EU-RAIL SYSTEM PILLAR

# Traffic CS Technical Design Decisions

**Version: 1.0**

# Traffic CS - Technical Design Decisions

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|---|---|
| Abstract | The objective of this document is to outline the foundational concepts that are essential for defining the Traffic Control System (Traffic CS). It aims to provide explanations of key principles, terminologies, and frameworks that will serve as the basis for subsequent specifications and design processes related to the Traffic CS. The selected key principles in the present document form one base for the technical specification of the Traffic CS Subsystems: - Plan Execution System (PES) - European Trackside Protection System (ETPS) - Automatic Train Operation - Trackside (ATO-TS). |
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# Table of Content

### Approval by approvers

| Type of Approval | Document Approval |
|---|---|
| Approvals | Schmidt Steffen (I-NAT-GST-ERTM) : Approved |

### Approval by reviewers

| Type of Approval | Document Review |
|---|---|
| Approvals | Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |
| Comments | **#1 Approval comment** by **LOEFFLER Christian** on 2026-05-07 14:28<br>Conditional Approval with the following conditions given:<br><br>Chapter 9:<br><br>1. Artefacts due to Copy&Paste from RCA need to be removed/adapted (DPS, DPS States Full & None)<br>2. We need to agree if the Risk Path determination needs to be done for the complete Reserved Path of the MP or only for Permission Extent + Risk Buffer - images need to be reworked accordingly<br>3. Only Points are analysed in more detail to be compliant with STA concept. Other trackside assets still need to be analysed - until such an analysis has confirmed the compliance of the STA concept to the specific trackside asset type, the chapter shall not give the impression that STA concept can be applied to the specific trackside asset type (e.g. Level Crossing).<br><br>Chapter 10:<br><br>1. Only Points are analysed in more detail to be compliant with STA concept. Other trackside assets still need to be analysed - until such an analysis has confirmed the compliance of the STA concept to the specific trackside asset type, the chapter shall not give the impression that STA concept can be applied to the specific trackside asset type (e.g. Level Crossing). For actively Traffic CS controlled Gates and Bridges STA concept seems to be ok - if Traffic CS receives pure status information from these devices, application of STA concept seems to be questionable, needs to be analysed in detail and adapted if necessary.<br><br>Detailed comments are given in the actual working document. |

# 1 Preamble

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Meijer, A.J. (Albertjan) : Disapproved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , EL IDRISSI Youssef (EXT INGEVA) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Klose, Christoph (SMO RI R&D) : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |
| Comments | **#1 Approval comment** by **Meijer, A.J. (Albertjan)** on 2026-05-06 15:57<br>This document seems to contain a lot more that terminology, concepts, and principles, it looks like a part of the specification.<br><br>Due this larger scope there was too less time to review this document thoroughly.<br>So my approval is not possible at this moment. For more information check with Maarten Bartholomeus.<br>**#2 Approval comment** by **EL IDRISSI Youssef (EXT INGEVA)** on 2026-05-06 20:46<br>Conditional upon subsequent safety demonstration of the retained architectural choices, including the Black Box approach and the Anywhere-to-Anywhere train-centric paradigm. |



## 1.1 Purpose and Scope

The purpose of this document is to describe the key concepts and engineering decisions that underpin the Traffic Control & Supervision (Traffic CS) for:

- Plan Execution System (PES)
- European Trackside Protection System (ETPS)
- Automatic Train Operation - Trackside System (ATO-TS)

It sets out the engineering philosophy, reasoning, and architectural intent adopted for the development of the Traffic CS systems. This document is not intended to provide detailed design specifications, safety analysis or implementation rules. While specific technical solutions, interfaces, or mechanisms may evolve over time, the essential engineering principles and design philosophy described herein are intended to remain valid and guide future development and refinement. The content of this document has been informed by previous research, development, and innovation activities, including relevant European and national programmes. These prior works have been used as inputs to capture lessons learned, proven concepts, and established good practice.

The primary scope of this document is the description of “normal mode” operation, with respect to the European Train Control System (ETCS). Abnormal, degraded, and special operating modes are acknowledged but are not the main focus of this document and may be addressed elsewhere or in future documents.

This document is written to support a broad technical audience, including stakeholders who may not be specialists in System Pillar activities, by providing a clear and consistent explanation of the underlying concepts and decisions. This document forms the basis of the Traffic CS Specification team engineering work and the Traffic CS requirements specification outputs.
[SPT2TRAFFIC-20512 ]

The aim of this document is two-fold: It shall give guidance for the Traffic CS subsystem and interface specification work and also serve to achieve sector consensus on main design decisions forming the foundation of the Traffic CS specifications. The document may be updated in due course as need arises and is periodically presented to the sector. It is highlighting the major design topics and is not a comprehensive and detailed technical specification. [SPT2TRAFFIC-20519 ]

In March 2025, the SP Steering Group decided that the Traffic CS requirements and specification approach is implementation agnostic ("Implementation Agnostic Specification" - IAS). This document follows the IAS design approach, especially on the mitigation of risks caused by non-harmonised safety acceptance criteria of the different National Safety Authorities (NSAs) across Europe. Please refer to the PRAMS documentation ( PRAMS Plan and ERJU RAG Overview) for more details about all activities related to risk assessment in the ERJU System Pillar. [SPT2TRAFFIC-20511 ]

## 1.2 Context of this document

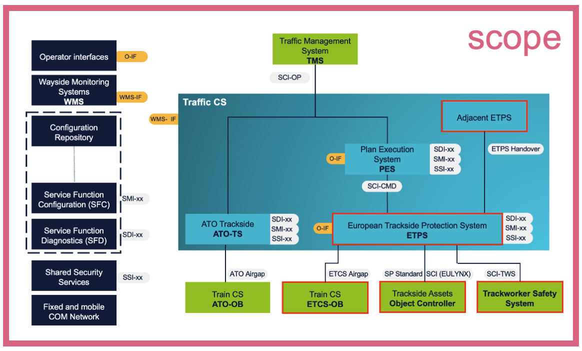
This document is part of a set of Traffic CS documents (see document overview below describing role and relation of each document). Readers should first familiarise themselves with the 'Traffic CS System Concept' and 'Traffic CS - Major Design Decisions' documents before reading this document. They provide the architectural and operational foundations for this document. [SPT2TRAFFIC-20510 ]

**Europe's Rail System Pillar - Domain Traffic CS**

Overview of the major Design Documents

**Traffic CS System Concept**

**Referenced version: SC2.4 v1.5; Update ongoing**




Scope:

How Requirements are fulfilled and assumptions on external systems

Input:

Railway Requirements

Status:

## Europe's Rail System Pillar - Domain Traffic CS

Overview of the major Design Documents

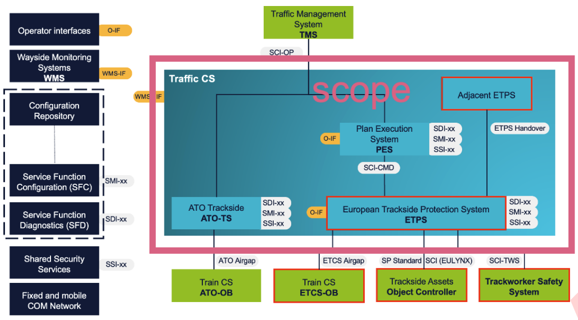
Agreed as general direction by Steering Group 03/2025Aim: Provide overview for internal and external stakeholders (SP domains, IP projects and others)

Summary:

- Describes high-level architecture and functionality of Traffic CS (before detailed specifications).
- Describes high-level concepts that fulfil the most important Traffic CS requirements.
- Assumptions and expectations to external systems are documented, including Traffic Management Systems (TMS), Trackside Objects and Train (onboard) systems.

### Traffic CS - Major Design Decisions

**Referenced version: SC2.4 v1.0**




Scope: Design Choices and Solutions at Traffic CS level

Input: CBOs + Traffic CS System Concept

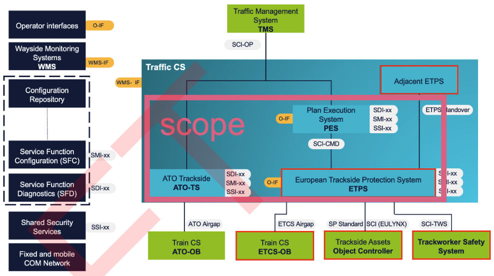
Status: Agreed as general direction by Steering Group 03/2025

Aim: Provide more detail behind System Concept content

- Preliminary results of Traffic CS top-down design (before detailed specifications)
- Describes key design decisions and strategic orientation and their rationales.
- Defines principles for Traffic CS specification activities.

### Traffic CS Technical Design Decisions

**First Release: ongoing in SC2.6**




Scope: Design Choices and solutions at Traffic CS subsystem level

Input: Traffic CS System Concept, Major Design Decisions, IAS Decision

Status: Input for Steering Group 06/2026

Aim: Gain consensus with the railway sector and external stakeholders to agree the key topics and elements of the Traffic CS System Requirements specifications.

- Defines domain objects, functions and signalling principles.
- Input for specification team to develop the Traffic CS subsystem specifications.
- Describes key elements for the safe separation of trains including Movement Permissions, Usage Restrictions, Flank Protection, Infrastructure Occupancy and Switchable Trackside Assets.
- Describes how Steering Group decision 03/2025 is implemented regarding a solution-agnostic specification which allows different implementations and safety configuration options under one harmonised specification. This can also facilitate the

| Europe's Rail System Pillar - Domain Traffic CS<br>Overview of the major Design Documents | |
|---|---|
| | safety approval processes with assessors and NSAs with the currently non-harmonised safety acceptance criteria across Europe.<br>• Identifies major open points that are subject to future clarification. |

[SPT2TRAFFIC-20523 ]

## 2 Specification Principles

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |



### 2.1 Design Principles

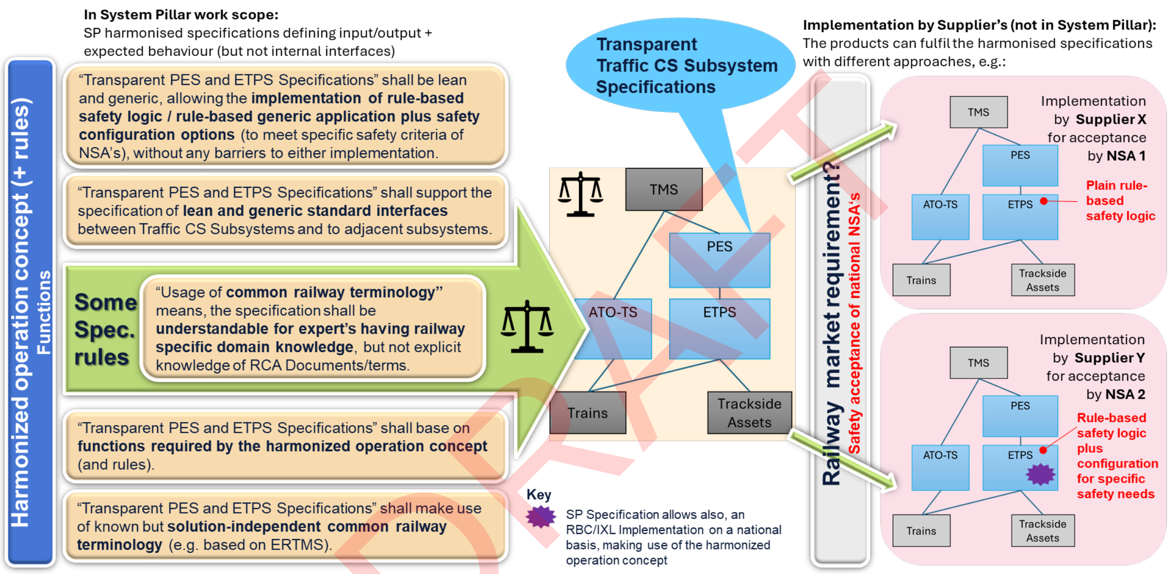
A core design principle is that the Traffic CS subsystems specifications are written as solution agnostic as reasonable, allowing freedom in the implementation. To facilitate the development of the specifications, the following rules apply to all specification work i.e. the process of converting harmonised operational concepts into capabilities and functions. The goal is to create a harmonised set of specifications describing a rule-based safety logic with additional optional safety configuration (see reference table below). The design approach followed is called Dynamic Train-Centric Control (DTCC) which is based on Moving Block to enable key business objectives like lower life-cycle cost and increased capacity. [SPT2TRAFFIC-20517 ]

| Terms / Definitions | Meaning |
|---|---|
| **Rule-based safety logic / rule-based generic application (without using optional safety configuration)** | Safety checks are based on a rule-based harmonised specification covering the generic harmonised operational needs.<br>When and how to configure engineering data needed for these safety checks is harmonised and clearly specified. The safety checks to be performed are selected by the specific application based on the configured engineering data. |
| **Rule-based safety logic / rule-based generic application** | Safety checks are based on a rule-based harmonised specification covering the generic harmonised operational needs.<br>The optional safety configuration allows to further restrict the behaviour/ functionality of the generic system to the project or country specific non- |

| Terms / Definitions | Meaning |
|---|---|
| **using optional safety configuration** | harmonised needs and can facilitate the approval processes with assessors and NSAs.<br><br>E.g. restricting Anywhere-to-Anywhere capability via additional engineering data (comparable to fixed routes) or requesting explicitly a specific flank protection measure at a specific location/for a specific element |

**[**SPT2TRAFFIC-20515**]**

The figure below illustrates the concept of a streamlined and generic Traffic CS Specification. **[**SPT2TRAFFIC-20513**]**






**[**SPT2TRAFFIC-14007**]**

*The figure above reflects the sector alignment on a implementation-agnostic specification of the SERA target, achieved in 03/2025 and later Traffic CS internal clarification results on IAS Principles for the specification of the Traffic CS Subsystems.*

There is no common European harmonised safety assessment criteria across European NSAs leading to different implementations. To reduce the risk of large amounts of variations between deployed systems, the Traffic CS domain has initiated a round of clarification with NSAs on this subject. The clarification goal is to create a harmonised safety acceptance criteria as far as is possible. The results will be documented in the PRAMS Plan (general conclusions) and ERJU RAG Overview (more detailed changes in the risk assessment methodology). **[**SPT2TRAFFIC-20502**]**

## 2.2 Specification Rules

### 2.2.1 Overall principles

1. The specification work is based on the harmonised Operational Concept and Common Business Objectives.

2. The system supports a rule-based safety logic with and without optional safety configuration:
    a. The system supports e.g. the option to pre-configure a set of routes with fixed entry and exit points to limit train movements.
    b. The specification work will not base any Traffic CS functions on legacy IXL and RBC functionality.
3. The specifications provides a clear allocation of functions to the different Traffic CS subsystems and standardised interfaces between them. The expected system behaviour of the different subsystems are predictable and therefore support exchangeability of the subsystems. The integration effort is low, even if the subsystems are provided by different suppliers.
4. The specifications allows for a standardised interface to systems adjacent to Traffic CS, such as TMS, Trackside Assets Object Controllers or the Operators workbench. The expected system behaviour of Traffic CS shall be predictable and therefore support exchangeability of the systems. The integration effort shall be low, even if the systems are provided by different suppliers.
5. The specification is written to allow the harmonised operational rules to be independent of the technical implementation, for all configuration options. That means the operational rules defined per actor using the system, such as Signaller or Train Driver, apply for any implementation.
6. Traffic CS only requires input from TMS in the form of the Operational Plan. The Operational plan data structure is independent of rule-based safety logic or rule-based safety logic with safety configuration options. The schedule calculation in TMS will however need to take into account limitations from safety configuration options.
7. The specification reduces the national integration effort as much as possible, e.g. by enabling the re-use of existing infrastructure and trackside asset installations.

