, the train location can be established based on train position information and the rest of the affected Unknown area can be cleared.

Guidance:

It can be assumed that it is the same train if the train continues to report train integrity confirmed, because the solution to Change Request 940 [CR940] ensures that train integrity reporting can only be done if the train data has been acknowledged. If the train is still reporting integrity confirmed, and train data has not been revalidated, then no change of train length has occurred.

Figure 40 highlights the areas of track that will transition Unknown to Clear.

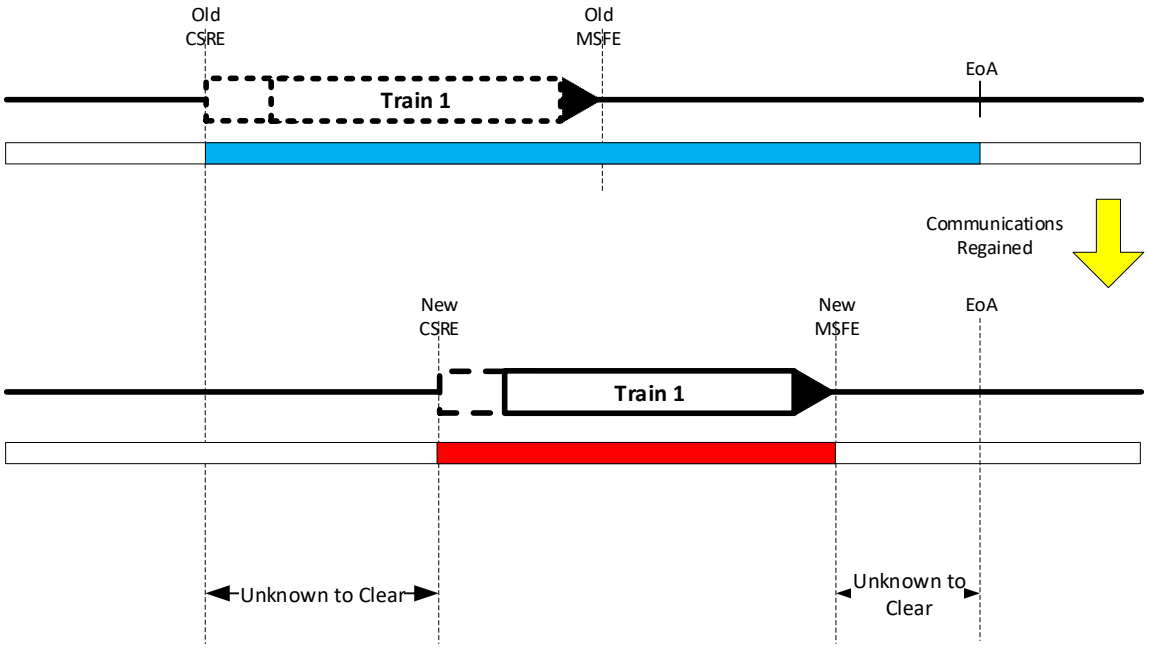

Figure 40: Unknown to Clear Transition following reconnection of communications

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-RecoveryMgmt-4

If the L3 Trackside establishes that the same train has reconnected, the L3 Trackside shall change the parts of the Unknown area of track now known to be occupied by the train to Occupied.

Rationale:

If the L3 Trackside is certain that this is the same train, the train location can be established based on train position information.

Guidance:

It can be assumed that it is the same train if the train continues to report train integrity, because Change Request 940 [CR940] ensures that train integrity reporting can only be done if the train data has been acknowledged. If the train is still reporting integrity, and train data has not been revalidated, then no change of train length has occurred.

Figure 41 highlights the areas of track that will transition Unknown to Occupied when the conditions in the requirement are met.

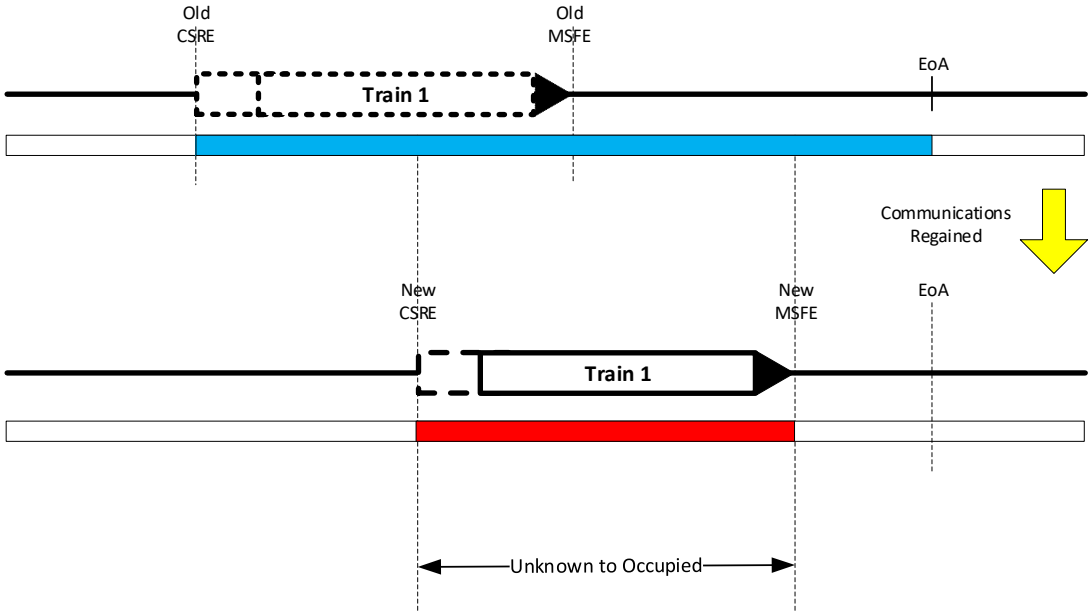

Figure 41: Unknown to Occupied Transition following reconnection of communications

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.15Radio Hole

6.15.1 Introduction

Due to the reliance on radio communication, the L3 Trackside must manage the issue of Radio Holes in a safe manner. The lack of TTD requires additional system functionality over that defined at ETCS L2.

The L3 Trackside can handle two types of Radio Hole:

a) Static: present in the communications system since the L3 trackside was commissioned

b) Dynamic: occur after the L3 Trackside is commissioned. These may be transient or become permanent.

Dynamic Radio Holes are predefined in the L3 Trackside when the system is commissioned, according to the location of radio transmitters and their coverage of the railway. They are then activated or deactivated by the TMS when a failure of the radio network infrastructure occurs.

To manage a Radio Hole, the L3 Trackside has two key functionalities:

a) An End of Authority Exclusion Area will be defined such that a train cannot obtain an EoA within the Radio Hole

b) The L3 Trackside will store information regarding when a train enters a Radio Hole, and alert the Traffic Management System if, after a pre-set timer has expired, the train has not reported clear of the area.

The concept of Radio Holes is already present in the existing ETCS specifications as a type of track condition transmitted to the ETCS On-board from the Trackside. It is expected that this functionality is implemented in parallel to the L3 Trackside functionality described here.

6.15.2 Requirements

REQ-RadioHole-1

The L3 Trackside shall provide a means for the TMS to activate or deactivate predefined dynamic Radio Holes.

Rationale:

Since this is a temporary issue, the trigger to activate the dynamic Radio Hole has to come from the Traffic Management System.

Guidance:

This is an optional requirement. Dynamic Radio Holes are predefined in the L3 Trackside, ready for activation by the TMS if required.

D5.2 Operational Rules:OPE-LossComms-2

D5.2 Engineering Rules:ENG-LossComms-3

REQ-RadioHole-2

The L3 Trackside shall establish an End of Authority Exclusion Area for each Radio Hole.

Rationale:

To avoid a train reaching an End of Authority in a Radio Hole and not being able to proceed (except in SR).

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-RadioHole-3

The L3 Trackside shall establish a timeout for how long a train should need to pass a Radio Hole under normal operation.

Rationale:

This is to monitor trains that have entered a Radio Hole and alert the dispatcher if they do not emerge from them.