[SPT2TRAFFIC-20503 ]

### 2.2.2 Black Box Principle for subsystem specifications

The Traffic CS subsystem specifications follow a black box approach. A black box approach involves specifying subsystems in terms of their inputs and computed outputs depending on subsystem states and functional relationship between them. This allows for a specification that can be functionally tested on the interfaces but does not limit supplier innovation and optimisation of internal design. It also allows for an unambiguous, testable and maintainable specification. Black box testing is specification based testing, either functional or non-functional, without reference to the internal structure of subsystems. Subsystems are 'loosely coupled' enabling maintainability, evolvability, upgradeability, exchangeability and scalability. [SPT2TRAFFIC-20504 ]

The black box principle applies only to the internals of the subsystems. The configuration data (especially track topology and engineering data) is clearly separated from the subsystem functionality and will have a harmonised format (ERA ontology, managed in System Pillar by CONEMP domain). Infrastructure Managers will retain control over creation, update and validation of configuration data, and there will be efforts made to ensure the generic safety case applies regardless of the data supplied (i.e. applicable in all allowable configurations of the system). The system configurations will be deployed with a coordinated mechanism via SMI interface to each concerned subsystem (e.g. ETPS, ATO-TS, Object Controller). [SPT2TRAFFIC-21287 ]

## 3 Glossary

To ensure acceptance by the sector, the Traffic CS specification should be understandable by signalling experts with no prior experience with the System Pillar. To help this understanding, both existing and new terminology is used, which can be found in the included glossary. This glossary is based on the following references:

- OD + Traffic CS Glossary
- ERA Railway Terminology Collection priority glossary
- EULYNX Glossary

**[**SPT2TRAFFIC-20505 **]**

| Term | Definition |
|---|---|
| Application Configuration Data | The Application configuration refers to use case-specific data for the Consuming Systems for a specific application. These can be detailed as SPT2TS-127776 - Infrastructure data i.e., Track edges, Track geometry, Track properties, Segment Profiles, etc. and SPT2TS-127777 - Vehicle data i.e., Braking and Traction efforts, Rolling coefficients, etc. |
| Area of Control | The Area of Control is a geographical limited area including Trackside Assets where the technical and operational responsibility lies with a specific SPP-43548 - CCS System. |
| Basic Integrity Level | Integrity attribute for safety-related functions with a TFFR higher than (less demanding) 10−5.h−1 or for non-safety-related functions. |
| CCS System | The Control Command and Signalling (CCS) system covers signalling, train control, positioning equipment and telecommunications. |
| Claim, Claims | General notion to express that a track extent is used by or reserved for an object. For instance, a *Movement Permission* would claim its full track extent, including any *Points* in a certain position. Or a *Usage Restriction* claims its extent so that it cannot be used in a conflicting way (higher speed, for instance).<br><br>A track extent consequently can only be used, if there is not any conflicting *claim*.<br><br>This notion is more general and implementation-independent than *lock* which already somehow suggests a boolean flag and tempts to assume that there can only be one *claim*. |
| Configuration Data | The (CCS/TMS) Configuration Data refers to a conglomerate of different configuration data required for CCS/TMS systems. These can be broadly classified as SPT2TS-127773 - Application Configuration Data, SPT2TS-127774 - System Configuration Data and SPT2TS-127775 - Software Configuration Data. CCS/TMS Configuration Data is provided via the configuration interface to the CCS/TMS Systems. The configuration data is assumed static within a version and changes occur only when there is a version change or increase, opposite to dynamic data, which may change within a configuration version of the system. |
| Consist | A consist is a rail vehicle or a sequence of coupled rail vehicles. |
| Danger Point | The location beyond the End of Movement Authority that can be reached by the front of the train without creating a hazardous situation. |
| Domain Model | Entity Relationship Model (ER Model or ERM) of entities (*Domain Objects*) and their relations within the railway *Traffic CS* domain.<br>*Concept: ETPS Specification patterns - Detail, Domain Model, Safety Rules* |
| Domain Object | A Domain Object is an instance of an entity from the Domain Model. It can represent real world objects such as Trackside Assets and control objects e.g. Movement Permissions. |
| Dynamic Train-Centric Control | A train-centric, communications-based train control system with continuous, automatic train control and protection system. Movement authorities are dynamically computed to any permissible location, independent of fixed blocks or predefined routes. Dynamic Train-Centric Control enables a train to receive movement authority to any permissible location on the infrastructure, provided that the movement complies with the applicable Safety Rules. This capability removes the inherent constraints of traditional block-based signalling, where |

| Term | Definition |
|---|---|
| | movements are limited to fixed, pre-defined block sections.<br>Dynamic Train-Centric Control combines route protection and train control features. Based on the operational plan obtained from the TMS, Traffic CS will allocate a **Movement Permission for the designated train** and determine the Movement Authority for the designated train. This is different from the current approach where train authorisations are determined for predefined routes that have been set by an IXL. |
| European Railway Traffic Management System | European Railway Traffic Management System (ERTMS) is a single European signalling and speed control system that ensures interoperability of the national railway systems, reducing the purchasing and maintenance costs of the signalling systems as well as increasing the speed of trains, the capacity of infrastructure and the level of safety in rail transport. (ERA definition) |
| European Trackside Protection System | The Trackside Protection System is the core system of Traffic CS, implementing the safety critical functions. The Trackside Protection System controls all Trackside Assets Control and Supervision (TACS) connected to ETPS, for example points, level crossings, and manages Movement Permissions for trains, whilst maintaining the safety of the railway. |
| FOULING POINT | The place where a vehicle standing on a converging line would come into contact with a vehicle on the other line. |
| Geometric Safety Logic | The Geometric Safety Logic is a safety logic which is train-oriented, in contrast to traditional block-oriented safety logic.<br>In train-oriented safety logic, direct train information is evaluated, where block-oriented safety logic, indirect information of an occupation is used.<br>That greatly simplifies the safety logic as it has not to make complicated mapping from occupations to trains. |
| INTERLOCKING | A general term applied to the controlling of the setting and releasing of “signals” and “points” to prevent unsafe conditions arising, and equipment which performs this function. |
| Infrastructure Manager | Means any body or undertaking that is responsible in particular for establishing and maintaining railway infrastructure. This may also include the management of infrastructure control and safety systems. The functions of the infrastructure manager on a corridor or part of a corridor may be allocated to different bodies or undertakings |
| Infrastructure data | Infrastructure Data is a detailed digital representation of the railway network that contains all infrastructure related information necessary for planning and performing railway operations, such as infrastructure characteristics, location and details of Field Elements, etc. The Infrastructure Data is static and remains unchanged until intended infrastructure updates occur. Infrastructure data is provided by the RINF represented by ERA ontology to be extended. |
| Legacy system | A legacy system is a system built without using SERA system specifications. It can use Class A or Class B train protection, e.g. interlocking with national light signals or interlocking with national ETCS L2 implementation without SERA operational rules. |
| Linear Element | Linear element is a linear object that defines an uninterrupted stretch of a railway track without divergence or convergence. A linear element is defined along the centre line of the 2D or 3D track alignment and has a finite length. A LinearElement is associated with NetRelation to determine navigabilities between linear elements.<br>The linear elements have an implicit direction. This direction is defined with respect to their start and end locations. The default orientation direction is start to end. The start of track edge is |

| Term | Definition |
|---|---|
| | identified as the point where length is 0 and the end of track edge is identified as the point where length is maximum. The maximum length is given by the parameter 'length' in LinearElement class. The start/end of linear element shall correspond to the location of a simple point (switch), or any form of end of track. The start/end of linear element corresponds to the tangent/secant point or the geometric start location of a simple point. |
| Linear Element Section | A Linear Element Section is a simple container for three attributes defining part of a LinearElement. It is used by other objects as supporting data-object (e.g. LinearElementGauges). Linear Element Sections have reference points defined to indicate their start and end locations. The reference points are defined using distance skips from start and end of linear elements. The starting/ending point is to calculated as a distance increment/decrement from start/end of linear element respectively. Linear Element Section is always limited to one linear element i.e., they cannot be defined over multiple linear elements. |
| MOVEMENT AUTHORITY | Permission for a train to run to a specific location within the constraints of the infrastructure. |
| Movement Permision | A Movement Permission is a discrete domain object that defines and secures the request ed/reserved operational path of a designated Train Object. It replaces the traditional split between route setting, signalling, and train control by integrating them into one unified concept.<br><br>Key characteristics:<br>· **Basis for Movement Authority**: An MP provides the trackside foundation from which an ETCS Movement Authority (MA) is derived and transmitted to the train.<br>· **Lifecycle**: MPs are created upon request, checked against topology and safety conditions, granted, supervised, and continuously updated (extended, shortened, upgraded, or removed).<br>· **Integration**: By merging route protection and movement granting, the MP enables efficient infrastructure use, reduces unnecessary locking of track elements, and supports flexible, automated operations.<br><br>Key Elements of the Movement Permission:<br>• **SPP-43549 - Reserved Path**<br>• **SPP-43551 - Permission Extent**<br>• **SPP-38086 - Risk Buffer**<br>• **SPP-44499 - Risk Path / Flank Protection**<br><br>A diagrammatic representation can be found here: SPT2TRAFFIC-20559<br><br>Movement Permission is not an “allowance to proceed” but **a dynamic, safety-checked allocation of infrastructure to a specific train movement**, forming the essential prerequisite for issuing a Movement Authority in ETCS.<br>Any infrastructure being part of the Movement Permission are logically locked and all elements are monitored in the defined position. |
| Moving Block | Moving block is a concept where Movement Authorities can end at any location on the track. The Safe Train Extent of each train moves with that train based on its reported position and train integrity status and is not constrained to fixed block locations. |

| Term | Definition |
|---|---|
| NetAreaReference | A NetAreaReference groups an arbitrary number of NetLinearReferences. The sections don't have to be connected / adjacent to each other. The Track Area groups the sections to a logical entity, usually to illustrate a technical or functional context. |
| NetLinearReference | Net Linear Reference defines a continuous path between two given reference points through different interconnected linear elements. The reference points are defined using TopologicalCoordinates. The NetLinearReference is only a container for directed edges, so it does not have an id and is used in other packages in composition-attributes. |
| Non-Trackbound Object | A Non-Trackbound Object is not limited to the railway track (e.g. e.g., construction equipment, track worker) |
| Operating State | The Operating State is the logical real-time representation of the actual state of the physical railway system in the Area of Control (e.g. information about the currently operating Train Units, the occupation of tracks, or the settings of Field Elements).<br>The knowledge about the Operating State enables TMS to keep itself current with the operational situation in the Area of Control and to recognise deviations from an Operational Plan during execution. |
| Operational Movement | An Operational Movement is part of the Operational Plan, and consist of a timetable or train service specifying when and where particular events are to take place. Some of these events could be a commercial stop, a run through over certain location or even a change of train composition or a handover to another Traffic Management System. The most simple way of representation of such timetable is in a tabular form indicating station or run through location, and arrival and departure time. More events could be associated a certain stations or locations depending on the Railway Undertaking needs. The Operational Movement is defined in such a way that the final user (passenger or freight company) knows if a particular timetable suits his/her needs. |
| Operational Plan | The Operational Plan is the result of the planning process performed by TMS. An Operational Plan will be issued by the TMS for any operationally relevant activity. This comprises all movements of Physical Train Units incl. shunting operations (Operational Movement), restrictions due to e.g., infrastructure maintenance and construction works, and warning measures during restrictions. |
| Parameter Data | Parameter Data define the system configuration data required for national and supplier-specific operative environments. A notable example of such data are ETCS national values. ETCS national values may be required for migration purposes and shall be replaced by SERA standardised values in the target system. |
| Permission Extent | The Permission Extent is a linear contiguous stretch of track that is part of the Reserved Path which defines up to which location (End of Movement Authority) the Movement Authority is granted.<br>The Permission Extent is part of the Movement Permission.<br><br>Note: The Permission Extent is always updated together with an updated Movement Permission. The Permission Extent can be shorter than the Reserved Path. The Permission Extent and the available Risk Buffer are translated to an authorisation (e.g. Movement Authority). |
| Plan Execution System | The Plan Execution System is a subsystem of Traffic CS which is responsible for:<br>• processing the Operational Plans provided by the TMS, which are based on the Operating State of the railway within the Area of Control and |

| Term | Definition |
| --- | --- |
| | • providing the Operating State within the Area of Control received from Trackside Protection System towards the TMS. |
| Position Report | The "Position Report" (PR) is a structured message sent from the train's On-board CCS (OBU) to the trackside CCS (such as the RBC). This report communicates the estimated position of the train, including its precise location, direction, speed, and other relevant status information. The Position Report allows the trackside system to continuously track the train's progress, ensure safety, and allocate new movement authorities accordingly. Position Reports are fundamental to ETCS because they enable accurate, real-time management of train movements without relying on trackside detection equipment. |
| RADIO BLOCK CENTRE | A centralised safety unit that receives train position information via radio and sends movement authorities via radio to trains. |
| Railway Vehicle | A single item suitable for circulation on wheels on railway lines, e.g., wagon or traction unit |
| Reserved Path | A *Reserved Path* is a linear contiguous stretch of the track that is reserved for the movement of a train.<br>The *Reserved Path* can be used for an authorisation to move a train according to /ETCS/ - Subset-026 (e.g. a Movement Authority that is transmitted to the train).<br>The *Reserved Path* is part of the Movement Permission. |
| Risk Buffer | The *Risk Buffer* is a linear contiguous stretch of track that serves as the overrun protection to avoid an accident e.g. if the train brakes do not perform as well as expected and as a safety buffer in the event of a rollback of a chased train. The Risk Buffer is part of the Movement Permission.<br>A *Risk Buffer* exists if there is a Danger Point or project-specific safety margin greater than zero. |
| Risk Path | A *Risk Path* is one potential path (a linear contiguous stretch of track) by which a non-permitted vehicle movement could result in a flank collision with a vehicle moving along the *Movement Permission (the Reserved Path)*.<br>A Movement Permission can contain zero or more *Risk Paths*. |
| SERA Enablers | The development of the SERA Target functionality is a long-term process. In this process standalone functional units so-called "SERA Enablers" are developed belonging to the SERA Target system. Individual SERA Enablers might be suitable for early rollout in legacy projects, which still use national specifications and legacy systems. Therefore, SERA Enablers are standalone subsystems having standardized interfaces, which are specified, developed, tested and approved according to the needs of the SERA Target. If needed, adapters can be used to integrate them in legacy systems (part of migration strategy).<br>Currently identified SERA Enablers are:<br>• Object controllers with SP Standard interfaces (partially based on EULYNX)<br>• PES and ETPS with SP Standard interfaces (i.e. SCI process interfaces and service interfaces SDI, SMI and SSI)<br>• Central services with SP Standard interfaces (i.e. service interfaces SDI, SMI and SSI), which provide supporting functions for operation of SERA systems: configuration, maintenance and Service Function Configuration, security, communication.<br>• TMS with SP Standard interfaces (i.e. SCI-OP process interface and service interfaces SDI, SMI and SSI)<br>• FRMCS for radio communication, replacing GSM-R<br>• Safe train integrity and train length information of rolling stock, enabling safe traffic control for mixed traffic |

| Term | Definition |
|---|---|
| | • ATO-TS ( for ATO GoA1/2) with SP Standard interfaces (i.e. SCI process interfaces and service interfaces SDI, SMI and SSI), based on harmonized operation concept and related rules |
| SERA Phase | The SERA Phase is a deployment phase, which starts when the SERA Target - comprising all SERA Enablers (refer to SERA Enablers list in Glossary) - is ready (i.e. tested and approved) for implementation (rollout) in projects. The key SERA Enabler will be the moving block with the DTCC safety principle (either implemented with GSL or CBTC based solutions) based on the harmonized operation concept and related rule set.<br>In this context the trackside infrastructure is equipped for moving block (allowing TDD reduction) enabling degraded modes and mixed fleet operation (i.e. parallel movement of equipped and non-equipped trains with or w/o safe train length and integrity).<br>Core elements for rollout of the SERA Target are the subsystems ETPS and PES (ATO-TS optional) plus the related process interfaces SCI between them and to the adjacent systems like:<br>• TMS<br>• Operators Workplace<br>• Object Controllers.<br>Additionally, also adjacent auxiliary systems and related interfaces SDI, SMI, SSI plus related tools (e.g. for engineering, testing, simulation) must be available as well. For example, these auxiliary systems are:<br>• Central services, which provide supporting functions for operation of the core systems: configuration, maintenance and Service Function Configuration, security, communication. |
| SERA Pre-Phase | The SERA Pre-Phase is a deployment phase, which starts when the first SERA Enablers (belonging to the SERA Target; see SERA Enablers list in Glossary) are ready for implementation (rollout) in projects, where legacy subsystems can be replaced already by equivalent SERA Subsystems. Such projects still use national specifications and legacy systems. This approach forms a significant part of the overall migration strategy towards SERA.<br>As a sample this might comprise the early introduction of certain SERA Enablers like object controllers having SP Standard interfaces (based on EULYNX) in combination with legacy system components (supporting legacy L2/FB/FVB principles; optional ATO GoA2).<br>This allows early benefitting - during the long-term SERA Development process - from their advantages (e.g. performance increase and cost reduction) and ensures protection of investment<br>The gradual rollout of those SERA Enablers is part of the migration path towards the later SERA Phase and its target system. SERA Enablers in this pre-phase must be functional units of reasonable size and standalone testable and approved - e.g. like an SERA ready object controller unit. Related migration use cases and concepts are specified in separate SP Documents. |
| Safe Train Extent | The Safe Train Extent represents the extent of the track that may be occupied by a connected train. It is calculated from train-side information (Confirmed Rear End and Max Safe Front End derived from the ETCS Position Report) and track-side information (track vacancy proving sections like track circuits or axle counters), taking into account the most recent information available from these train- and track-side information sources. |