Guidance:

A timer could be used, configured according to the line speed, train characteristics, and the length of the Radio Hole. The timer could have a special value to disable the function.

Other timers, such as the mute timer, may have to be suppressed when the train is in the Radio Hole, so as not to trigger other degraded procedures.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LossComms-2

REQ-RadioHole-4

Upon expiry of the Radio Hole timer, the L3 Trackside shall treat the train the same as for loss of communications.

Rationale:

This is because there could be a train unable to contact the L3 Trackside to proceed with its movement: either because it has suffered a failure within the Radio Hole, or it has failed to reconnect upon exiting the Radio Hole.

Guidance:

Figure 42 below shows the area of track which changes to Unknown after expiry of a Radio Hole Timer.

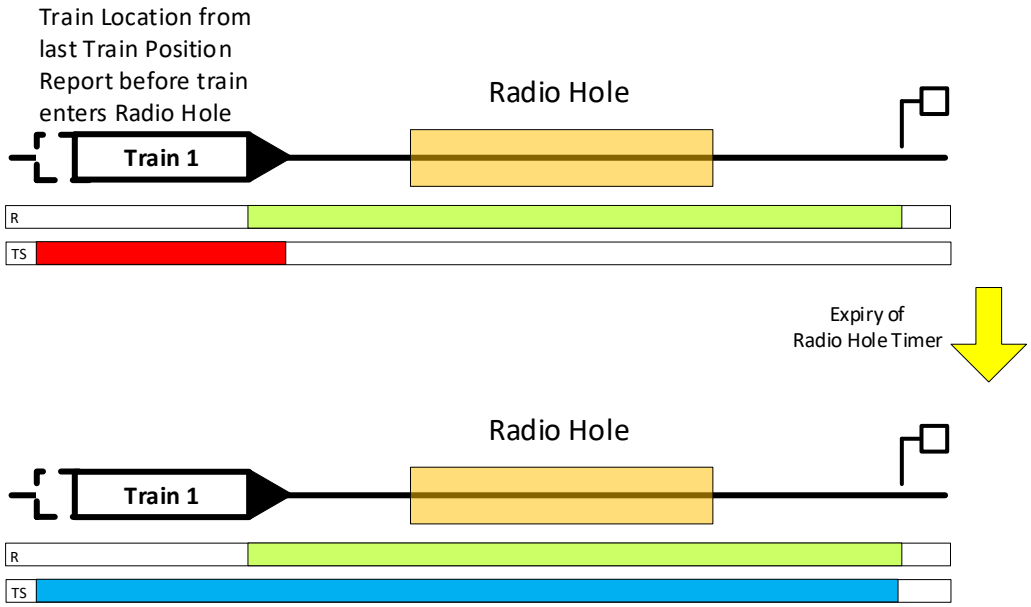

Figure 42: Unknown area after expiry of Radio Hole Timer

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-RadioHole-5

Upon expiry of the Radio Hole timer, the L3 Trackside shall inform the TMS that a train has not emerged from a Radio Hole.

Rationale:

This is because there could be a train unable to contact the L3 Trackside to proceed with its movement: either because it has suffered a failure within the Radio Hole, or it has failed to reconnect upon exiting the Radio Hole.

Guidance:

Alternatively, operational procedures can be defined based on an application specific solution or use TTD at the borders of the static Radio Hole area.

D5.2 Operational Rules:OPE-LossComms-4

D5.2 Engineering Rules:None

6.16Reverse movement

6.16.1 Introduction

Due to the fact that Movement Authorities can be issued up to the rear of a preceding train, reversing in L3 needs additional consideration. Prior to a train being authorised to commence a reversing manoeuvre, the L3 Trackside shall ensure the area in rear of the train is Reserved, to avoid it being authorised for use by another train.

This section covers movements in RV mode, in PT mode and rollaway movements.

6.16.2 Requirements

REQ-Rev-1

When a train has been given Reversing Area information, the L3 Trackside shall prevent authorising other trains into the area where the train may reverse.

Rationale:

This is to avoid sending a Movement Authority into an area where a train has already been authorised to reverse.

Guidance:

This can be achieved by keeping the track in rear of the reversing area Reserved until the train has passed the end of the reversing area. Figure 43 illustrates the extent of the Reserved area, including the Reversing area, Reversing distance and an additional Margin. This Margin considers the length of the train permitted to reverse and an estimated distance for the train to brake to stop if overpassing the permitted reversing distance.

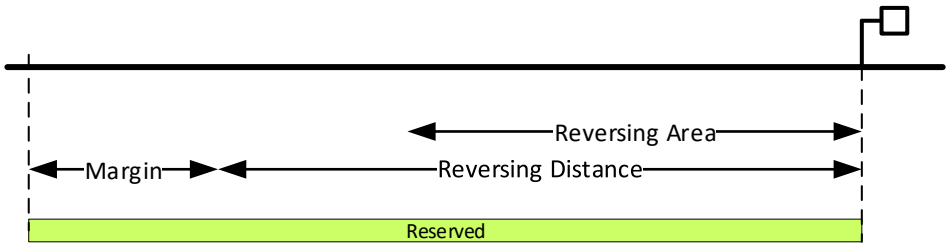

Figure 43: Reserved area in rear of a Reversing Area

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-Rev-2

The L3 Trackside shall only extend the permission to reverse (by increasing the Reversing Distance) when the extension is already covered by the Reserved area in rear of the train.

Rationale:

This is to avoid unforeseen impact on other movements.

Guidance:

The L3 Trackside may decide to only give the first part of the possible Reversing Distance and extend it later, if needed. However, if the full Reversing Distance was not reserved at first, then it is not possible to extend it unless also this part is Reserved.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-Rev-3

When a train has proceeded beyond the Reversing Area, the L3 Trackside shall release the Reserved area behind the train.

Rationale:

This is to release this part of the railway for other train movements.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.17End of Mission

6.17.1 Introduction

The L3 Trackside will need to store the train location when a train performs End of Mission, as defined in section 6.1.

The purpose of storing this information is to permit matching when the train next performs a Start of Mission, thus enabling the Track Status to be changed from Unknown to Occupied.

Lack of train integrity information has a significant impact on the performance of the line during End of Mission. It is important that the L3 Trackside receives a recent Train Position Report with the Integrity Confirmed just prior to End of Mission. If this does not occur, then there is the potential for a large area of the railway remaining unavailable, due to the CRE being a large

distance in rear of the train. This could have significant operational impact if the CRE remains over points and crossings.

6.17.2 Requirements

REQ-EoM-1

The L3 Trackside shall update the stored information of the train performing the EoM.

Rationale:

This is to provide a quick recovery of the system when the train performs a SoM again.

Guidance:

See sections 6.1 (REQ-TrainLoc-9) and 6.2 (REQ-TrackStatus-13) for the information stored.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-EoM-2

The L3 Trackside shall consider as Unknown the location of a train that reports EoM.

Rationale:

The L3 Trackside needs to protect the area occupied by the train after EoM.

Guidance:

For a train that was reporting integrity confirmed, the area of Unknown will be from the CSRE to the Max Safe Front End.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-EoM-3

The L3 Trackside shall add a Safety Margin ahead of a train that has performed EoM and consider this area of the track Unknown.

Rationale:

This is to protect a stationary train from potential collision, as well as guarding other train movements from a potential rollaway situation.

Guidance:

The factors considered in the calculation of this safety margin are application specific.

A margin based on the value of D_NVROLL and including the distance required for a train to come to a stand when Standstill Protection is activated should be considered.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-6

REQ-EoM-4

The L3 Trackside shall recalculate the Safety Margin in rear of a train that has performed EoM and consider this area of track Unknown.

Rationale:

This is to protect a stationary train from potential collision, as well as guarding other train movements from a potential rollaway situation. Upon performing EoM, some of the train parameters may have changed and so the Safety Margin needs to be updated.

Guidance:

The length of the Safety Margin should not cause an adverse change to the rear of the Train Location which could cause the Movement Authority of a following train to be changed.

A margin based on the value of D_NVROLL and including the distance required for a train to come to a stand when Standstill Protection is activated should be considered.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-Generic-6

REQ-EoM-5

The L3 Trackside shall remove any Reserved area of track for a train that has performed EoM.

Rationale:

After performing EoM, the train is no longer authorised to move, and so it is no longer necessary to reserve track for the train to move.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-EoM-6

The L3 Trackside shall be able to cope with differences in the confidence interval provided in the position report of a train that reported EoM even when related to the same train position.

Rationale:

This is due to an ambiguity in the ETCS specifications around how to calculate the train location accuracy when linking information is deleted due to the change to SB mode. This issue is currently subject of a CR in the ERA CCM Process [CRProcess]. As long as the CR is not solved, both behaviours described in the CR (recalculate or not the confidence interval) could be expected. Even if the CR is solved, the ambiguity already exists in the current specifications. Therefore, the L3 trackside shall be able to deal with On-boards regardless of how they solve the issue.

Guidance:

The L3 Trackside will not apply a safe reaction if a train reports a different confidence interval without the train moving (Different L_DOUBTOVER and L_DOUBTUNDER with the same D_LRBG and LRBG). It is also recommended not to update the train location when the confidence interval changes for the reasons mentioned above.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.18Loss of Train Integrity

6.18.1 Introduction

Following Loss of Train Integrity by a train, the area of track from the Max Safe Front End of the train to the last Confirmed Safe Rear End of the train will change to Unknown.

If Train Integrity is restored, then the track previously Unknown becomes Clear up to the new Confirmed Safe Rear End if the train length is unchanged, and there is no other obstruction.

If Train Integrity is not restored, then the track will be maintained as Unknown, and it will need to be cleared by some other method.

6.18.2 Requirements

REQ-LossTI-1

When receiving loss of train integrity information from the ETCS On-board, the L3 Trackside shall maintain the Confirmed Rear End (CRE) at the last known location at which the train reported Integrity Confirmed, and the associated Confirmed Safe Rear End (CSRE).

Rationale:

To maintain a safe train location when there is a loss of integrity. The Safety margin must be maintained, as there is the chance that there is a wagon located with its rear end at the CRE.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossTI-2

At the time that loss of Integrity is reported, the L3 Trackside shall consider as Unknown the area from the Confirmed Safe Rear End (CSRE) until the Max Safe Front End of the train.

Rationale:

This is to protect the rear end of the train and other trains from collision. Once the Unknown area is established, recovery mechanisms can be applied such as sweeping etc.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossTI-3

For a train that has never confirmed integrity, the L3 Trackside shall consider as Unknown the area from the last rear end boundary until the Max Safe Front End of the train.

Rationale:

This is to protect the rear end of the train and ensure there are no collisions in the L3 area.

Guidance:

For a train that has never confirmed integrity since arriving in the L3 Area, the rear of this Unknown area will be at the boundary where the train entered. This is because the train has never had a Confirmed Rear End in the L3 area.

For a train which has operated with integrity confirmed but has not confirmed integrity since performing SoM in the L3 Area, the Unknown area will start at the boundary of the Unknown area created when the train performed EoM.

For a system using Trackside Train Detection, the Unknown area will start at the boundary of a TTD section which has been cleared by the train.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossTI-4

The L3 Trackside shall have a configurable reaction to a reported loss of train integrity based on application specific requirements.

Rationale:

Loss of Integrity is a degraded mode of operation that the L3 Trackside must protect and attempt to recover from. As such, it will be beneficial to have a standard reaction to a report of Loss of Integrity configured for a particular L3 Trackside.

Guidance:

The reaction taken by the L3 Trackside will depend on application specific requirements. Possible reactions could include:

- Trip the Train
- The Safety Margin may be recalculated
- The Movement Authority may be shortened/updated
- Allow train to run to the end of the MA.

Note that the first option (tripping the train) could result in a Hazard whereby if a train is tripped in a Reversing Area it would be unable to reverse.

In addition to a configurable reaction for the L3 Trackside, a reaction for the ETCS On-Board could also be configured. This reaction could be managed using National Values in the same way as supervision of safe radio connections. This function would require a change to current ETCS specifications. See section 7.5 for further details.

In most cases, when train integrity is lost, the rolling stock will apply the brakes.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LossTI-5

REQ-LossTI-5

The L3 Trackside shall be able to consider the train integrity as lost when 'No integrity info' is reported longer than a configurable time.

Rationale:

This is to implement a reaction in case 'No integrity info' is reported for a long period of time.

Guidance:

The timer shall be reset upon receipt of Train Position report with "Train Integrity Confirmed".

Once a Train is considered 'Integrity Lost' by the L3 Trackside, the mechanism in REQ-LosTI-2 and RE-LossTI-4 is applied.

It is application specific whether to implement this function. The timer will have a special value that means the function is disabled.

Note that in this situation, the Driver will not be aware of the train being treated as "Integrity Lost" by the L3 Trackside and as such cannot be expected to react in any manner.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LossTI-1

REQ-LossTI-6

If, after reporting loss of train integrity, the ETCS On-board reports integrity confirmed again, the L3 Trackside shall change the state of the areas between the old CSRE and New CSRE with state Unknown to Clear if:

- the L3 Trackside is able to locate the train unambiguously, and
- no other obstacle has entered the Unknown area since train integrity was lost.

Rationale:

This is to provide a fast recovery after losing integrity.

Guidance:

This could apply if there was no real loss of train integrity, but a failure of the Train Integrity Monitoring System.

This could also apply if it has been possible to re-couple the lost vehicle.

If a train is using the same communications session as when train integrity was lost, then the L3 Trackside can assume it is the same train.

If the train is using a new communications session, to ensure it is the same train that has recovered the L3 Trackside must perform a series of checks on the data received from the train. These checks include comparing Train length (L_TRAIN), Train Location.

Figure 44 shows the area of track which transitions Unknown to Clear when the conditions in the requirement are met.

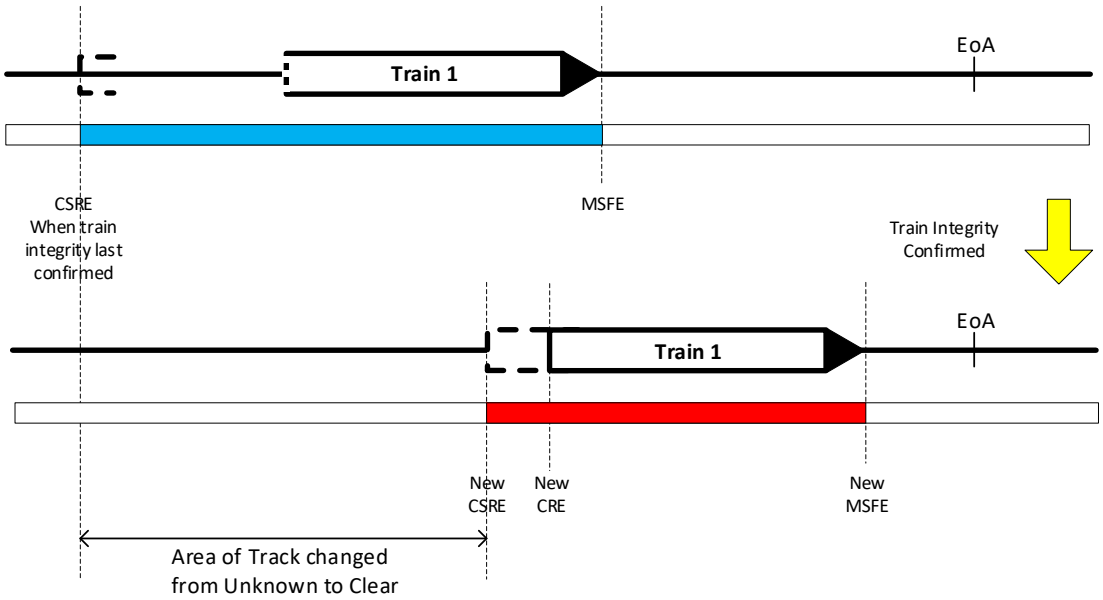

Figure 44: Unknown to Clear Transition following regaining train integrity

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossTI-7

If, after reporting loss of train integrity, the ETCS On-board reports integrity confirmed again, the L3 Trackside shall change the state of the areas between the New CSRE and old MSFE with state Unknown to Occupied if:

- the L3 Trackside is able to locate the train unambiguously, and
- no other obstacle has entered the Unknown area since train integrity was lost.