| Term | Definition |
|---|---|
| | Remarks:<br>• The Safe Train Extent for a train will be updated when new information becomes available.<br>• For a moving train, it is likely that the train will move outside the Safe Train Extent between updates |
| Service Function Configuration | The Service Function Configuration (SFC) is the implementation of the Configuration Management System.<br>The SFC is a central location technical system that is responsible for managing the BuildingBlock Configurations.<br><br>Each BuildingBlock deployment is managed by exactly one SFC. |
| Single European Railway Area | Defining the fundamental design principles and process for adopting a functional architecture for rail as a system, with a focus on CCS, CMS and TMS supporting the implementation of the SERA (Single European Railway Area) |
| Software Configuration Data | The Software Configuration data refers to executable binary files from suppliers which are usually required to install software on the systems. Software Configuration Data is provided via configuration interface to the CCS/TMS Systems. |
| Subsystem - Maintenance and Data Management | The Subsystem - Maintenance and Data Management performs the services required for the operation of the EULYNX System. Service functions may be provided also to the adjacent systems. |
| Switchable Trackside Asset | A Switchable Trackside Asset is a Trackside Asset that enables (for example, points, derailers, movable bridges, gates) or allows (for example, border light signals, level crossings) the continuation of movement beyond this asset when it is set and controlled to a particular state. In the TCCS data model a Switchable Trackside Asset is the representation of a physical switchable trackside asset that comprises a group of Switchable Trackside Asset Sections (STAS). |
| Switchable Trackside Asset Section | The Switchable Trackside Asset Section is one of the 1..n driveable paths within a Switchable Trackside Assets. |
| System Configuration Data | The System Configuration data refers to the static data set required to configure systems with primary information before being put into operation. These data are elaborated as SPT2TS-127829 - Parameter Data |
| TRAIN DATA | Defined set of data which gives information about the train. Data that characterises a train and which is acquired by ERTMS/ETCS in order to perform a mission. |
| TVP section | The status of a TVP section indicating the presence of a rail vehicle. |

| Term | Definition |
|---|---|
| , occupancy | |
| Track Vacancy Proving Section | EULYNX synonym for TTD section, see: SPP-38146 - Trackside Train Detection |
| Trackbound Object | A Trackbound Object is composed of one or several railway vehicles that are physically linked together, that can only move on the railway track. |
| Trackside Asset | Trackside Assets are elements on or near the track which are used to monitor (using sensors) and/or control (using actuators) the movement of vehicles through the railway network to provide a safe route through the railway network. They can be switchable or non-switchable and are controlled by the actors Trackside Asset Control and Supervision. |
| Trackside Asset Control and Supervision | They refer to the controllers of SPP-38145 - Trackside Asset, synonymous to the EULYNX definition of Object Controllers. Not to be confused with the System Pillar Domain "Trackside Assets CS". |
| Trackside Train Detection | Trackside Train Detection is a system which determines the occupancy status of TTD sections. TTD section may be a Track Circuit or an Axle Counting system section. EULYNX synonym for TTD section: SPP-46354 - Track Vacancy Proving Section |
| Traction Unit | A powered railway vehicle able to move itself and other railway vehicles to which it may be coupled |
| Traffic Control and Supervision | Traffic Control and Supervision is the CSS Trackside System in charge of the control and supervision of the Railways Traffic. It includes ETCS Trackside and ATO Trackside. |
| Train | A train is defined as (a) traction unit(s) with or without coupled railway vehicles with train data available operating between two or more defined points. |
| Train Integrity Monitoring System | A technical system that supervises SPLI-1087 - TRAIN INTEGRITY |
| Train Object | Train Object is the object created by the CCS system to manage the connected trains. It stores the information needed by the subsystems referring to the connected train (e.g. Onboard ETCS identity, Validated train data, Safe Train Extent). |
| Train Position Report | The term Train Position Report refers to either Position Report packet (packet number 0) or Position Report based on two balise groups packet (packet number 1) according to /ETCS/ - SUBSET-026, chapter 7. Also see SPP-26782 - Position Report. |
| Unresolved Trackb | |

| Term | Definition |
|---|---|
| ound Object | Unresolved Trackbound Object is the object needed by ETPS to manage occupancies of track areas where track vacancy is not proven and that cannot be associated with a connected train (Train Object). |
| Unresolved Trackbound Object Extent | Unresolved Trackbound Object Extent is the extent of the track that may be occupied by a railway vehicle not associated to a Train Object, i.e. it cannot be directly associated to a Safe Train Extent. |
| Usage Restriction | A Usage Restriction (UR) limits or constraints operation on a part within the Area of Control. URs can be created according to an Operational Plan (e.g. for enabling construction works) or in response to an incident (e.g. as a mitigation measure). There are various limitations possible for a UR, e.g. speed restriction, full track closure or deactivate automatic operation.<br><br>Older term: Usage Restriction Area (URA) |
| Vehicle data | Vehicle Data is a detailed definition of the static train/vehicle characteristics used for the parametrisation of the CCS on-board. The parametrisation variables include but are not limited to train data, braking curves and coefficients, operation of service brake, unique ID (NID_ENGINE), operated ETCS levels, odometry system settings, network / bus settings, distance between balise antenna and front end, available traction systems, operated track condition functions, displayed information on DMI, etc.Vehicle data is provided by the ERATV/ RDV represented by ERA ontology to be extended. |
| Wagon | A railway vehicle without traction. It can be either a freight wagon capable of carrying good or a coach capable of carrying passengers. |
| Wayside Monitoring System | Wayside Monitoring Systems are used for diagnostic and maintenance purposes as well as for hazard identification. In this context WMS Systems are applied for monitoring of rolling stock (vehicles) and/or the wayside infrastructure.<br><br>Some examples include (not exhaustive):<br>Acoustic Bearing Defect Detectors<br>Avalanche detection<br>Hot axle box detection. |
| Standard Communications Interface – Operational Plan | Standard Communications Interface – Operational Plan |



## 4 Abbreviations

| Abbreviation | Definition |
|---|---|
| ASTP | Advanced Safe Train Positioning |
| AoC | Area of Control |
| BIL | Basic Integrity Level |
| CBO | Common Business Objective |
| DTCC | Dynamic Train-Centric Control |

| Abbreviation | Definition |
|---|---|
| ERTMS | European Railway Traffic Management System |
| ETPS | European Trackside Protection System |
| GSL | Geometric Safety Logic |
| GUI | Graphical User Interface |
| IM | Infrastructure Manager |
| LES | Linear Element Section |
| MA | MOVEMENT AUTHORITY |
| MB | Moving Block |
| MDM | Subsystem - Maintenance and Data Management |
| MP | Movement Permission |
| O-IF | Operator Interface |
| OB | On-Board |
| PES | Plan Execution System |
| PR | Position Report |
| RBC | RADIO BLOCK CENTRE |
| SCI-CMD | Standard Communication Interface - Command |
| SCI-IO | Standard Communication Interface - Input Output |
| SCI-LC | Standard Communication Interface - Level Crossing |
| SCI-LS | Standard Communication Interface - Light Signal |
| SCI-OP | Standard Communications Interface – Operational Plan |
| SCI-P | Standard Communication Interface - Points |
| SCI-SCMD | Standard Communication Interface - Safety-relevant Command |
| SCI-TDS | Standard Communication Interface - Train Detection System |
| SCI-TWS | Standard Communication Interface - Trackworker Safety System |
| SERA | Single European Railway Area |
| SFC | Service Function Configuration |
| SPRA | System Pillar Reference Architecture |
| SSS | Shared Security Service |
| STA | Switchable Trackside Asset |
| STAS | Switchable Trackside Asset Section |
| STE | Safe Train Extent |
| TA | Trackside Asset |
| TACS | Trackside Asset Control and Supervision |
| TFFR | Tolerable Functional Failure Rate |
| TIMS | Train Integrity Monitoring System |
| TO | Train Object |
| TPR | Train Position Report |
| TTD | Trackside Train Detection |
| TVPS | Track Vacancy Proving Section |
| Traffic CS | Traffic Control and Supervision |
| UID | Unique Identifier |
| UR | Usage Restriction |
| UTO | Unresolved Trackbound Object |
| UTOE | Unresolved Trackbound Object Extent |
| WMS | Wayside Monitoring System |

# 5 Determining Track Occupancy

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , Adomeit, Sven (SMO RI R&D TC PE) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |

## 5.1 Introduction

Whilst the infrastructure occupancy functionality focuses on localising objects and their extents, safety critical functions (granting a movement authority or moving a point etc.), requires the signalling system to prove that there is no train at any given location i.e. that the track is clear. ETPS safely manages localising objects, ensuring that all physical objects have a corresponding occupancy to safely determine that sections of the track are clear. **[**SPT2TRAFFIC-20347 **]**

Railway vehicles not equipped with ETCS, for example wagons or construction equipment, can be detected using Trackside Train Detection (TTD) systems. Railway vehicles equipped with ETCS, in addition to being localised with TTD Systems, can transmit location information themselves.
**[**SPT2TRAFFIC-21207 **]**

The focus of this chapter is on a system operating in normal operational conditions(trains in FS,OS,disconnected) with only certain trains which have disconnected; Trains in Shunt will be covered in the future. For heavily degraded operations the system as a whole would be required to provide the signaller with train tracking(stepping TRNs based on track occupancy states) to allow the signaller to guide trains around and to allow them to call the driver. However, this is typically not a SIL4 function, so it will be decided in the future where this function is allocated within the system based on OD's operational design. There will also be a need where signaller reset / change / overwrite an occupancy state in the Operating State due to e.g. sensor failure this will also be decided in the future based on the process.
**[**SPT2TRAFFIC-21209 **]**



## 5.2 Inputs

ETPS has three sources of information from which to check where in the track is free:

- Trackside Train Detection (TTD) section occupancies
- Train Detection Points(TDP)
- ETCS Train Position Reports (TPR)

**[**SPT2TRAFFIC-20506 **]**

### 5.2.1 Trackside Train Detection

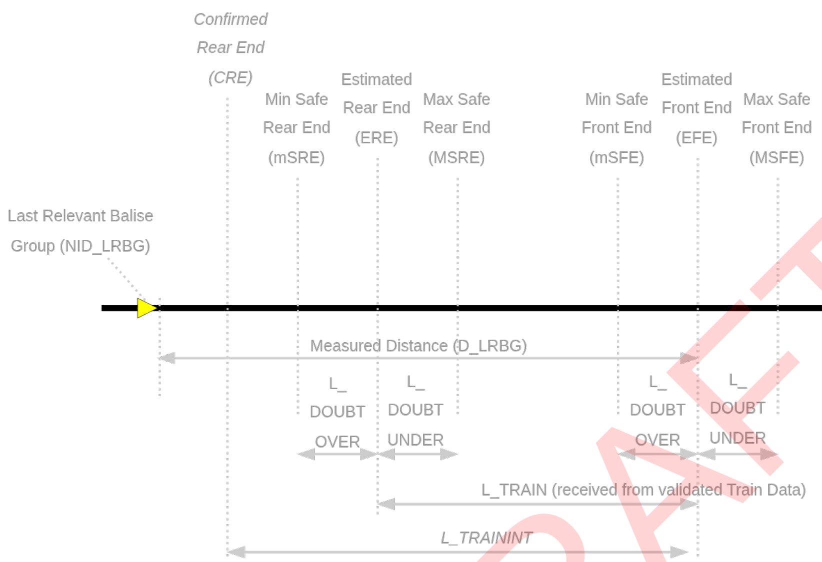
Trackside Train Detection either Axle counters or Track circuits produce occupancies for a section of track, these are most precise at the boundaries between sections but consistently accurate.
**[**SPT2TRAFFIC-21283 **]**

### 5.2.2 Train Detection Points

Axle counters provide direction information aswell, this is not normally captured in TTD section occupancy but can be captured via TDP. [SPT2TRAFFIC-21282 ]

### 5.2.3 ETCS Train position Reports

The ETCS TPR contains(Estimated Front End, L_DOUBTOVER, L_DOUBTUNDER) and mSRE, ERE and MSRE are information deduced from the L_TRAIN if it remains constant in SPT2TRAFFIC-20319 are shown below. [SPT2TRAFFIC-20525 ]




[SPT2TRAFFIC-20319 ]



## 5.3 Object Types

### 5.3.1 Train Object

A Train Object (TO) is a dynamic domain object within ETPS that represents a connected, communicating ETCS-equipped train, containing all safety-relevant attributes required to determine, supervise, and update its Safe Train Extent, operational state, and interaction with Movement Permissions discussed in Chapter 6. When ETPS has successfully established a communication session with an ETCS-OBU and has received a Start of Mission TPR, then a Train Object (TO) for this ETCS-OBU is created.It needs to be clarified if a Train Object is created on connection of a Train without a valid position. [SPT2TRAFFIC-21186 ]

Each TO stores all information ETPS needs to maintain a safe operational view, including:

- Safe Radio connection status
- Train ID (NID_ENGINE)
- Validated Train Data (e.g., L_TRAIN)
- Latest Train Position Reports
- Computed **front** and **rear end** of the **Safe Train Extent**
- Timestamp of last valid update

[SPT2TRAFFIC-21185 ]

The TO has a geometric extent which is called the **Safe Train Extent**. The Safe Train Extent is a calculated safety margin of the area that ETPS recognizes the occupying train. This extent determines which track areas/sections are clear and can be released for other trains, it is defined by:

- Max Safe Front End (MSFE)
- Min Safe Rear End (mSRE)
- Confirmed Rear End when integrity is proven
- TTD correlation where applicable

**[**SPT2TRAFFIC-21184 **]**

### 5.3.2 Unresolved Trackbound Object

A UTO(Unresolved Trackbound Object) is a dynamic domain object within ETPS that represents an area of a TTD Section which is not proven clear and cannot be safely linked to a localised communicating ETCS train. Below is The UTO has a geometric extent which is called the UTO Extent. The UTO will store the linked TrainID if it was created because of a disconnected train, although it could also not have a TrainID if it was not created because of a disconnected train. When a UTO is created because of a disconnected train at first it will be the length of the disconnected train however it may propogate either the boundary with the next clear TTD or the next know train with a Safe Train Extent. UTO propogation will need to be analysed in it's own concept in particular in regards to run-away vehicles and a safety analysis will be performed. **[**SPT2TRAFFIC-20527 **]**

## 5.4 Operating State

These objects described, with their extents, are both mapped on to the topology data and represented in the Operating state of ETPS. The topology data is from a central Service Function Configuration specified by the CONEMP domain) are represented in the Operating State. The Operating State of ETPS is continuously updated and shared with all relevant (sub)systems(e.g PES, TMS, Operators workbench etc). **[**SPT2TRAFFIC-20529 **]**

## 5.5 Lifecycle of the Train Objects and UTOs

### 5.5.1 Creating, Updating and Deleting a Train Object

There are different reasons for ETPS to create or update a Train Object:

| Create / Update Train Object | Description |
|---|---|
| Train Start of Mission position report received with validated Train Data | Occupancy extent of Train Object created from Max safe front end to min Safe rear end. For example, when receiving a position report when remembering and comparing with a previous TPR from a previous Mission only done in SoM |
| First Train Position Report when a new train is entering an area of control | When a train enters the ETPS area of control the first train position report needs to be used to locate the train within the ETPS area. |
| Update front by Train Max Safe Front End | Front of the occupancy extent of the Train Object is updated using Max Safe Front End derived from the Train Position Report |
| Update rear by Train Confirmed Rear End | Rear of the occupancy extent of the Train Object is updated using the Confirmed Rear End derived from the Train Position Report |

| | |
|---|---|
| Update rear with new value of Train Length | Rear of the occupancy extent of the Train Object is updated using the new value of Train Length. The new value of the Train Length will be used in the next TPR from the Confirmed Rear End as above |
| Update front by clear TTD | Front of the occupancy extent of the Train Object is shortened using clear TTD section |
| Update rear by clear TTD | Rear of the occupancy extent of the Train Object is shortened using clear TTD |