Rationale:

This is to provide a fast recovery after losing integrity.

Guidance:

This could apply if there was no real loss of train integrity, but a failure of the Train Integrity Monitoring System.

This could also apply if it has been possible to re-couple the lost vehicle.

To ensure it is the same train that has recovered the L3 Trackside must perform a series of checks on the data received from the train. These checks include comparing Train length (L_TRAIN), Train Location.

Figure 45 shows the area of track which transitions Unknown to Occupied when the conditions in the requirement are met.

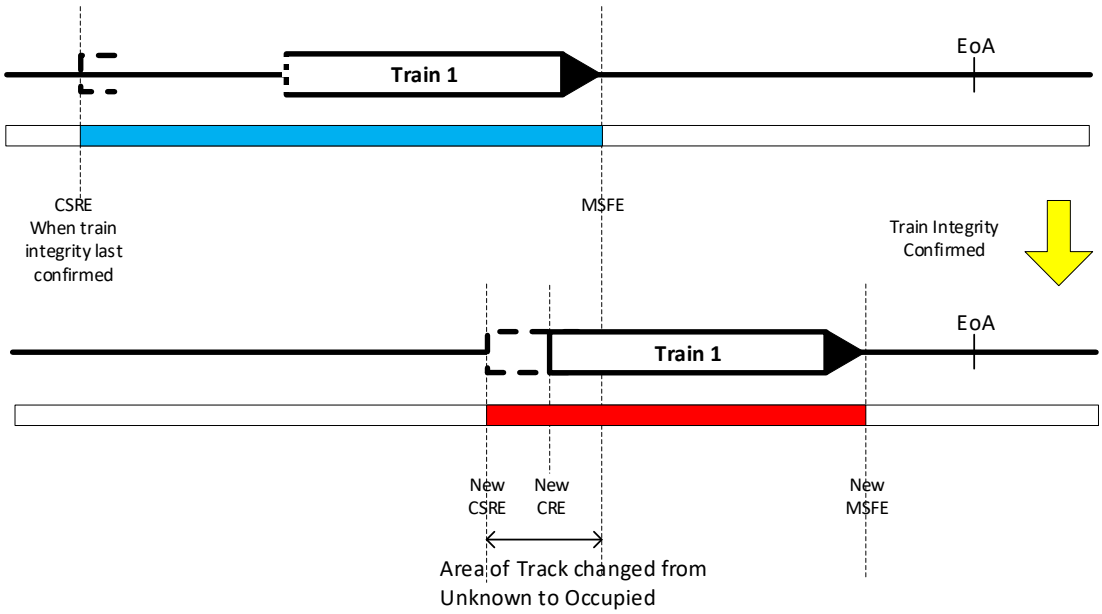

Figure 45: Unknown to Occupied Transition following regaining train integrity

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossTI-8

After a loss of integrity, the driver shall be made aware of the situation via an indication in the cab.

Rationale:

This is to inform the driver that there is a loss of integrity. In this way, Driver can take appropriate measures according to operational procedures defined.

Guidance:

As TIMS is a separate system to the ETCS On-Board, there is opportunity to display the status of Train Integrity derived by the TIMS equipment to the driver through alternative means e.g. through a separate indication in the cab.

The TIMS information could be displayed to the driver via the DMI, however this implies a change in the current ETCS specifications. See section 7.2 Train Integrity information in the DMI

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-LossTI-9

The L3 Trackside shall be able to be configured whether to accept Train integrity confirmation by the driver.

Rationale:

It is configurable whether to accept confirmation of integrity by the driver, as some Infrastructure Managers may not want to accept the risk associated with this procedure.

Guidance:

If confirmation of Integrity by the driver is not accepted, then the L3 Trackside can ignore any reports with Train Integrity Confirmed by Driver.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LossTI-3

REQ-LossTI-10

The L3 Trackside shall be configurable as to whether it authorises a Movement Authority for a train that has lost Integrity.

Rationale:

Movement of a train without integrity within the L3 area could have significant impact on the operational availability. However, in some situations it may be required, for example to move a train without integrity into a siding.

Guidance:

It is proposed that this requirement is configured once for the entire L3 Area.

The configuration options should include:

- Issue an MA irrespective of integrity status
- Do not issue an MA unless integrity is confirmed
- Only issue an MA when no integrity is confirmed with the authority of the Dispatcher.

This requirement would also apply to trains arriving at the L3 area boundary without train integrity confirmed.

D5.2 Operational Rules:OPE-StartTrain-2

D5.2 Engineering Rules:ENG-LossTI-4; ENG-StartTrain-1

REQ-LossTI-11

If the L3 Trackside receives new validated train data for a train with a length reported different to previous, then the L3 Trackside shall immediately consider the Train as having lost Integrity.

Rationale:

If the train reports loss of train integrity as a result of joining or splitting, then this will already result in the Track Status becoming Unknown. This requirement is to catch the situation where the new train length is received before the loss of train integrity.

Guidance:

When new train data is entered, the ETCS on-board will not confirm train integrity until the new train data is acknowledged by the L3 Trackside. This behaviour is as defined in Change Request 940 [CR940]. In this case the L3 Trackside should not time out train integrity as required section REQ-LossTI-5.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.19Level Transition

6.19.1 Introduction

Level Transition functionality is performed in the same way as in L2. However, operating in L3 brings additional challenges, in particular due to the lack of TTD. The issue to be solved in L3 is related to the detection of possible non-communicating trains that attempt to enter the L3 area.

6.19.2 Requirements

REQ-LevelTrans-1

The L3 Trackside shall have means to detect non-communicating trains about to enter the L3 area.

Rationale:

This is to prevent a train from entering the L3 area unnoticed by the L3 Trackside.

Guidance:

This can be done by scheme engineering, such as a small TTD at the border or other means that are application specific.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LevelTrans-1

6.20Trackside Initialisation

6.20.1 Introduction

This section includes requirements associated with starting or restarting the L3 Trackside system.

In order to provide a safe initialisation, the L3 Trackside has to start in the most restrictive state.

This means that there must be a process in which the L3 Trackside can identify those parts of the area that can be considered Clear. For that purpose, in an ETCS Level 3 Moving Block system without TTD, it will be advantageous for the L3 Trackside to effectively manage stored information to accelerate the initialisation and capture the state of the railway. Without such methods, the L3 Trackside would have to resort to sweeping the entire Area of Control.

When a Trackside initialisation is needed, it is likely that some subsystems also need to be restarted.

This section details the functionality when an entire Area of Control is initialised due to the L3 Trackside being restarted. To take individual areas out of action (such as a section of line between

two stations) the dispatcher can utilise the functionality in section 6.2 Track Status to declare an area of Unknown, and utilise existing L2 functionality such as Track Possession Reminders where necessary.

6.20.2 Requirements

REQ-TrackInit-1

The L3 Trackside shall consider the entire L3 Area of Control in state Unknown when the L3 Trackside initialisation starts.

Rationale:

This is to start with the most restrictive state.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackInit-2

The L3 Trackside shall utilise valid Stored Information to enable faster initialisation.

Rationale:

Historic information on the state of the railway from before the L3 Trackside was restarted can enhance the Initialisation process.

Guidance:

The location of all trains in communication prior to the restart, along with the extent of any MAs issued will be valuable information to be utilised.

The validity of the information used must be carefully considered, as if the L3 Trackside has been offline for some time the State of the Railway is likely to have changed.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackInit-3

The L3 Trackside shall provide a means for the person responsible for the Initialisation to confirm that the procedure is completed.

Rationale:

The person in charge of initialising the L3 Trackside has to confirm when the procedure has concluded. They have the authority to confirm that all the obstacles on the railway are known to the L3 Trackside.

Guidance:

None.

D5.2 Operational Rules:OPE-TrackInit-5

D5.2 Engineering Rules:None

REQ-TrackInit-4

Upon receiving confirmation of completion of the Initialisation procedure from the responsible person, the L3 Trackside shall set the remaining Unknown areas not associated with any obstruction as Clear.

Rationale:

During Initialisation, the L3 Trackside will create Occupied areas for Trains in communication, create Unknown areas based on stored data, and accept any additional Unknown areas created at the request of the TMS. Once the procedure is confirmed to be completed, the remaining track can be considered clear.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-TrackInit-5

The L3 Trackside shall send Authorisations to trains in the Area of Control only after receiving confirmation from the responsible person that the Initialisation procedure has been completed.

Rationale:

This is to prevent the L3 Trackside sending authorities to move during the Initialisation procedure which could be hazardous when trying to identify the state of the track.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.21Handover

6.21.1 Introduction

The Handover procedure is the same as in L2 except for termination of the communication session with the Handing Over L3 Trackside, as introduced by the solution to Change Request 940 [CR940].

When there are no TTDs, it is important to define how a possible propagation of the Unknown Track state is achieved over an L3 Trackside-L3 Trackside boundary.

6.21.2 Requirements

REQ-HO-1

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.

Rationale:

This is because the adjacent L3 Trackside could have already sent an MA covering this area or be about to do it.

Guidance:

There may need to be a mechanism to remove the Reserved area if the train does not arrive in the Accepting L3 Trackside.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-HO-2

The L3 Trackside shall be able to manage a possible propagation of the Unknown state over an L3 Trackside-L3 Trackside boundary.

Rationale:

This is to inform the adjacent L3 Trackside about the need to protect its Area of Control with Unknown state.

Guidance:

This functionality could be implemented directly in the L3 Trackside-L3 Trackside interface which requires a change in the current ETCS specifications. See section 7.6 for further details.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-LossTI-2

REQ-HO-3

When the Handing Over L3 Trackside receives a position report and detects that the Confirmed Safe Rear End of the train has crossed the border, it shall send a session termination order to the ETCS On-Board equipment.

Rationale:

This is to allow the Handing Over L3 Trackside to consider the track clear in the area in rear of the border.

Guidance:

In implementing this requirement, consideration needs to be taken of the location of the reported rear end of the train and any additional margins. In the current specifications [BL3 R2], trains can only be requested to report their position when their Min Safe Rear End or Max Safe Front End is at a certain location. Section 7 details a proposed change to the current specifications that would enable the ETCS On-board to report its position when its CRE is at a certain location.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-HO-1

6.22Shunting movement

6.22.1 Introduction

A challenge for an ETCS Level 3 Moving Block system without TTD is to manage shunting movement as the trains disconnect while in SH mode. The best way to handle this is to limit shunting to predefined areas and consider an active shunting area as having the state Unknown.

The ETCS Level 3 Moving Block system should be able to manage a possible driver request for shunting anywhere on the line but could decide to reject this and restrict shunting to predefined shunting areas.

Stored information could be useful to provide a quick recovery after SH movements.

Two different types of SH areas are foreseen:

- Permanent SH areas: where there is a predefined area in the track dedicated to shunting
- Temporary SH areas: where there are predefined Shunting Areas which can be activated or deactivated under Traffic Management System control.

A train transitioning to Shunt mode is considered as an End of Mission by the L3 Trackside. As such, the requirements in section 6.17 End of Mission apply to this situation.

6.22.2 Requirements

REQ-SH-1

The L3 Trackside shall be configurable with predefined Permanent and Temporary Shunting Areas.

Rationale:

Areas where it is known that there will be shunting operations can be engineered when the system is designed.

Guidance:

None.

D5.2 Operational Rules:None

D5.2 Engineering Rules:ENG-SH-1

REQ-SH-2

The L3 Trackside shall provide an interface to allow the TMS to enable and disable Temporary Shunting Areas.

Rationale:

Temporary Shunting Areas need to be enabled and disabled.

Guidance:

None.

D5.2 Operational Rules:OPE-SH-1; OPE-SH-2

D5.2 Engineering Rules:None

REQ-SH-3

The L3 Trackside shall consider the track status of an active Shunting Area to be Unknown.

Rationale:

While shunting the L3 On-board is not connected to the L3 Trackside and therefore any train movements in SH mode are unknown to the L3 Trackside.

Guidance:

This applies to Permanent and Temporary Shunting areas.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.23Joining

6.23.1 Introduction

Joining procedure in L3 is similar to the procedure in L2, but there are some additional requirements.

The terminology used is as defined in ETCS Specification [BL3 R2]:

- Train to be joined The stationary train waiting to be joined
- Joining Train The train which moves towards the train to be joined.

In addition, the following term is used:

- Joined Train The train after joining.

This section covers the situation where the train to be joined does not perform End of Mission.

The joining train will perform End of Mission.

There are no separate requirements for the derivation of the Train Location and Occupied Track Status for the joined train. This is covered in sections 6.1 and 6.2.

6.23.2 Requirements

REQ-Join-1

When there is Joining without End of Mission, the L3 Trackside shall remove the areas with Track Status Unknown corresponding to the Train to be Joined and the Joining Train if the Joined Train meets the following conditions:

a) The Joined Train has a new L_TRAIN which is equal to the sum of the L_TRAIN for the Train to be Joined and the L_TRAIN for the Joining Train, plus or minus a tolerance
b) The Joined Train has confirmed Train Integrity.

Rationale:

The areas of Unknown corresponding to the Train to be Joined and the Joining Train can be removed if the new Joined Train accounts for all the rail vehicles in the Train to be Joined and the Joining Train.

Guidance:

The tolerance is the same as that defined for the configurable minimum length of Unknown areas, as defined in section 6.2.

When a train reports new train data, it is considered to have Lost Integrity (REQ-LossTI-11). As such, the Train to be Joined will be located in an area of Unknown.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-Join-2

If the Joined Train leaves the Unknown area, and the Joined Train has L_TRAIN less than the sum of the L_TRAIN of the Train to be Joined and the L_TRAIN of the Joining Train, then the L3 Trackside shall reduce the length of the area with Track Status Unknown by L_TRAIN of the Joined Train.

Rationale:

The areas of Unknown corresponding to the Train to be Joined and the Joining Train cannot be fully removed if the new Joined Train does not account for all the rail vehicles in the Train to be Joined and the Joining Train.

Guidance:

Figure 46 shows the Joined Train leaving, and the reduction in the area of Unknown remaining:

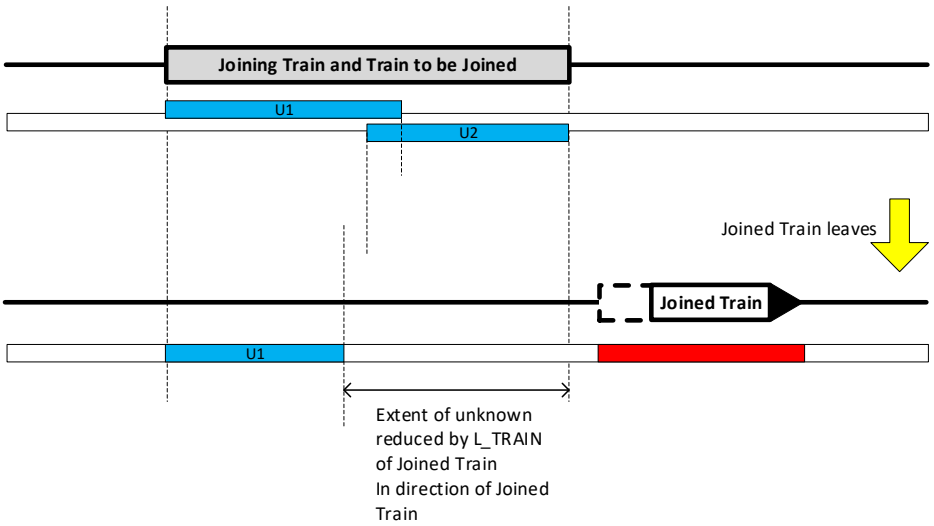

Figure 46: Joining – Shorter Joined Train leaves Unknown Area: update of extent of Unknown area

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

REQ-Join-3

If the Joined Train leaves the Unknown area, and the Joined Train has L_TRAIN less than the sum of the L_TRAIN of the Train to be Joined and the L_TRAIN of the Joining Train, then the L3 Trackside shall subtract the Length of the Joined Train from the length stored for the remaining Unknown area.