[SPT2TRAFFIC-20556 ]

The following reason will be used by ETPS to delete a Train Object(More reasons will be added when additional functionalities (e.g. level transitions, etc.)):

| Delete Train Object | Description |
|---|---|
| Train is no longer communicating with ETPS after End of Mission | ETPS considers that this train is no longer in communication after End of Mission and removes the Train Object from Operating State and would create a UTO in its place. |
| Train having left the ETPS Area of Control | ETPS considers that the train is no longer in its Area of Control and will remove the Train Object from the Operating State. |

[SPT2TRAFFIC-20516 ]

### 5.5.2 Creating, Updating and Deleting a UTO

A UTO will be created if there is a TTD Section Occupancy that cannot be associated with a ETCS OBU. Examples of when this could be, is that a Train which had a corresponding Train Object has perfomed End of Mission. Another one could be that it is unable to connect as it is a vehicle such a wagon. UTO will be deleted when the TTD Section Occupancy can be associated with a ETCS OBU (for example Start of Mission is performed) or the Section can be assured clear via Sweeping or if the underlying TTD is clear. Clearing UTOs via Sweeping or if the underlying TTD is cleared will be clarified in a future concept. [SPT2TRAFFIC-20518 ]

## 5.6 Handling Asynchronous Occupancy Information

In systems using occupancy information from both TPRs and TTD Sections, it is likely that updates of the occupancy information are not received at exactly the same time or based on the same position. For example if a train enters a new TTD section the TTD occupancy information is sent before a train sends a new TPR(or vice versa). TTD provides occupancy information of a section, whereas TPR is the train front end information (not linked to the TTD section limits). [SPT2TRAFFIC-20520 ]

ETPS, in accordance with SUBSET-026, must be able to handle the following situations in a way that ensures a consistent Safe Train Extent:

- A TTD section becomes occupied before the train reports a position within that section.
- A train reports a position within a TTD section before the TTD section becomes occupied.
- A TTD section becomes clear after the train has physically left the section but before the train reports a position beyond the section limit.
- A train reports a position clear of a TTD section before the TTD section becomes clear

[SPT2TRAFFIC-20522 ]

## 5.7 Train Occupancy Examples

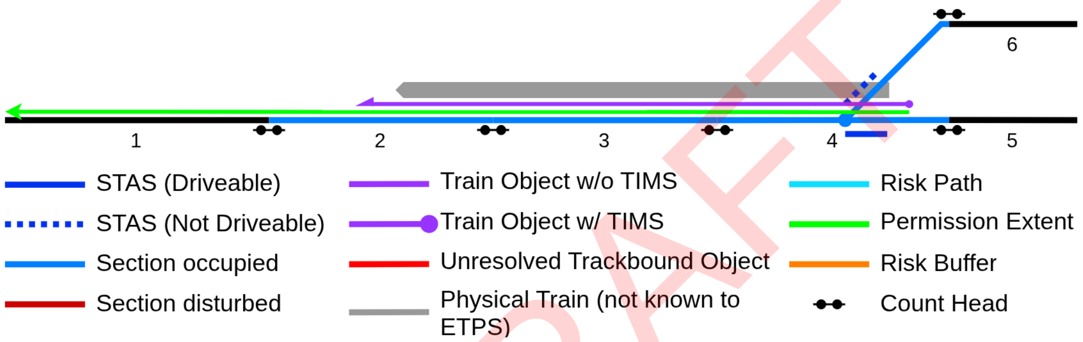
The following section contains a selection of examples to show the application of the above concept to common scenarios. They illustrate how TOs or UTOs are created,deleted or updated.
**[**SPT2TRAFFIC-20524 **]**

### 5.7.1 Example 1

SPT2TRAFFIC-20290 shows a train object which is equipped with ETCS OBU and TIMS. Train T1 comes to a halt. Three adjacent TTD sections were clear before being occupied by train T1.

- The occupancy extent is represented as Train Object
- The TTD subsections at the front and at the rear of TO can safely be regarded as clear, hence no need to create UTO's.

**[**SPT2TRAFFIC-20507 **]**



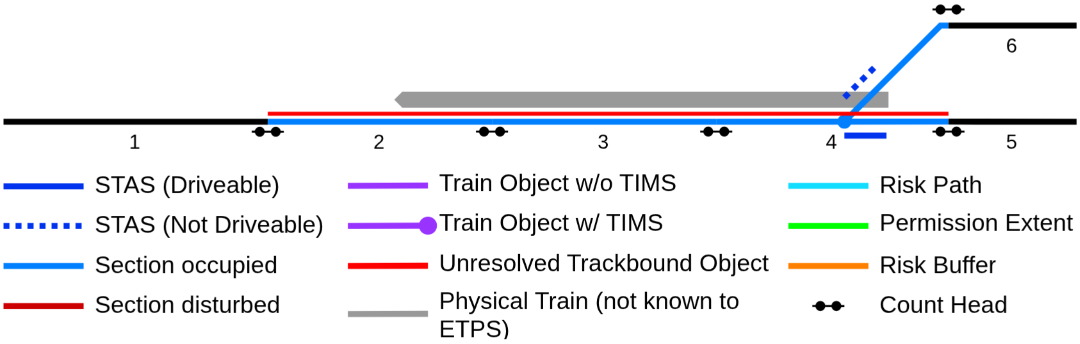

**[**SPT2TRAFFIC-20290 **]**



SPT2TRAFFIC-20318 shows the Train Driver performs End of Mission, terminating the communication between ETCS OBU and ETPS.

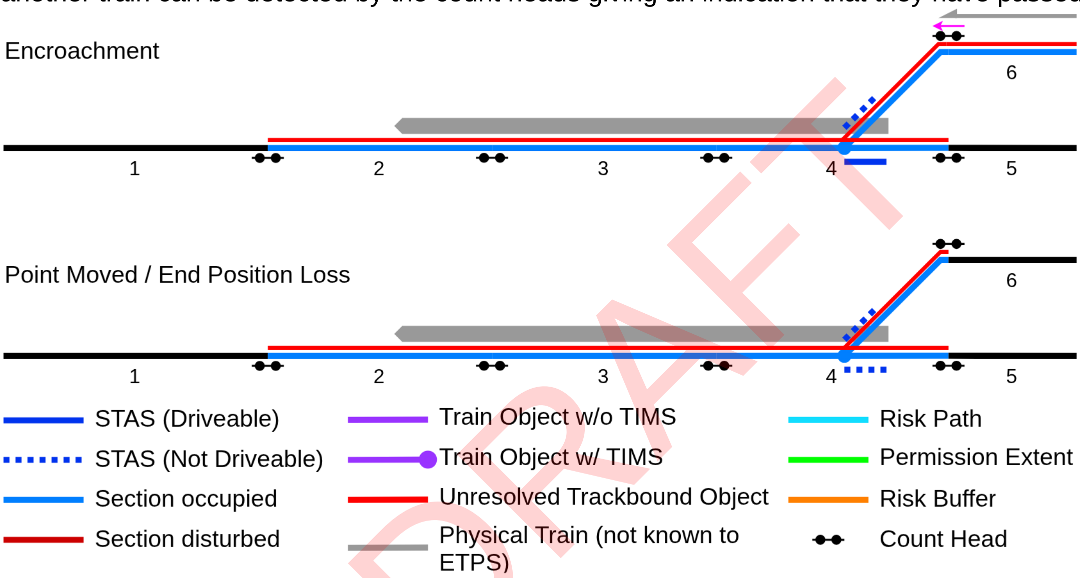
- ETPS deletes due to the loss of communication (there is a configurable relative time until a loss of communication leads to the deletion of a TO)
- The deletion of means that there are occupancy extents remaining without additional information about the cause, hence ETPS creates one or multiple UTO's.
- Please note that the UTO in this example is only created in the right branch of the point in section 4. Creating one in the left branch would be obstructive. One example is a connection of parallel tracks where one point is covered by a UTO and a train run shall happen on the other track. If the UTO covered both branches, Flank Protection would become difficult.

**[**SPT2TRAFFIC-20508 **]**




[SPT2TRAFFIC-20318 ]

Keeping the UTO on only one branch can only work as long as the point remains in the original position (neither moved nor end position lost) and no other vehicle entered the section. This encroachment of another train can be detected by the count heads giving an indication that they have passed.






[SPT2TRAFFIC-21173 ]

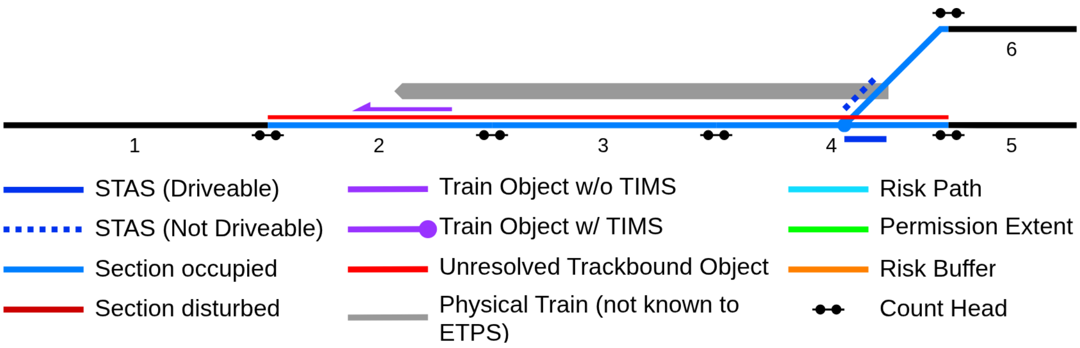
### 5.7.2 Example 2

SPT2TRAFFIC-20533 shows the next Train Driver performs Start of Mission of Train T1
[SPT2TRAFFIC-20509 ]

Start of Mission TPR message not indicating TIMS is sent to ETPS and a new TO created by ETPS in Operating State:

- Available train data is stored in TO
- The occupancy extent of TO is the distance between max safe front end and min safe front end

[SPT2TRAFFIC-21308 ]



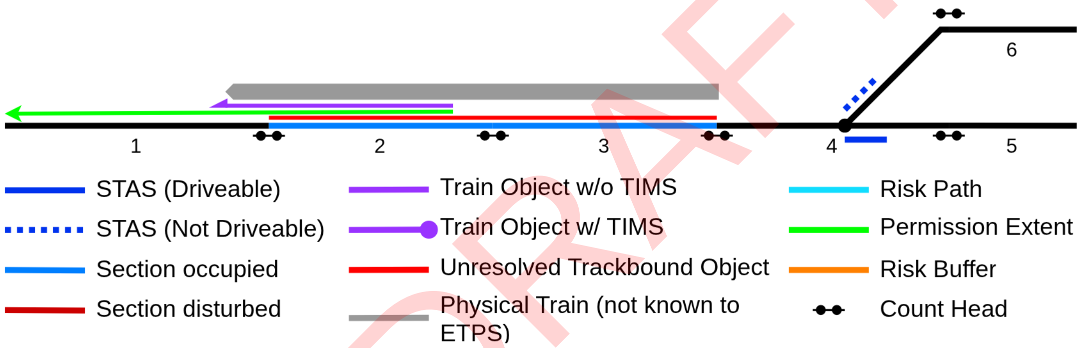

**[**SPT2TRAFFIC-20533 **]**

### 5.7.3 Example 3

SPT2TRAFFIC-20531 shows Train T1 starts moving (after having received an MA):

- Every TPR received after Start of Mission and when starting a movement, will potentially lead to an update of TO through ETPS is deleted after the TTDSection has been cleared

**[**SPT2TRAFFIC-20532 **]**




**[**SPT2TRAFFIC-20531 **]**



## 6 Movement Permissions

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , Adomeit, Sven (SMO RI R&D TC PE) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |

### 6.1 Introduction

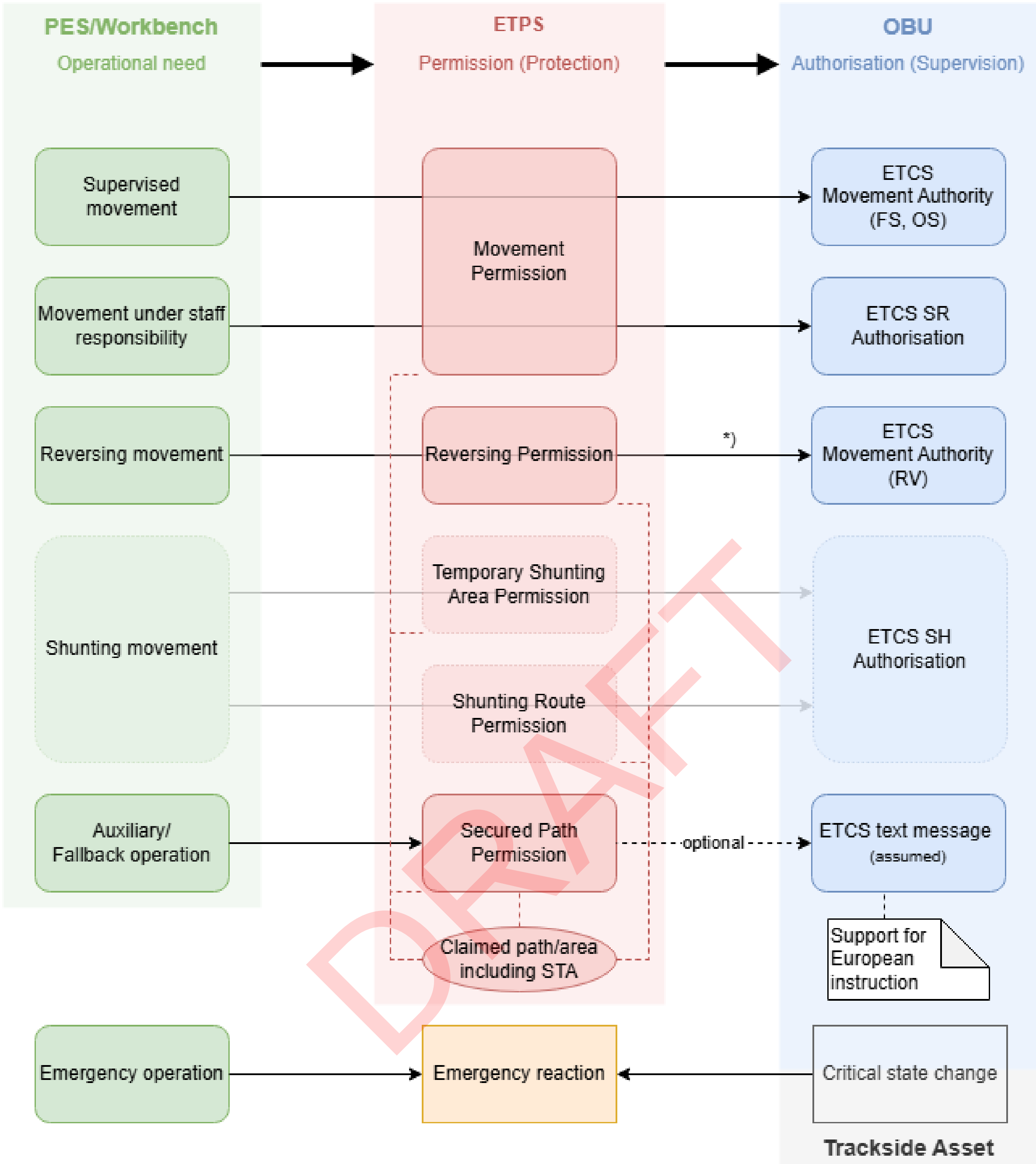
A Movement Permission (MP) encompasses the infrastructure reservation and locking of track elements, train separation as well as train protection for a specific train. A MP represents the safe assignment of track elements to be used for a specific train movement. An MP Request is compiled in PES using applicable safety rules, and then sent to ETPS, that checks the MP Request against applicable safety rules. When the safety rules are met, ETPS authorises that specific train movement.The Movement Permission concept follows the Dynamic Train-Centric Control approach described in the System Concept: **[**SPT2TRAFFIC-20544 **]**

Dynamic Train-Centric Control (DTCC) combines route protection and train control features. Based on the operational plan obtained from the TMS, Traffic CS will allocate a Movement Permission and determine the Movement Authority for the specific train. This is different from the approach where train authorisations are determined for predefined routes that have been set by an interlocking.
Dynamic Train-Centric Control permits movement ending at any location on the track (as long as this movement is allowed by the set of Safety Rules). I.e. it moves away from traditional block based systems that primarily depend only on signals, track vacancy section occupancy, established routes, and specific national regulations. **[**SPT2TRAFFIC-11716 **]**

Dynamic Train-Centric Control can be implemented in different ways as long as full compliance to the harmonised system specification, harmonised subsystem specifications and harmonised interface specifications is ensured. **[**SPT2TRAFFIC-11717 **]**

### 6.2 Movement Permissions Overview

The following diagram shows the different types of permissions to authorise train movements. Going from left to right the operational need is converted to a particular permission (ETPS) that generates the appropriate authorisation for the train onboard system. Note this document version has not yet specified all permission and authorisation types e.g. shunting movements.