Rationale:

As the new Joined train does not account for all the rail vehicles in the Train to be Joined and the Joining Train, an Unknown area remains. The Stored Train length associated with the remaining area must be updated to account for the departure of the Joined Train.

Guidance:

Figure 47 shows the Joined Train leaving, and the reduction in the stored train length for the remaining area of Unknown:

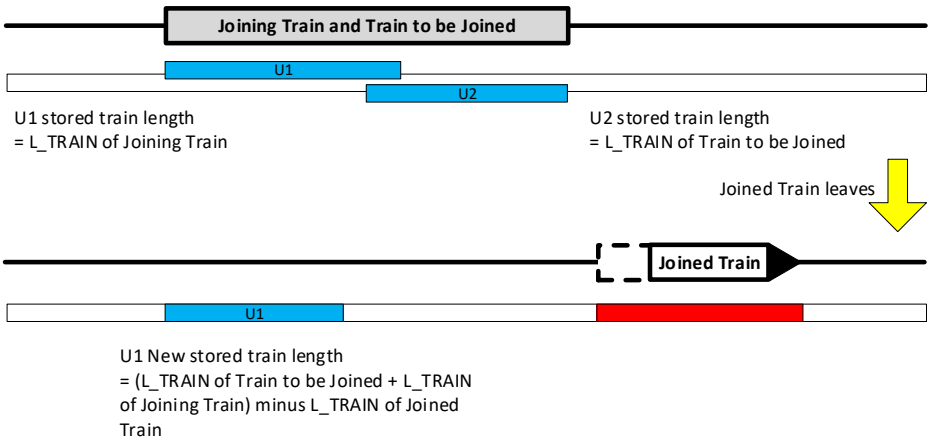

Figure 47: Joining – Shorter Joined Train Leaves Unknown Area: update of stored train lengths

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.24Splitting

6.24.1 Introduction

Splitting procedure in L3 is similar to the procedure in L2, but there are some additional requirements.

The terminology used is as defined in ETCS Specifications [BL3 R2]:

- Train to be split The train before splitting

- Front train after splitting The front part of the train after splitting
- New train after splitting The other part of the train after splitting.

This section covers the situation where the train to be split does not perform End of Mission.

There are no separate requirements for the derivation of the Train Location and Occupied Track Status for the front train after splitting and the new train after splitting. This is covered in sections 6.1 and 6.2.

There is a specific hazard associated with Splitting. If the front train after splitting reports a new train length (L_TRAIN) greater or equal to the train length of the train to be split, the Unknown area resulting from the splitting is removed, and the new train after splitting becomes a Ghost Train. See assumption about Train Length in section 3.3.6.

6.24.2 Requirements

REQ-Split-1

The L3 Trackside shall be able to reduce the length of the area with Track Status Unknown due to loss of train integrity or reception of new validated train data when a train confirms integrity reporting within the Unknown area.

Rationale:

This represents the reduction in the area of Unknown after one of the trains after splitting has confirmed train integrity.

Guidance:

The train which leaves the area can leave in either direction. The length of the area with Track Status Unknown is reduced depending on the direction in which the train has left.

The length of the train which has left (L_TRAIN) is used to reduce both the length of the Unknown Area., and the train length stored for the Unknown Area.

Figure 48 shows Train 1 leaving in one direction:

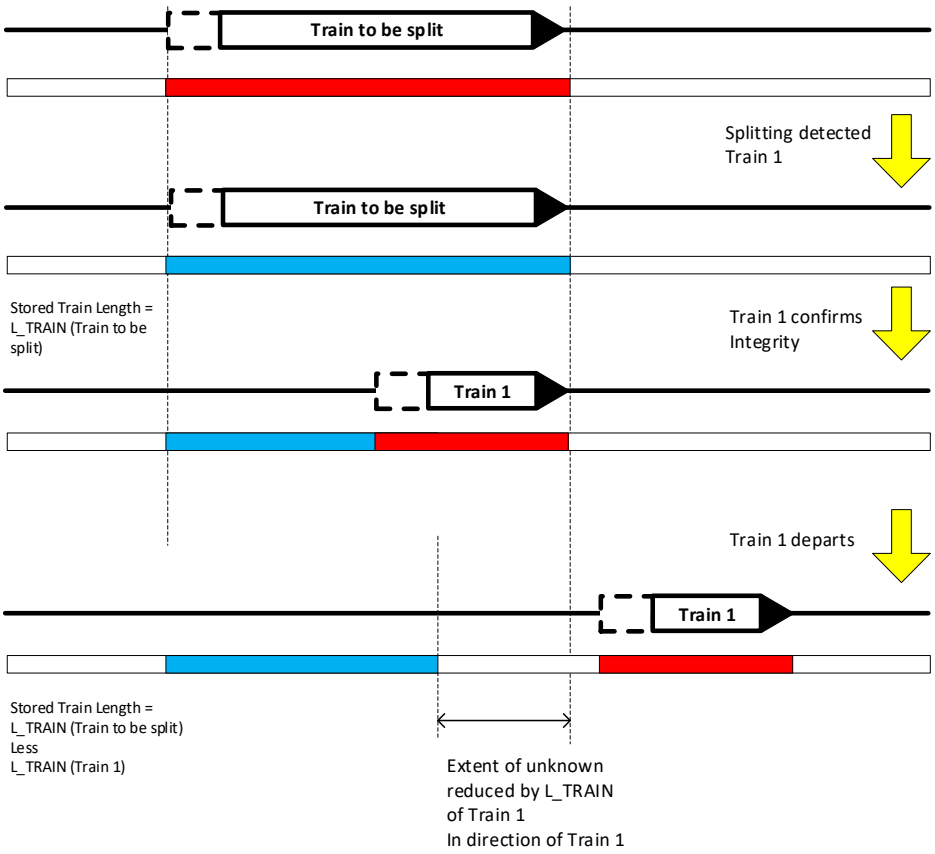

Figure 48: Splitting – Train 1 leaves Unknown Area

The process above is repeated if a second train leaves the Unknown area.

If the total length for the Train to be Split is accounted for by the reduction in stored train length, then the Unknown area is completely removed.

There is an allowed tolerance, which is the same as that defined for the configurable minimum length of Unknown areas, as defined in section 6.2.

D5.2 Operational Rules:None

D5.2 Engineering Rules:None

6.25Recovery

6.25.1 Introduction

The operations required for recovery of a failed train are covered by other requirements, for example the changing of areas of track to Unknown, movement of trains in Staff Responsible mode, and the issuing of Movement Authorities with On Sight mode profile.

6.26Mixed Traffic

6.26.1 Introduction

In a Mixed traffic area there are, in normal operation, trains moving which are not able to report Train Integrity confirmation - even if equipped with ETCS On-Board. This could be the case during migration to Level 3, pending ETCS on-board and/or TIMS installations, or for applications giving priority to ETCS equipped trains able to report train integrity confirmation during peak hour traffic.

The L3 Trackside will require additional controls to permit the operation of trains which are not able to report train integrity confirmation. These controls could be provided by TTD, or by other technical or procedural means, as appropriate to the traffic level and railway type.

There could be optical signals in areas with mixed traffic, i.e. the ETCS Level 3 Moving Block system is an overlay on a conventional signalling system. Therefore, the possibility to benefit from train integrity confirmation and authorise another communicating ETCS train into a route occupied by a train with confirmed train integrity depends on if the train drivers will be allowed to pass a signal at stop or if some signal additional aspect can be used for such authorisations.