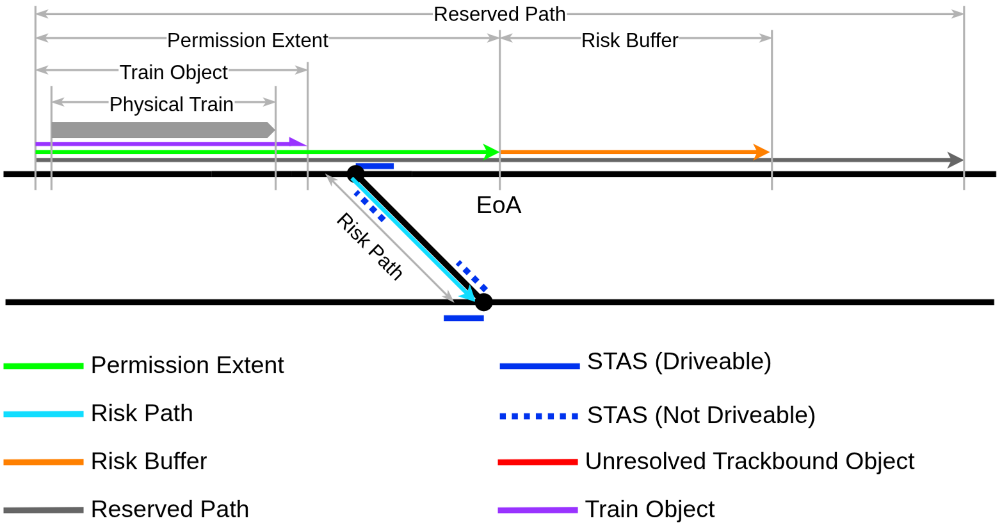



*) Provided as *Reversing Area* wherein the Train Driver can select RV mode
**[**SPT2TRAFFIC-20540**]**

It is important to note that there is a difference between Permission and Authorisation. The Permission reserves an extent on the railway track for use by a specific Train. In normal operation, this leads to an Authorisation sent to the Train. If an automatic authorisation cannot be sent to the Train , the Permission remains, ensuring that no other contradicting MPs can use that extent on the railway track. **[**SPT2TRAFFIC-20539**]**

### 6.2.1 Elements of a Movement Permission

The Movement permission consists of the permission extent, Risk Buffer, Reserved Path and Risk Path. These are show in the diagram below and explained in the respective sections.




**[**SPT2TRAFFIC-20559 **]**

### 6.2.1.1 Permission Extent

The Permission Extent is a linear contiguous stretch of track that defines how far portion of the track reserved for the trains movement. This part of the Movement Permission is equivalent to an ETCS Movement Authority and its end location is the End of Authority. An MP Request includes the speed profile and mode for the Permission Extent. Two Permission Extents cannot overlap even if going in the same direction. **[**SPT2TRAFFIC-20538 **]**



### 6.2.1.2 Risk Buffer

The Risk Buffer is a linear continuous stretch of track that serves as protection in case the train passes the end of the Permission Extent. The end of the Risk Buffer is the location used in the Movement Authority to define the Danger Point. This allows a train to approach the EoA with a release speed, while providing protection in case the train does not stop before it.
The length of the Risk Buffer can be dependent on a multitude of factors, among others:

- Speed
- Wheel-Rail Adhesion variability
- Speed Measurement Compensation
- Gradient

**[**SPT2TRAFFIC-20537 **]**

### 6.2.1.3 Reserved Path

The Reserved Path is a linear contiguous stretch of the track which defines where infrastructure elements are reserved ("claimed") for the Train Object to which the MP belongs. If Infrastructure Managers would like to use fixed routes, they can configure a fixed set of Reserved Paths enabling ETPS to only accept MP Requests, where the requested Reserved Path is identical to one of the preconfigured Reserved Paths. If no preconfigured Reserved Paths exists, ETPS will accept MP Requests with Reserved Paths of any length, which could be identical to the Permission Extent plus the Risk Buffer. It is possible for Reserved Paths to overlap(given they are in the same direction). [SPT2TRAFFIC-20536 ]

#### 6.2.1.4 Risk Path

A Risk Path is one potential path (a linear contiguous stretch of track) that is used to mitigate the risk of a non-permitted movement resulting in a flank collision. A Movement Permission can contain zero or more Risk Paths. Further details can be found in Chapter 9. [SPT2TRAFFIC-20548 ]

### 6.2.2 Switchable Trackside Asset Section

A Switchable Trackside Asset Section (STAS) is a topologically-defined linear contiguous section of track that belongs to a Switchable Trackside Asset (STA). It represents one possible driveable path through that asset. Each STAS corresponds to one "way" that the asset can be safely set, and its driveability state determines whether that path can be used for a Movement Permission. [SPT2TRAFFIC-20541 ]

STAS is the **core abstraction** that ETPS uses to determine:

- Whether an STA is **in the correct position**,
- Whether a path is **driveable**,
- Whether a Movement Permission can safely extend through the asset,
- Whether flank protection is adequately provided.

[SPT2TRAFFIC-20547 ]

Each STAS corresponds to a **Track Edge Section** (TES) or similar linear segment in the topology. The STAS extent **covers the physical moving area** of the asset (e.g., point blades, bridge span). Each STAS has a **driveable = TRUE/FALSE** status derived from Object Controller (e.g., SCI-P) reports. ETPS relies on this state for:

- MP safety checks,
- Path continuity,
- Rejection of unsafe MP or STA commands.

[SPT2TRAFFIC-20545 ]

STAS is used for:

- Validate that the requested **Movement Permission** uses only driveable paths.
- Reject STA movement if any STAS is **claimed** by at least one MP or occupancy.
- Provide **track-enforced flank protection** where applicable.

[SPT2TRAFFIC-20543 ]

#### 6.2.2.1 Train Object

A discussed in *5.3.1 - Train Object* the TO is the safe representation of a connected train to ETPS, the TO is the **reference entity** for:

- Assigning and supervising Movement Permissions
- Releasing track behind the train
- Determining when the MP rear can be shortened
- Validating safety rules regarding separation

[SPT2TRAFFIC-20553 ]

### 6.3 Movement Permission Lifecycle

The technical process of establishing a Movement Permission, ensuring safe train separation and authorisation of train movements (up to release of the Movement Permission after use) involves several steps:

- **Preparation by PES**. Based on the Operational Plan received from TMS, PES identifies all Switchable Trackside Assets impacted by an intended train movement including the Risk Buffer and *Risk Path*s and orders them in advance in the correct intended position. This is only possible if they are not *claimed* already, e.g. for another active Movement Permission or are occupied and could not be switched. To avoid that *ETPS* rejects a request, *PES* needs to be aware of the Operating State which is reported by *ETPS* whenever a state change occurs.
- **Initiation by PES**. Based on the *Operational Plan* received from *TMS*, *PES* implements the operational movement for a train by sending a *Movement Permission Request (MP Request* which includes the intended mode and speed)to *ETPS*. Such a request can either be for a new *Train Object* without any current *Movement Permission* (*Start of Mission* scenario) or can extend a current *Movement Permission*.
- **Verification by ETPS**. Upon receiving the *MP Request*, *ETPS* verifies that the *MP Request* does not violate safety rules. If *Reserved Paths* have been preconfigured, ETPS only supports train movements that match a preconfigured directed *Reserved Path*. For identifying the corresponding requested route the requested Risk Buffer exactly matches the preconfigured overruns for the routes.)
- **Rejection of Requests**. If a safety rule or any other requirement is violated, *ETPS* rejects the (unsafe) request and reports the reject reason to *PES*, ensuring that the present state of the related *Movement Permission* in the *Operating State* (in ETPS) remains unchanged.
- **Granting and maintaining the *Movement Permission***. If no safety condition is violated, *ETPS* builds, secures and grants the *Movement Permission,* stores it in the *Operation State* and communicates the state change.
- ***Authorisation* of train movement**. Based on the *Movement Permission*, *ETPS* generates and sends the requested *Movement Authority* to the corresponding train.
- **Release of *Movement Permission***. When there is an update of the *Train Object*'s *Safe Train Extent* indicating that a part of the rear of the *Movement Permission* is no longer required, *ETPS* releases the rear of the *Movement Permission* to the new rear location of the Safe Train Extent.
- **Release of elements**. Elements which are not longer claimed by the *Movement Permission* (left behind the train) are released. This includes track extent and *Switchable Trackside Element*s in the (released part of the) *Permission Extent* but also in any *Risk Path* which is now no longer needed. However, if an element was *claimed* not only by the released *Movement Permission* but by other *Movement Permission*s, these other *claims* remain unchanged (only one *claim,* the *claim* of this *MP,* is removed).

Note: The handling of Level Crossings will be defined at a later stage. **[**SPT2TRAFFIC-20554 **]**

## 7 Usage Restrictions

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , Adomeit, Sven (SMO RI R&D TC PE) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |

## 7.1 Introduction

For safe railway operations, train movements must be compliant to certain track-specific restrictions while running across the track network. These restrictions can be static track properties like the permissible maximum speed but also temporary restrictions like a track closure due to construction work. Static track properties are configured in the pre-engineered Topology Data (according to the ERA Ontology) and are valid until an update of the Topology Data occurs. Since updates of the Topology Data are complex and involve several actors, there is a need for adding additional **temporary** restrictions in a relatively fast and easy process. *Usage Restrictions (URs)* are a concept and domain object to represent such temporary restrictions in a generic way. (However - if wanted - it is not forbidden to use them for a static purpose.) The generic description language of the URs allows them to integrate a wide range of different safety rules, and thus enables ETPS to be future-proof by allowing the addition of new safety statements with a common behavior.

In theory 'every' track property or track condition might be formulated as a *UR* but the principle *Is it really a temporary condition?* should be obeyed. This means that track conditions of the same type may in some cases be managed using a UR, but in other cases not using a UR, depending on whether they are temporary or permanent in nature. Permanent track characteristics could be stored in the Topology Data, e.g. the gradient which is absolutely non-temporary or a physical speed limitation caused by the track geometry.

A typical example of a UR is the creation o a *Temporary Speed Restriction* (*TSR*). The resulting speed in the ETCS *Movement Authority* is the lowest value between the pre-engineered track properties of static speed and the speed given in the *TSR*. This is a **train-related** Usage Restriction.

Not all restrictions affect the usability of the track by trains directly. The UR can also affect ***Switchable Trackside Assets*** so that the *STA* cannot be switched (neither by PES, nor by the Signaller). Especially in degraded situations (e.g. trailed point), an operational procedure including the Signaller and Maintainer is performed. During that operational procedure it will not be possible for the specific point to be moved by automatic functions (*PES*) or by a Signaller.

A third group of Usage Restrictions limit who can control an element: **operation related** URs (*Manual Operations Area, Locally Controlled Area, Demand-only Operation*). Operations could be performed automatically (PES), manually by a Signaller, or temporarily assigned to local operational staff. Operations that could be restricted include requesting the switching of *Trackside Asset*s or changes to the *Movement Permissio*s.

To sum up, restrictions can be of three types:

1. **Train related** (the train's usage of the track is affected*);*
2. **Trackside Asset related** (the switchability is affected);
3. **Operation related** (the origin - manual or automatic - of an operational request for *Trackside Asset* or *Movement Permission* is affected)

[SPT2TRAFFIC-13362 ]

## 7.2 Structure of this chapter

In the following, consideration is given to temporary or pre-defined restrictions (cf section 7.3). Section 7.6 describes the principle application of a *UR* to the *Movement Permission* and/or the resulting *Movement Authority*. How trains altogether are affected (depending on their *MP* covering the *UR* when it is created) can be seen from section 7.8.

After the introduction of the *UR,* it is put into relation to operational needs (cf section 7.9).
**[**SPT2TRAFFIC-13364 **]**

## 7.3 Sources of URs

### 7.3.1 Originators of restrictions

URs can originate from:

- A Request of the PES due to an Operational Plan from TMS
- A Request of PES according to an Operational Plan from the Signaller or another human role like a trackside Maintainer
- A Demand from the Operator's Workbench or some other operator panel (e.g. of posts etc.) in safety-critical situations,
- ETPS itself (e.g. in cases of automatic processes like a software/configuration update),
- ETPS itself as a reaction to a sensor input (e.g. by a Wayside Monitoring System via the I/O interface).

**[**SPT2TRAFFIC-12901 **]**

### 7.3.2 Temporary vs recurring restrictions

The need for a UR can occur spontaneously but more often than not the UR will be pre-planned, especially for complex URs, as pre-planning reduces the risk of failure. The pre-planned UR can be validated and stored for a later activation.
Another argument for pre-planning URs is that a UR is re-used repeatedly between creation and deletion e.g. for safeguarding of work near a track only during working hours. In this case, it is beneficial that such *UR*s do not have to be repeatedly entered manually over and over again but are predefined in the pre-engineered Topology Data or some other data repository for activation/deactivation, with the initial state being inactive.

The pre-planned URs can also be validated by a second person if a four eyes principle is necessary, e.g. in case of complex URs like for construction works. The pre-configured UR could also to be triggered by a certified sensor for example in case of an avalanche.

From *ETPS*'s point of view, a UR is always either created or deleted: The calling system (like *PES*) for a predefined *UR* lets *ETPS* create it and remove it as required. To enable this, the calling system always transfers all needed data (e.g. the affected area) as taken from either the central configuration management (*the Service Function Configuration)* or from operator input. If a recurring UR is required to be activated and deactivated based on a schedule, PES or the Operators Workbench each time would just send a UR Creation or Deletion command to ETPS based on that schedule. This allows for simplified handling within ETPS of URs.

**[**SPT2TRAFFIC-13363 **]**

## 7.4 Lifecycle

The lifecycle of a UR contains several phases:

1. A Planned UR:
   A UR might be required to be planned, this means that all details (affected area, restriction types etc.) are defined, if necessary validated, and then stored for later activation.
2. A Scheduled UR:
   The activation and/or deletion time of the UR will be scheduled and sent to the TMS and Operator's Workbench. The TMS will consider it in its further planning and optimisation. This phase is optional.
3. A Partially activated UR:
   The UR is created in ETPS and ETPS supervises that the restriction is not violated by any incoming requests. However, there might still be Trains with a conflicting Movement Permission (in case the

UR has been Demanded cf Chapter 7.8) or UTOs which are in conflict with the UR. This state is only relevant for some train-related URs such as Temporary Speed Restrictions. ETPS informs all interested systems by sending a state update message.

4. A Fully activated UR:
   The UR is created in ETPS and ETPS supervises that the restriction is not violated by any incoming requests. There are no supervised trains in conflict with the UR and the Signaller has ensured that no UTO violates the UR. ETPS informs all interested systems by sending a state update message.
5. A Deactivated UR:
   If all deletion criteria for the UR is fulfilled, which is usually ensured by the Signaller, then the UR is deleted in ETPS upon Signaller request. However, it could be stored outside of ETPS for a later reactivation.

This lifecycle is applicable for planned and unplanned restrictions triggered by TMS or the Signaller which are requested but does not apply for URs that are triggered via a demand in an emergency. The latter ("demanded") URs are directly created in ETPS without passing the previous lifecycle-steps (see chapter 7.8.2).
**[**SPT2TRAFFIC-20457**]**

## 7.5 Persistency

*UR*s created in *ETPS* need to be made persistent so it can be guaranteed that they are still in place even after planned (maintenance activities) or unplanned (*ETPS* crash) downtime. That means that non-falsification, consistency (relation to Topology Data), and validation of data must be considered; After *ETPS* is restarted, it has to be guaranteed that all former *UR*s are active again. **[**SPT2TRAFFIC-13801**]**

## 7.6 Enforcement of UR

Train-related URs can have two effects:

1. They might influence whether ETPS grants a *Movement Permission*
2. They define content to be added to the *Movement Authority* which must be respected by the *OBU*.

If *ETPS* detects that a *Movement Permission* Request violates a *UR*, the *MP* Request will be rejected. Examples would be a *UR* applying a track closure but a subsequently requested *MP* would conflict with this *UR.* Another example, would be that a*UR* covering an area in which the ETCS EoA of a requested MP sits. (Please refer to section 7.8 for the case that such conflicts already exist when the *UR* is requested.)

If the enforcement of the *UR* can only be supervised by the OBU, *ETPS* will support this by including the related restriction (e.g. ETCS *Track Condition*) into the *Movement Authority* so the *OBU* can supervise it during the train run. Examples would be temporary track conditions such as allowed current consumption or sound horn.

For planned URs or non-time-critical unplanned URs, TMS or the Signaller should already consider the UR before it is activated to avoid trains conflicting with the UR. This means that the operational plans of train movements etc. should already be adapted to comply with the UR that is going to be activated. In time-critical emergency situations, the Signaller may demand a UR that is conflict with existing trains (see chapter 7.8.2).
**[**SPT2TRAFFIC-13365**]**

## 7.7 Parts of a UR

### 7.7.1 Filter

A *UR* can apply for all trains or a subset of trains. A filter can be used to select a subset of train with this being evaluated by ETPS (e.g. depending on train running number, train category, Traction). If there is no optional filter or if the required data to evaluate the filter is not available, then the restriction applies to every train. This Filter concept is subject to further analysis. **[**SPT2TRAFFIC-13368**]**

### 7.7.2 Affected Area

A UR is always applicable to a certain Track Area:

- a stretch of track (*Net Linear Reference*; can be direction-dependent);
- an area of connected tracks (*Net Area Reference*);
- even a set of possibly non-connected tracks, e.g. parallel station tracks

The affected area of a UR can contain *Switchable Trackside Asset*s, so *STA* related or operation related restrictions can be applied to them.
**[**SPT2TRAFFIC-13367**]**

### 7.7.3 Types of restrictions

*UR*s can have different effects, depending on the type of restriction. The types of restrictions could be the following:

1. Train related:
    - Speed restriction
    - Track closure
    - ETCS Mode
    - EoA exclusion
      (stops should be avoided in a certain area)
    - *Track Conditions*
        - Sound horn
        - Change of allowed power consumption
        - Radio hole
        - Reduced adhesion factor
2. Trackside Asset related:
    - Non-switchability (= logically locked)
3. Operation related:
    - Local operation (no remote requests, neither automatic nor manual)
    - Manual operation (remote central but not automatic)
    - Demand-only operation (no request but only safety-critical demands are accepted)

The list of types of restrictions might not be final at the current state of the document but might evolve with further operational use cases.
**[**SPT2TRAFFIC-13366**]**

### 7.7.4 Creation parameters

Creation parameters can configure how ETPS reacts when the UR is created, for example:

- Binding preconditions
- That a creation reason is communicated to the Signaller or the Train Driver.

Creation parameters are optional. **[**SPT2TRAFFIC-20044**]**

### 7.7.5 Deletion parameters

Deletion parameters can define binding preconditions for deleting the UR, for example:

- Whether the UR can be removed by ETPS itself or shall be deleted by a Signaller

- A necessary sensor state for deleting the UR
- A necessary follow-up UR

Deletion parameters are optional. **[**SPT2TRAFFIC-20045 **]**

## 7.8 Influence of created URs on existing MPs

Within ETPS there are two ways that URs can be created via a Request or via a Demand:

- Request: ETPS will only accept the UR is there are no conflicting Movement Permissions
- Demand: ETPS shall enforce compliance of existing Movement Permissions to the UR(For use in time-critical situations where a safety reaction is required)

**[**SPT2TRAFFIC-21286 **]**

### 7.8.1 Request

If ETPS receives a Request for UR creation, this Requested UR shall not affect trains that have a Movement Permission which overlaps the affected area to avoid negative impacts. When a UR is Requested that overlaps existing Movement Permissions ETPS will react in one of two ways:

1. If all existing MPs are don't violate the newly requested UR (e.g. because their operational plans have already reflected the new restriction), ETPS can grant the UR creation if none of further checks fails.
2. If an existing MP violates the existing UR after its creation, ETPS would reject the UR creation.

It is the responsibility of TMS and/or the Signaller to avoid that Requested URs are being rejected by ETPS in case 2. Ideally, TMS would have already adapted the Operational Plans of conflicting train movements, however, this is not always possible. Then the TMS or the Signaller has two options:

a. UR creation is delayed until the conflicting MP no longer overlaps the affected area.
b. They could request new MPs for the affected trains (Cooperative Shortening would be required).

**[**SPT2TRAFFIC-13371 **]**



### 7.8.2 Demand

In case ETPS receives a Demand for UR creation, an immediate implementation of the UR is the wanted behaviour (usually to mitigate an imminent safety threat), even if there are MPs overlapping the UR that would stay in conflict with the MP after its creation. Therefore, after the creation ETPS would not accept any new request for Movement Permissions that are not compliant to the UR and execute the following steps:

1. ETPS sends a state update that the UR is partially activated (see *7.4 - Lifecycle*).
2. ETPS enforces proper reactions to force the existing Movement Permissions to be compliant to the UR. Such reactions could be emergency stop, co-operative shortening of *MA*, re-sending of the *MP/ MA*, ...). Which exact reaction is to be applied in which situation is left to the specification per situation.
3. When there is no conflict between the UR and an already issued Movement Permission anymore, ETPS would send a state update that the UR is now fully activated.

UR Demands would usually come from the Operator. Furthermore, it could be possible that incident prevention systems trigger predefined and certified URs as Demand as a reaction to an imminent safety threat that they have detected.
**[**SPT2TRAFFIC-14383 **]**

## 7.9 Operational use cases for UR and further examples

### 7.9.1 Atomic examples

For better understanding, a number of operational use cases is enumerated (non-exhaustive list). <affectedArea> is the placeholder for the concrete physical extent on the railway network; the affectedArea can be directed (*UR* only valid for trains in one direction). The list needs to be updated with the identified operational needs after they have been evolved by the OD domain.

- **A temporary speed restriction - all trains (normal case)**
  Filter: none
  Area: <affectedArea>
  Effect: restriction of speed (in MA)
- **A temporary speed restriction - train-dependent**
  Filter: train category
  Area: <affectedArea>
  Effect: restriction of speed (in MA)
- **Track inspection by track walker**
  Trains may approach from the front (track worker is obliged to watch out) but no train approaches from the back (track worker is not obliged to look back).
  Filter: none
  Area: directed <affectedArea> (in inspection direction)
  Effect: blocked (MP rejection)
- **Radio hole**
  Filter: none
  Area: <affectedArea>
  Effect 1: Track Condition Radio Hole (in MA)
  Effect 2: EoA exclusion (MP rejection)
- **Construction site**
  Combined URs:
  - Zone itself
    Filter: none
    Area: <affectedArea>
    Effect: blocked (MP rejection)
  - Neighbour tracks around <affectedArea> (<affectedAreaNT>)
    Filter: none
    Area: <affectedAreaNT>
    Effect: restriction of speed (in MA)
- **An avalanche sensor has detected a spilled track**
  Filter: none
  Area: <affectedArea>
  Effect: blocked (MP rejection)
- **Activating/Deactivating Automatic Plan Execution**
  Filter: none
  Area: <affectedArea>
  Effect: Manual operation

(etc.) **[**SPT2TRAFFIC-13370 **]**

### 7.9.2 Combination of restrictions

If restrictions belong together because they have a logical relation, they can be combined for:

1. The same affected area but for different restrictions
2. Different affected areas and different restrictions.

This is beneficial for a grouped handling of URs, for example: if a group of *UR*s is created together they can be deleted together.

Example 1: The *Track Condition* Radio Hole only contained within the *MA* so that the *OBU* can obey it (T_NVCONTACT handling) it would also means that no *MP*s will end within the affected area. This can be combined easily; the example was already given in section 7.9.

Example 2: A construction site is closed for commercial trains and trains on neighbouring track(s) are slowed down; the example was as well already given in section 7.9.

The filter specification, if present, would be valid for all the contained combinations of affected areas and restrictions, and all would together form the *UR* (not the parts would be an *UR* each).
**[**SPT2TRAFFIC-13369 **]**

# 8 Clearance Conflicts

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , Adomeit, Sven (SMO RI R&D TC PE) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |

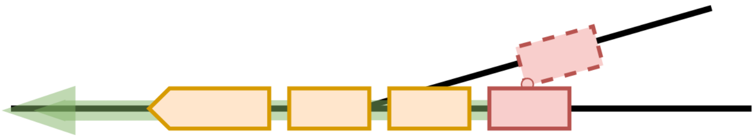


## 8.1 Introduction

The path of a train shall be kept clear at all times, not only of objects located directly on the track, but also of objects within the physical space that may be occupied by a train. This includes objects positioned close to the track, such as marker boards, as well as objects located on adjacent tracks, for example another train standing near a point. The extent of this required clearance is defined by structure gauge profiles (for example UIC G1, G2), which take into account both static dimensions and dynamic effects, such as vehicle movement, suspension behaviour, and tilting. While compliance with structure gauge profiles is ensured during the design and construction of railway infrastructure, dynamic structure gauge conflicts may arise during operation. Such conflicts typically occur at locations where track paths interact, for example at points where one track joins or crosses another. At these locations, static gauge compliance alone is not sufficient to guarantee safe operation. Instead, a dynamic clearance assessment is required to ensure that simultaneous or sequential train movements do not result in a physical conflict. Three representative use cases in which such dynamic train-to-train or train-to-infrastructure clearance conflicts may occur are described in the following sections. **[**SPT2TRAFFIC-13707 **]**

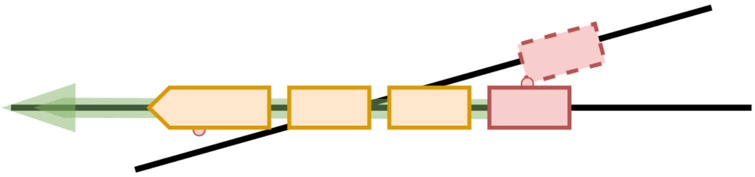
## 8.2 Clearance Conflicts Use Cases

### 8.2.1 Case 1: Joining tracks (Simple Point)



**[**SPT2TRAFFIC-13389 **]**

### 8.2.2 Case 2: Crossing tracks (Diamond Crossing)



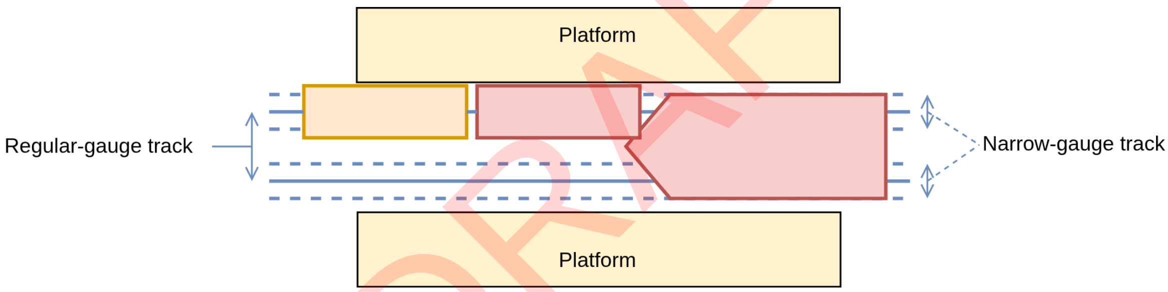
Note: This is similar for a *Switched Diamond Crossing* (with movable frogs) but this does not change this general case. [SPT2TRAFFIC-13388 ]

### 8.2.3 Case 3: Parallel tracks (including interlaced tracks)

The flank collision risk occurs when tracks do not join nor cross but have an insufficient track-track distance (including interlaced tracks).
[SPT2TRAFFIC-13396 ]

Example 1: [SPT2TRAFFIC-13393 ]

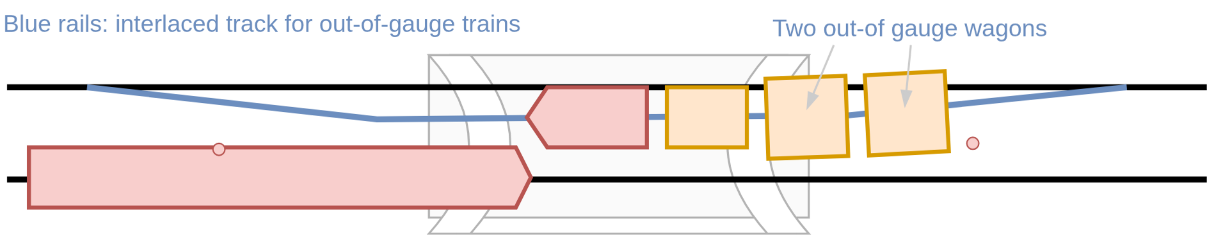
Hint: Unlike in most other figures, not only the track middle line but two lines representing both rails are shown:




[SPT2TRAFFIC-13387 ]

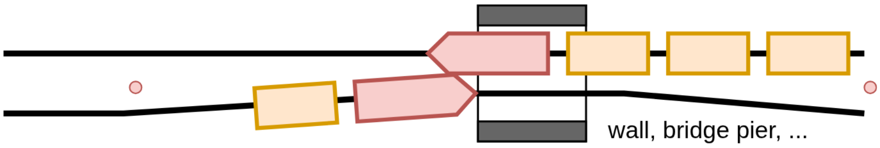
This situation occurs for instance in Kaufungen (https://en.wikipedia.org/wiki/Gauntlet_track) where narrow-gauge trains have to be as close to the platform as regular-gauge trains. [SPT2TRAFFIC-13395 ]

Example 2:
In the Gemmenich tunnel (https://de.wikipedia.org/wiki/Gemmenicher_Tunnel), the clearance profile of the two-track tunnel tube is insufficient for exceeding loading gauges, so a third track was interlaced within the regular double track layout for these trains: [SPT2TRAFFIC-13394 ]




[SPT2TRAFFIC-13391 ]

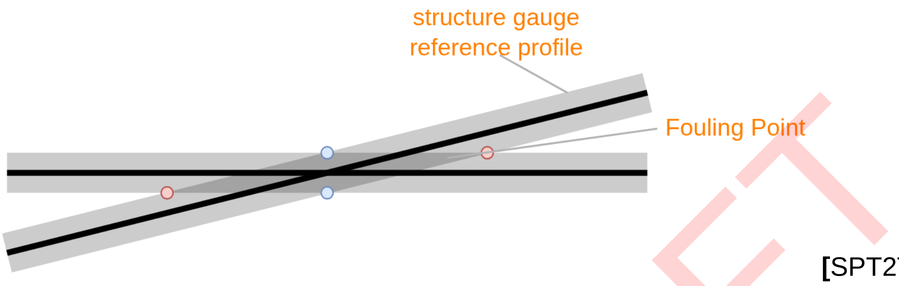
Example 3:
Finally, this situation where both tracks have insufficient track-track distance by topographical restrictions (tunnel wall, general wall, bridge pier) can appear: [SPT2TRAFFIC-13392 ]



[SPT2TRAFFIC-13390 ]

## 8.3 Fouling Point

If we consider the structure gauge reference profile, then it can intersect with that profile of another track at the *Fouling Points* (shown for a *Diamond Crossing*): [SPT2TRAFFIC-13702 ]



[SPT2TRAFFIC-13887 ]

This means that within the *conflict zone*, there is a risk of flank collision. [SPT2TRAFFIC-13708 ]

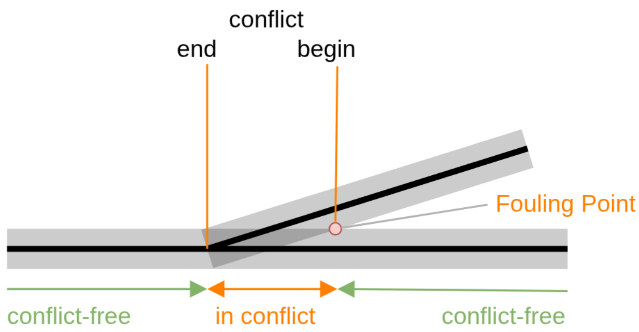
## 8.4 Conflict zone

The conflict zone is that area where any two vehicles on different paths get in physical conflict with respect to their structure gauge reference profiles.
The flank collision risk starts at the *Fouling Point* and ends at

- Case 1: the *Track Node* of the *Simple Point*;
- Case 2: the middle of the *Diamond Crossing* to both opposite sides;
- Case 3: the next *Fouling Point* where track-track distance is sufficient again.