The functionality required for Mixed Traffic operation is already covered by the following sections: Trackside Train Detection (section 6.5), Movement Authorities (section 6.7) and Loss of Train Integrity (section 6.18).

6.27Traffic Management System interface

6.27.1 Introduction

There are several sections in this specification where there are requirements for output of information to the Traffic Management System (TMS), and for interaction between the L3 Trackside and the TMS.

The exported requirements for the TMS are included below. The following tables summarise the interactions between the TMS and L3 Trackside and the associated requirements. Section 6.27.2 details a single exported requirement for the interface between the Dispatcher and the TMS.

L3 Trackside → TMS	
Interaction	**Requirement ID**
The L3 Trackside shall report the location and status for all trains in L3 Area	REQ-TrainLoc-10
The L3 Trackside shall report the Track status of the entire L3 Area	REQ-TrackStatus-12
The L3 Trackside shall report the Reserved status of the entire L3 Area	REQ-Reserved-2
The L3 Trackside shall send all Movement Authorities issued to trains to the TMS	REQ-MA-7
The L3 Trackside shall alert the TMS to a train that is reporting an invalid or unknown position.	REQ-StartTrain-3
The L3 Trackside shall calculate an SR distance and send it to the TMS.	REQ-MovSR-2
The L3 Trackside shall notify TMS of a train that has not emerged from a Radio Hole.	REQ-RadioHole-5
TMS → L3 Trackside	
Interaction	**Requirement ID**
The TMS shall be able to set areas of Unknown.	REQ-TrackStatus-5
The TMS shall be able to clear areas of Unknown.	REQ-TrackStatus-8
The TMS shall be able to move points within an Unknown area by emergency procedure	REQ-PTS-3
The TMS can provide an estimated location for a train to the L3 Trackside.	REQ-StartTrain-4
The TMS can provide the SR distance to the L3 Trackside	REQ-MovSR-3
The TMS can validate the SR distance calculated by the L3 Trackside	REQ-MovSR-2
The TMS must authorise Sweeping of Unknown area before Trackside issues MA (if configured).	REQ-MA-9
The TMS can activate and deactivate dynamic Radio Holes.	REQ-Radiohole-1
The TMS can establish and remove temporary shunting areas.	REQ-SH-2
The TMS can enable and disable shunting areas.	REQ-SH-3

6.27.2 Requirements

REQ-TMS-1

The TMS shall provide means for the Dispatcher to assign a position to a train that is reporting unknown or invalid position.

Rationale:

This is to allow the Dispatcher to locate the train on the track after a specific operational procedure. Whilst this functionality is available at L2, it is different at L3 with Moving Block as the train can be located anywhere in the L3 Area and not in a specific block.

Guidance:

The Driver needs to be able to identify the train position and report it to the Dispatcher.

D5.2 Operational Rules:OPE-StartTrain-5

D5.2 Engineering Rules:None

7 Changes in Current Specifications

The compilation of the requirements for ETCS Level 3 Moving Block has been carried out to ensure minimal changes to the existing specification. The items in the following section outline possible changes to the existing CCS TSI identified by the work package. These changes will be reviewed further during X2Rail-3, before being submitted to the ERA CCM Process [CRProcess] for consideration.

7.1 New train position report when the CRE has passed a specific location

Problem detected

In an ETCS Level 3 Moving Block system it is important to have a quick release of the track by train passage to provide significant increases of the capacity. The importance of a quick track release is even more relevant when points or other elements in the line are affected.

Depending on the position report rate and frequency of TIMS reporting, it could happen that, even when the train has physically released a specific location, a new position report with new CRE information is not yet received.

Usually, this delay is not meaningful in plain track. But there could be specific locations where a quicker track release makes the difference to railway performance.

Solution proposed

In a L2 system the Trackside can request the On-board to send a position report when the Min Safe Rear End or the Max Safe Front End of the train has passed a specific location.

The proposal would be to use the same approach including the Confirmed Rear End as a new value for variable Q_LGTLOC.

In this way, L3 Trackside could request the On-board to send a position report as soon as the CRE of the train has passed a specific location. This would improve performance at specific points on the railway. Note that this proposal would also require new Engineering Rules.

7.2 Train Integrity information in the DMI

Problem detected

A loss of train integrity detected by the TIMS is a new degraded situation that occurs in an ETCS Level 3 system.

According to current specifications, a loss of train integrity is reported from the ETCS On-board to the L3 Trackside. However, it is not visible to the Driver.

In a degraded situation such as where the train could have lost a wagon or there has been a derailment, it seems reasonable that the Driver is aware as soon as possible, and starts application of specific reactions or execution of predefined operational procedures.

Solution proposed

It is not considered necessary to continuously display the train integrity state, since it could be unnecessary for the Driver in most of the cases. Instead, making the Driver aware when a loss of train integrity occurs will be relevant to apply the corresponding procedure or for safety reasons.

Some emergency icons are shown to the Driver in the DMI to warn the Driver about, for example, a loss of communications, an applied emergency brake.

In the same way, a new icon could be defined to inform the Driver when the train integrity is lost. This information is already available in the On-board which means that it only has to be shown in the DMI.

7.3 TIMS status in cab

Problem detected

Many Infrastructure Managers and Operators have shown their concern regarding having L3 trains with a malfunctioning TIMS running through an L3 Area.

Once the train is inside the L3 area, if the TIMS stop working, the ETCS Level 3 Moving Block system has to be able to manage the situation using technical solutions or operational procedures. Nothing else can be done if this situation appears inside the L3 area.

However, allowing a train with a malfunctioning TIMS to enter the L3 line could be avoided in order not to face degraded situations later.

Solution proposed

The proposal consists on having an indication in the cab to show the Driver the status of the TIMS.

In this way, before the train leaves the Depot or the parking area on a side line, the Driver can check that the TIMS operational or not and act consequently.

Whilst this information could be also shown in the DMI, it is seen as infeasible to request this change to the DMI specification. It should be adequate to have this information in the cab, which could be obtained using a direct interface from TIMS in the cab.

7.4 Request of Train integrity update

Problem detected

According to the solution to Change Request 940 [CR940], it could occur that even when receiving new position reports, the CRE is not updated because there is no new information coming from TIMS confirming train integrity. The lack of train integrity confirmation could cause availability issues with the L3 railway.

One clear example could be during an End of Mission procedure. In case the last position report before starting the End of Mission does not provide train integrity confirmed information to update the CRE, the area considered Unknown because of the End of Mission could be longer than necessary. The problem could be more severe if points or other elements are inside this big Unknown area.

For high rates of train integrity confirmation, this issue is less likely to occur.

Solution proposed

The proposed solution is to provide the Driver with some mechanism to request the TIMS an update of train integrity state. This mechanism could be a button on the DMI or somewhere else in the cab.

When receiving this input, the TIMS would force the ETCS Level 3 Moving Block system to check the train integrity state and send this information to the On-board.

In the End of Mission example, the Driver could request an update of train integrity before starting an End of Mission procedure. In this way, L3 system can be sure that it has received the most updated information as possible.

7.5 National Value for loss of train integrity reaction

Problem detected

When the train sends a position report with information about a loss of train integrity, some reaction is expected.

This reaction could be different depending on the Operator, the type of train, the situation, the location.

Currently, the only possibility is that the Trackside is responsible for providing this reaction to the ETCS On-board.

Solution proposed

According to the current specifications, the reaction for a loss of communications is autonomously applied by the ETCS On-board based on National Values received from the L3 Trackside.

A similar solution could be also implemented to handle the reaction when there is a loss of train integrity. The proposal is based on the use of National Value to specify the reaction of the ETCS On-board when losing train integrity. In this way, the reaction would be applied faster without the need of L3 Trackside intervention. The reaction applied could be similar to that configured for Loss of Communications:

a) Train Trip
b) Apply Service Brake
c) No Reaction.

7.6 Propagation over an L3 Trackside-L3 Trackside boundary

Problem detected

It is proposed to implement a propagation functionality to protect against possible train movement due to brakes which have lost their brake power (defective brakes), unauthorised movements, etc.

When a propagation timer has expired, the Unknown area is extended until new limits.

However, it is needed to solve the situation when propagation is needed over an L3 Trackside-L3 Trackside boundary.

Solution proposed

The L3 Trackside has to inform the adjacent L3 Trackside about the need of protecting a configured area with Unknown state. In this context, a configured area is a predefined area starting in the L3 Trackside-L3 Trackside boundary that has to be protected. The length of this configured area could depend on the layout, gradient, the reason of the propagation etc.

The proposal is to modify the L3 Trackside-L3 Trackside interface to be able to handle this situation.

In principle, it would be sufficient with one bit acting as a trigger for the adjacent L3 Trackside to start propagating in its area.

However, the functionality can be improved with more bits and cover also the situation of an Unknown area that needs to be established in the adjacent L3 Trackside area because a train that is performing a Handover has lost communications. If this is the case, and the train already has an MA covering the Route Related Information area, this area also has to change to Unknown state. Currently this can be done by the Handing over L3 Trackside but there is no mechanism for the Accepting L3 Trackside to know it when, for example, the train is running with only one radio.

Note that this proposal could also require new Engineering Rules.

7.7 Position report parameters in a Level Transition to L1

Problem detected

ETCS Specifications [BL3 R2] 4.9.1.3 says “In case of entering level 1, MA Request Parameters, Position Report Parameters and Track Ahead Free Request shall be deleted.”

For all other level transitions (also taking into account the related mode transition) the position report parameters will be retained after the level/mode transition.

Therefore, the definition of a position report parameter for reporting Confirmed Rear End when exiting the L3 area will not work for transitions to L1. Moreover, the ETCS On-Board will report when Min Safe Rear End passes the border, when passing an LRBG compliant Balise group, when reaching standstill, when the mode changes etc, but there will be no cyclic position reporting once L1 has been entered.

Solution proposed

After some investigations and having analysed the possible reasons for deleting the Position Report Parameters when there is a Level Transition to L1, we have not found any consistent argument to justify this behaviour.

In fact, according to current ETCS specifications, Position Report Parameters information would be stored in a Level Transition to Level 0 or Level NTC, but not to Level 1.

Therefore, the proposal is to delete current requirement 4.9.1.3 from ETCS Specifications SUBSET 26 BL3 R2 [BL3 R2] since it would be beneficial for an ETCS Level 3 Moving Block system to store Position Report Parameters also during a Level Transition to L1. This would allow specific and more frequent position reports from the ETCS On-board to Trackside which leads to a quicker release of the L3 area without establishing Unknown areas.

8 Future Work

The System Requirement Specification presented in this document cannot yet be considered fully complete, and work will continue on its refinement in the next phase of the project (X2Rail-3). A number of activities planned for X2Rail-3 will feed into the update of this document:

- Further work on safety analysis
- Knowledge gained from undertaking prototyping work and application analysis

In addition to these points, the sections below detail specific elements of functionality that will be analysed and specified further.

8.1 Track Status state machine

The work on a Track Status state machine describing the conditions that lead to changes in the Track Status has already started and will be finished during next project phase.

The work process is based on the following tasks:

a) Define the different track states that are going to be used

b) Identify the scenarios where there is some impact in Track states

c) Collect all situations where a change of Track state occurs in a L3 Trackside system

d) Analyse all possible transitions between different track states

e) Agree a final track state machine

f) Agree a final table including all transition conditions.

This work has to include not only the state machine for an ETCS Level 3 Moving Block system without TTD, but also cover system types including TTD or Fixed Virtual Block sections.

Part of this work would involve a comparison of the results with the State Machine presented in the Hybrid Level 3 Principles document [HL3]. This work would aim to understand the differences between the two systems and assess their compatibility.

Once this work is finalised, there will be a clear view of the track state in every situation and the corresponding L3 Trackside behaviour according to the state.

8.2 Stored information analysis

During the work in this project phase the need of a detailed analysis about stored information has been identified. Whilst there is some information present in the requirements, further analysis will be performed during next project phase.

The analysis of stored information will answer three questions:

1. What information needs to be stored by L3 Trackside?
2. Under which conditions this information is considered valid/invalid?
3. What mechanisms are defined to use this stored information?

The work process is based on the following tasks:

a) Identify the scenarios where stored information is needed to provide advanced functionality

b) Collect all situations inside each scenario that could represent variants and have some impact on the information to be stored

c) Perform an assessment about the information that could be useful to store for each situation previously identified

d) Evaluate conditions that have to be fulfilled to apply the stored information, e.g. ageing of the information, train integrity, reliability etc.

e) Define technical solutions to apply the stored information.

8.3 Safety Margin analysis

During this project phase there have been many discussions about the parameters to be considered when calculating the Safety Margin.

Following these discussions, it was also mentioned that this Safety Margin is not always needed and, thus, it is completely dependent on the specific situation.

Trying to close the pending open points regarding this function, some further work will be done during the next project phase including the following tasks:

a) Identify the scenarios where a Safety Margin is needed, including during splitting and joining

b) Collect all situations inside each scenario that could represent variants and have some impact on the parameters to be considered in the Safety Margin calculation, as well as considering when the Safety Margin must be recalculated

c) Perform an assessment about the parameters that could be useful to consider for each situation previously identified

d) Safety analysis of the final results to see if they are valid from a safety point of view.

8.4 Inclusion of Change Requests

During this project an ETCS starting point of Baseline 3 Release 2 was considered, along with the proposed solution to Change Request 940 [CR940]. Future work would need to consider any new accepted CRs and their potential impact on the Specifications given here.

8.5 Development of Propagation Functionality

In section 6.2 Track Status the concept of Propagation is introduced (REQ-TrackStatus-9 and -10). Further work is required to establish the use cases and functionality to be specified. The following should be taken into consideration:

a) Identify the scenarios where propagation should be applied

b) Identify the triggers for starting propagation in the different scenarios

c) Decide the rules for configuring the Propagation timer

d) Identify the boundaries to act as a limit for propagation.

9 Conclusions

This specification defines the system requirements for an ETCS Level 3 Moving Block system, relative to an ETCS Level 2 system.

The baseline of ETCS Level 2 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]

The work has aimed to minimise the changes to Baseline 3 Release 2.

The requirements in this specification cover the different ETCS Level 3 Moving Block system types identified by the project:

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

As a result of the work within X2Rail-1 WP5, there are some proposed enhancements beyond ETCS Baseline 3 Release 2 and Change Request 940 [CR940]. These are described in section 6 Changes in Current Specifications.

As originally planned, the work is not finished in X2Rail-1. Further work is proposed to be carried out within the follow-on project X2Rail-3, and later X2Rail-5. The topics for further work in X2Rail-3 are listed in section 7 Future Work.

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.

[NGTCD5152] "D5.1 Moving Block Principles"
"D5.2 Validation of Moving Block Principles"
Deliverables from EU project: Next Generation of Train Control systems Seventh Framework Programme EC Contract Number: FP7 605402

[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

[CRProcess] Change Control Management process ERA_ERTMS_0001_v.2.0

This is the process for changing the documents which make up the ETCS Baselines.

[D2.1] X2Rail-1 Deliverable D2.1 "Reference Architecture"
This was developed by X2Rail-1 WP2.

[GLO] X2Rail-1 Integrated Glossary.

[HL3] Hybrid ERTMS/ETCS Level 3 Principles, ERTMS Users Group, V. 1C 13/07/2018
This is the principles document describing the behaviour and state machine of the Hybrid Level 3 concept.

[SS091] SUBSET 91, Safety Requirements for the Technical Interoperability of ETCS in Levels 1 & 2, see [BL3 R2] for version.

[15560] ETCS Driver Machine Interface ERA_ERTMS_015560, V3.6.0, 13/05/2016

[Article10-2017] ERA Technical Opinion ERA/OPI/2017-2