[SPT2TRAFFIC-13726 ]

For the example of case 1: [SPT2TRAFFIC-13725 ]

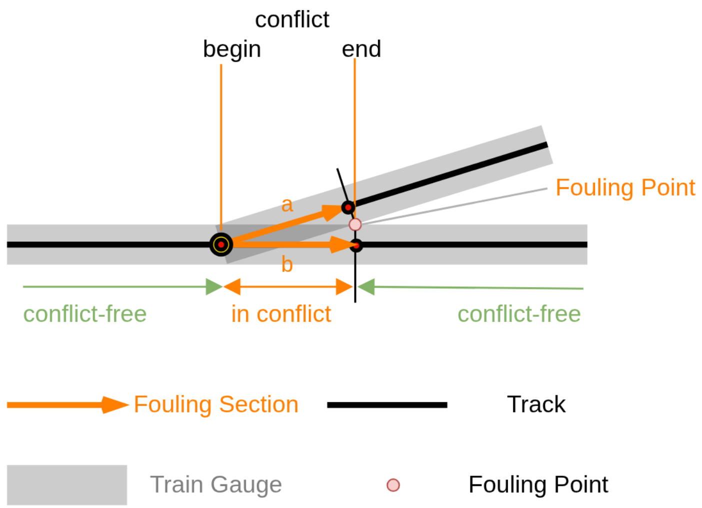


[SPT2TRAFFIC-13398 ]

This conflict zone is made visible to the Safety Logic of *ETPS* by the definition of *Fouling Sections*.
[SPT2TRAFFIC-13724 ]

## 8.5 Fouling Section

Taking into account the structure gauge, *Fouling Section*s are defined (like for the example of case 1): **[**SPT2TRAFFIC-13404 **]**




**[**SPT2TRAFFIC-13397 **]**

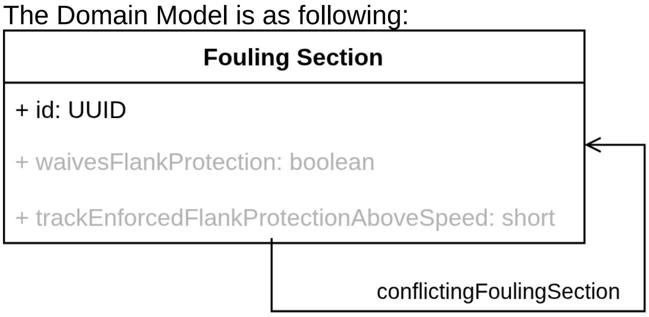


*Fouling Sections* are represented as directional elements, although they are valid for movements in both directions. The direction assigned to a Fouling Section indicates the direction in which Risk Path construction is initiated, as described in *9.2 - Fouling Sections*. The extent of each Fouling Section shall be engineered in the Topology Data for every occurrence of the three defined conflict cases. The extent is derived from the corresponding Fouling Point, which is defined as the vertical projection of the conflict location onto the track centre line. Fouling Points are identified using established engineering rules that consider:

- the required minimum distance between adjacent tracks,
- line characteristics (for example, station areas or open line),
- vehicle overhang, and
- any additional allowances required due to local conditions.

The derivation and placement of Fouling Sections can be fully or partially automated. For example, for standard point layouts, predefined patterns for Fouling Points and their associated Fouling Sections may be reused to ensure consistency and reduce engineering effort. Fouling Sections shall not be used freely. Once a Fouling Section is claimed, either by track occupancy or by an active Movement Permission, its corresponding Conflicting Fouling Section shall not be used by any other Movement Permission at the same time.
Fouling Sections therefore exist as pairs, with each pair representing the mutual exclusion between two conflicting track paths. This pairing reflects the underlying physical conflict between the tracks and is enforced by the domain model to prevent unsafe simultaneous use. **[**SPT2TRAFFIC-13734 **]**

The Domain Model is as following:



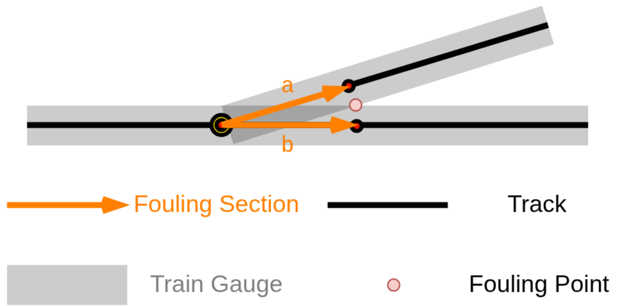

**[**SPT2TRAFFIC-13747 **]**

(The greyed-out attributes are needed for a potential weakening of flank protection and are not further elaborated in this edition.) **[**SPT2TRAFFIC-13745 **]**

### 8.5.1 Application of Use Cases

This section shows that any, even a specific, situation can be derived from three use cases. **[**SPT2TRAFFIC-18530 **]**

#### 8.5.1.1 Simple Point (case 1)

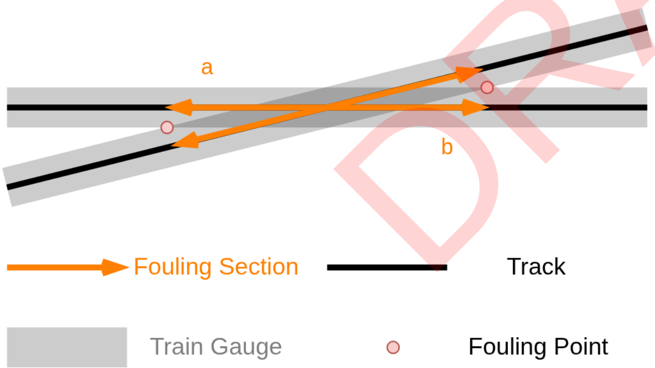



Fouling Section pair {*a*, *b*}

**[**SPT2TRAFFIC-13886 **]**



#### 8.5.1.2 Diamond crossing (case 2)

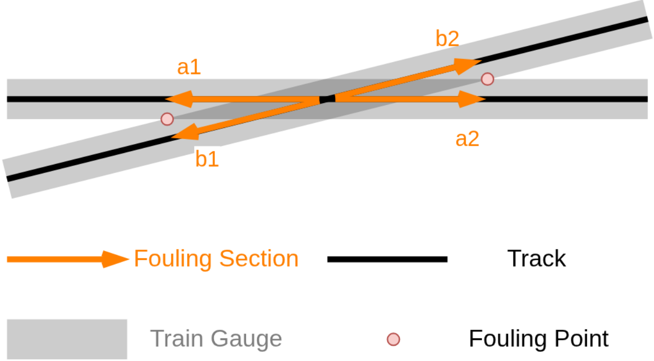



Fouling Section pair {*a*, *b*}

**[**SPT2TRAFFIC-13885 **]**

Note: A simplification for the two further *Fouling Point*s in the obtuse angle was made but will hardly play a role (only if the crossing angle  is significantly less flat). **[**SPT2TRAFFIC-13743 **]**

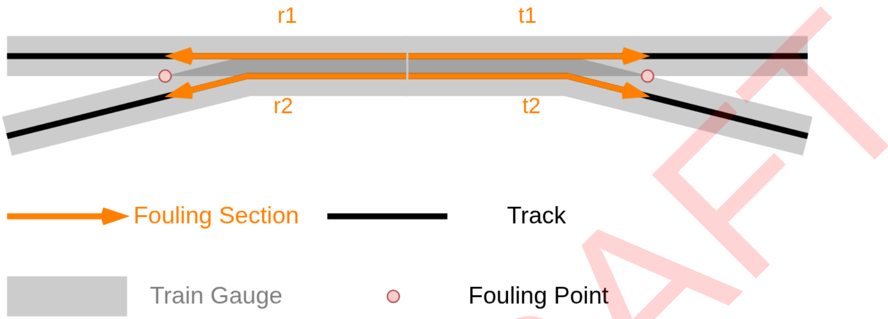
Note: For a more efficient use of the crossing, even two pairs of *Fouling Sections* could be defined:




Fouling Section pairs {$a_1$, $b_1$}, {$a_2$, $b_2$}

**[**SPT2TRAFFIC-13741 **]**

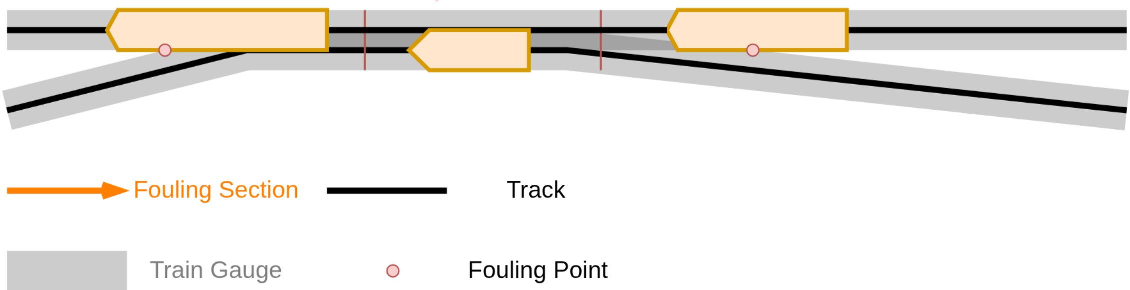
### 8.5.1.3 Parallel tracks (including interlaced tracks) (case 3)




Fouling Section pairs {$r_1$, $r_2$}, {$t_1$, $t_2$} **[**SPT2TRAFFIC-13897 **]**



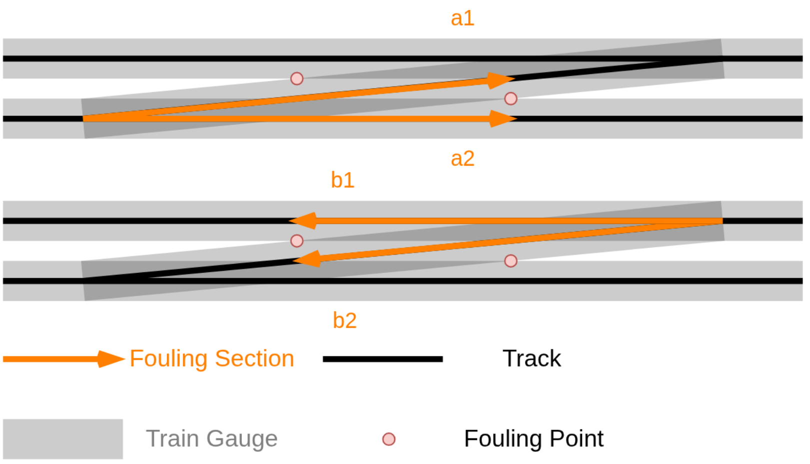
Note: If the distance between the *Fouling Points* is small compared to a minimum operational train length, only one pair of *Fouling Sections* is sufficient. The longer the conflict zone is, the more it should be considered to add pairs of *Fouling Sections* (split); consider this situation which would enable following movements only when the *Fouling Sections* are split - in this case to three parts: **[**SPT2TRAFFIC-13740 **]**




**[**SPT2TRAFFIC-13895 **]**

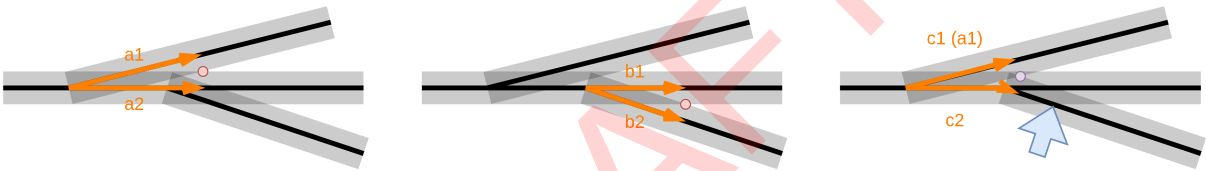
Splitting is a simplified approach and the number of sections (here: 3 on each track) is depending on the estimated line throughput need. However, this should not even be relevant for the normally short extent. **[**SPT2TRAFFIC-13742 **]**

#### 8.5.1.4 Interlaced Points at track links (based on case 1)




[SPT2TRAFFIC-13893 ]

#### 8.5.1.5 Interlaced (double) Points (based on case 1)

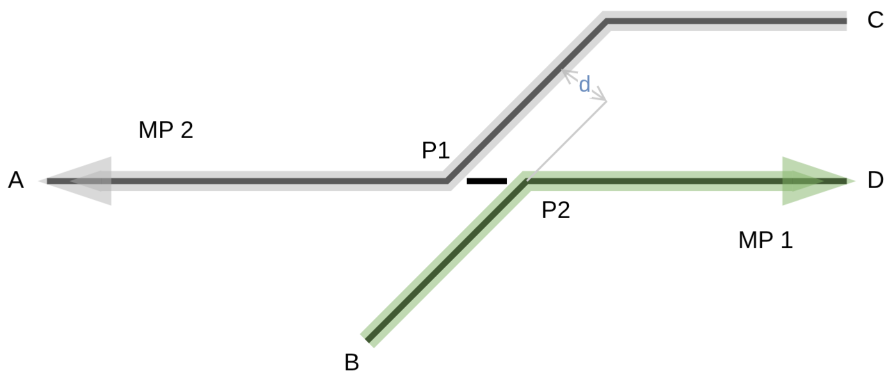



[SPT2TRAFFIC-13891 ]

Note that there are indeed three *Fouling Points*.
Three FS pairs {$a_1$, $a_2$}, {$b_1$, $b_2$}, and {$a_1$, $c_2$} would be engineered in *Topology Data*. However, to have all three pairs is only needed if the utmost capacity should be squeezed out (usage of leftmost part - blue arrow - of the lower branch of the right *Point* whilst an occupation on the upper branch). If that is not needed, a simplification to two pairs could be made. [SPT2TRAFFIC-13744 ]

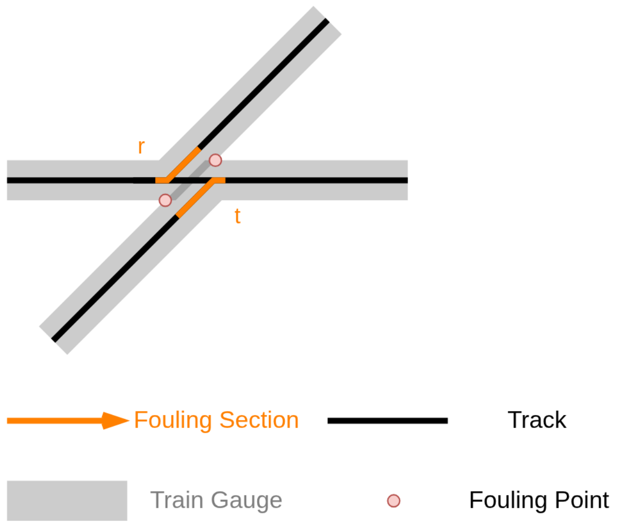
#### 8.5.1.6 Two facing Simple Points with structure gauge conflict (based on cases 1 and 3)

When there is an insufficient distance *d*,




[SPT2TRAFFIC-13746 ]

an additional pair {*r*, *t*} of *Fouling Sections* needs to be engineered to prevent conflicting movements (in this case, requested *Movement Permission 2* would be in conflict with existing *Movement Permission 1* and would be rejected). **[**SPT2TRAFFIC-13748 **]**

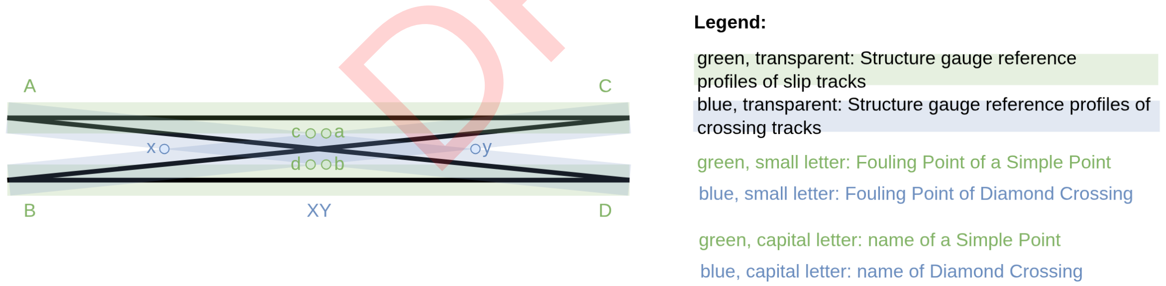



FS pair {*r*, *t*} **[**SPT2TRAFFIC-13889 **]**

Note that the already needed pairs of *Fouling Section*s for P1 and P2 themselves are not depicted. **[**SPT2TRAFFIC-13749 **]**

### 8.5.1.7 Slip Points (based on cases 1, 2, and 3)

Slip *Point*s are a combination of four simple *Point*s and a diamond crossing, all interlaced. Six (in fact eight when not ignoring the obtuse angle of the diamond crossing) *Fouling Point*s exist: **[**SPT2TRAFFIC-13737 **]**

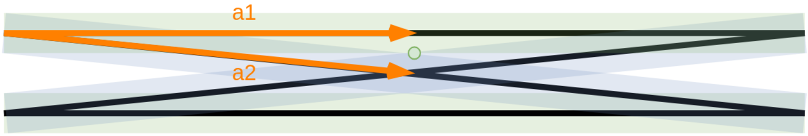



Hint: This (and that for cases 1 and 2 below) is a schematic diagram not suggesting that the two parallel tracks A-C and B-D can be used simultaneously - the chosen representation is to leave sufficient space. Case 3 below has an adapted representation which shows that parallel tracks cannot be used simultaneously. **[**SPT2TRAFFIC-13888 **]**

Resulting *Fouling Section*s are:

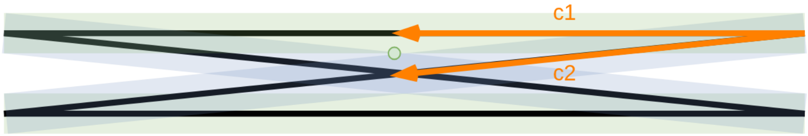
### 8.5.1.7.1 Case 1

Simple *Point* **A** (and **B** - if mirrored horizontally)




**[**SPT2TRAFFIC-13890 **]**

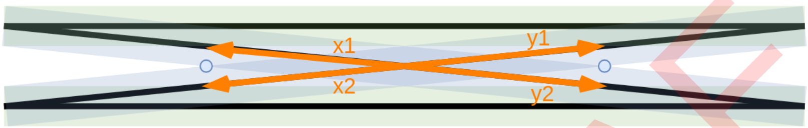
Simple *Point* **C** (and **D** - if mirrored horizontally)




**[**SPT2TRAFFIC-13892 **]**

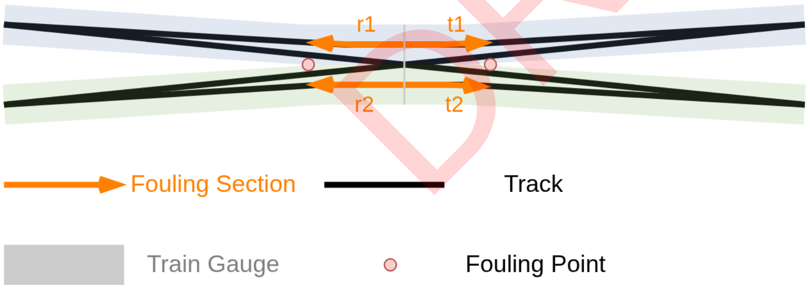
### 8.5.1.7.2 Case 2

Diamond Crossing **XY**




**[**SPT2TRAFFIC-13894 **]**

### 8.5.1.7.3 Case 3




**[**SPT2TRAFFIC-13896 **]**



(Hint: this diagram was vertically compressed compared to the previous ones to better explain the track-track distance problem.)

There are eight *Fouling Section* pairs {$a_1$, $a_2$}, {$b_1$, $b_2$}, {$c_1$, $c_2$}, {$d_1$, $d_2$}, {$x_1$, $x_2$}, {$y_1$, $y_2$}, {$r_1$, $r_2$}, and {$t_1$, $t_2$}. **[**SPT2TRAFFIC-13739 **]**

From a systematic point of view, all need to be derived. However, because of (lesser) capacity requirements mentioned already above, fewer can be engineered (coarsened to the safe side). Typically, a type pattern for a single (double) slip *Point* would be used. **[**SPT2TRAFFIC-13738 **]**

## 8.6 Safety checks

A request for a Movement Permission (MP) shall be rejected if the requested Movement Permission would intersect with a Fouling Section for which the corresponding Conflicting Fouling Section is already claimed.
A Fouling Section is considered claimed if it is:

- occupied by a Train Object or an Unknown Train Object (UTO), or
- reserved by an existing Movement Permission.

***Generic safety rule for Fouling Sections***
Fouling Sections are defined and managed as pairs, denoted {a, b}, representing two track paths that are in geometric conflict.
For a given Fouling Section pair {a, b}, the following rule applies:

- If Fouling Section a is claimed by a Train Object or by an existing Movement Permission p1, then the Conflicting Fouling Section b shall not be claimed by another Movement Permission p2.
- The same rule applies symmetrically if Fouling Section b is claimed.

ETPS shall reject any Movement Permission request p2 that violates this rule. This rejection is independent of other applicable safety checks, which may also lead to rejection of the request. Note on subsection usage. This rule does not prohibit the simultaneous use of different, non-overlapping subsections of the same Fouling Section by different Movement Permissions. The same applies to the corresponding Conflicting Fouling Section, provided that the subsection claims do not result in a geometric conflict. **[**SPT2TRAFFIC-13403 **]**

## 8.7 Representation for operator

The Graphical User Interface (GUI) of the Operator Workbench can indicate *Fouling Section*s if needed as it has the same *Topology Data*. In fact, display the *Fouling Sections* makes sense especially for insufficient track-track distance (case 3 above) so the Signaller can know the reason of exclusion of two *Movement Permissions*. **[**SPT2TRAFFIC-13710 **]**

# 9 Flank Protection

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , Adomeit, Sven (SMO RI R&D TC PE) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |

| | |
|---|---|
| Comments | **#1 Approval comment** by **LOEFFLER Christian** on 2026-05-07 13:15<br>Conditional Approval with the following conditions given:<br>1. Artefacts due to Copy&Paste from RCA need to be removed/adapted (DPS, DPS States Full & None)<br>2. We need to agree if the Risk Path determination needs to be done for the complete Reserved Path of the MP or only for Permission Extent + Risk Buffer - images need to be reworked accordingly<br>3. Only Points are analysed in more detail to be compliant with STA concept Other trackside assets still need to be analysed - until such an analysis has confirmed the compliance of the STA concept to the specific trackside asset type, the chapter shall not give the impression that STA concept can be applied to the specific trackside asset type (e.g. Level Crossing)<br><br>**#2 (reply to #1 Approval comment)** by **LOEFFLER Christian** on 2026-05-07 14:23<br>Detailed comments are given in the actual working document. |

### 9.1 Introduction

Flank Protection looks for the ways another train could approach the side of an authorised train movement that could cause a conflict or collision. For each way, it makes sure there is something that stops it or slows it enough before it can reach the authorised movement. Flank Protection is an ETPS safety function that ensures the risk of collision between an authorised train movement and a potentially conflicting movement approaching from the flank is acceptably controlled. Flank protection is achieved by identifying and controlling Risk Paths that could lead to a flank collision, and by ensuring that each such Risk Path is terminated or sufficiently constrained before it can intersect the authorised Movement Permission.
**[**SPT2TRAFFIC-15486 **]**



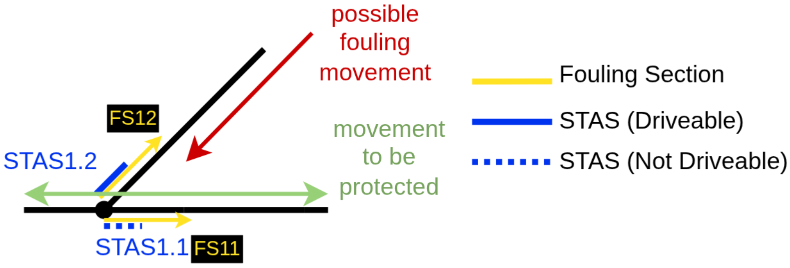
### 9.2 Fouling Sections

A fouling section is a defined area of track topology that represents the spatial extent where a train, vehicle, or part thereof would infringe another track path if occupied, thereby creating the potential for a conflict or collision with an authorised Movement Permission. Fouling sections are statically engineered elements of the network topology. They are used as reference points for safety analysis, in particular for the identification and construction of Risk Paths associated with flank collision risk. A fouling section marks the point at which a movement from one track becomes geometrically capable of encroaching upon another track, independent of whether such a movement is currently authorised. As such, it does not denote an operational permission or state, but a geometric and safety-relevant boundary.

Within Chapter 9, fouling sections are used to:

- Identify where potential flank conflicts may arise,
- Define the starting or limiting points for Risk Paths, and
- Support the assessment of whether flank protection is required and how it is achieved.

**[**SPT2TRAFFIC-13730 **]**




[SPT2TRAFFIC-13729 ]

*Fouling Section*s mitigate flank collision risks by building and checking the *Movement Permission*'s *Risk Path*(s): To check if a new protected movement, at its *Fouling Section* is sufficiently safeguarded, the *Risk Path* of the conflicting *Fouling Section* is followed and checked. [SPT2TRAFFIC-13402 ]

*Risk Path*s are considered for all *Fouling Section*s within the *Movement Permission* (*b* in the example). They start at the end of the conflicting *Fouling Section* (start at the end of *a* in the above diagram) and run towards the potential fouling movement until they are sufficiently terminated (e.g. by a *Point* in repelling position). Where $r_a$ is this *Risk Path* in the above diagram. [SPT2TRAFFIC-13732 ]

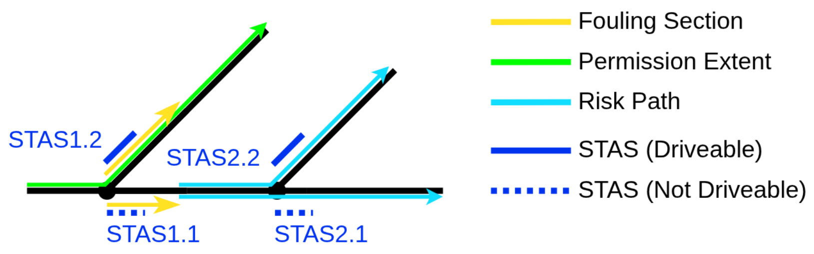
A *Risk Path* is one potential path by which a non-permitted vehicle movement could result in a flank collision with a vehicle moving along the *Permission* extent. The *Risk Path* starts at each end of the relevant *Fouling Section* in the extent of the *Movement Permission* (including the *Risk Buffer*) and is limited through a sufficient method to provide flank protection. Example methods include using a *Switchable Track Asset* or limiting a *Movement Permission*. [SPT2TRAFFIC-18526 ]

Although the underlying risk is that an uncontrolled vehicle may enter the conflict zone and travel towards that zone, Risk Paths are defined in the opposite direction. Their direction is aligned with the associated Fouling Section rather than with the potential movement of the uncontrolled vehicle. A Risk Path starts at the “from” end of the Fouling Section and extends away from the conflict zone, following the track path along which a potentially conflicting movement could propagate. This direction is chosen to support a systematic and conservative analysis of flank-collision risk. Each Risk Path must be terminated or sufficiently constrained before it can lead to an intersection with an authorised Movement Permisison (see SPT2TRAFFIC-14666 - Topo.FP.trackEnforcedFlankProtectionAboveSpeed). Where the track topology allows multiple alternative continuations, a Risk Path may split into multiple branches, each of which must be considered independently.
[SPT2TRAFFIC-14751 ]

A *Risk Buffer* represents overrun protection in the direction of the authorised movement. Risk Buffers are defined as a single continuous extension of a Movement Permission, and Risk Paths are defined as potentially multiple structures providing flank protection. It is colinear with the Movement Permission, extending only forward along the authorised track path. There are no alternative branches to consider, because the train is assumed to overrun only along its authorised running direction.
[SPT2TRAFFIC-21172 ]

### 9.3 Splitting of Risk Paths

Splitting of Risk Paths is required when a single potential conflict path diverges into multiple, distinct geometric or functional alternatives. Without splitting, the system would either miss a credible flank-collision scenario, or incorrectly assume that protection applied on one branch also protects all others. Splitting therefore ensures that each independent flank-collision scenario is analysed, protected, and assured in its own right. If the search for extension of a *Risk Path* reaches a split of the track (facing *Point*), the *Risk Path* 'splits'. However, rather than splitting it, a new *Risk Path* is built as a 'copy' of the current *Risk Path* (so that both originate in the same *Fouling Section*). Then, both are extended *on their own* until both are terminated:
[SPT2TRAFFIC-14761 ]




**[**SPT2TRAFFIC-21107 **]**

## 9.4 Elimination of Risk Path candidates

Arising from the principle, that all situations can be derived by the combination of the three base situations, many *Risk Path*s will be built. Base situations are a defined set of generic conflict configurations used to structure the analysis of flank-collision risk in a systematic and complete manner. Each base situation represents a fundamental way in which a flank conflict could arise between an authorised Movement Permission and a potentially conflicting movement on an adjacent or intersecting track.
Base situations are analytical constructs, not operational scenarios and describe geometric and topological relationships between tracks that are known to be relevant to flank-collision risk, independent of the signalling technology or control solution applied. The role of base situations is to ensure that the identification of flank-collision risks is:

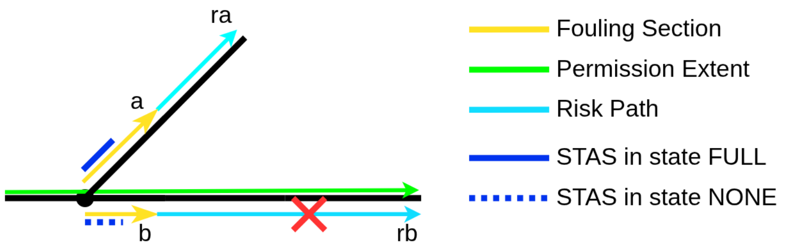
- complete, by covering all relevant categories of conflict,
- consistent across different layouts and Areas of Control, and
- independent of project-specific or supplier-specific solutions.

Each base situation acts as a starting point for the derivation of Risk Path candidates. When a base situation is applicable to the current topology and Movement Permission context, one or more Risk Path candidates are constructed to represent the possible ways in which the corresponding flank conflict could be realised. Base situations therefore define where a potential flank conflict exists, while Risk Path candidates define how that conflict could be approached along the track network. Subsequent steps in the analysis determine whether these Risk Path candidates can be eliminated, need to be split into multiple branches, or must be terminated or constrained by flank-protection measures. By separating the generic identification of conflict patterns (base situations) from their concrete evaluation and mitigation (Risk Paths), Traffic CS avoids embedding layout-specific assumptions and supports a technology-independent treatment of flank protection consistent with ETCS-based operation. Particularly when considering that *Risk Path*s later can split, it is beneficial to resolve unnecessary *Risk Path*s to avoid the checking of too many of them. An eventually unneeded number can arise because of combination of cases 1, 2, and 3 (see again *8.5.1.7 - Slip Points (based on cases 1, 2, and 3)*). **[**SPT2TRAFFIC-14749 **]**



### 9.4.1 Elimination of Risk Path(s) in a new Movement Permission

*Risk Path*(s) overlapping the *Reserved Path* of the requested *MP* are no true Risk Paths and are immediately eliminated (in the following example *rb*): **[**SPT2TRAFFIC-14765 **]**




**[**SPT2TRAFFIC-21106 **]**

### 9.4.2 Elimination of Risk Path(s) along the same track path

Risk Paths originating from different Fouling Sections may partially or fully overlap when they converge onto the same track path. In such cases, the overlapping Risk Paths can be eliminated so that only a single Risk Path remains. Where multiple Risk Paths overlap along the same track, the Risk Path with the earliest starting point is retained, as it represents the most conservative case. All later-starting Risk Paths along the same path are eliminated, since they do not introduce any additional flank-collision risk beyond that already covered by the retained Risk Path.
An example of this situation can be found in the case of *Slip Point*: $a_1$ in 8.5.1.7.1 - Case 1, $y_1$ in 8.5.1.7.2 - Case 2, and $t_1$ in 8.5.1.7.3 - Case 3. All examples extend onto the same track beyond Point C and overlap from that point onwards. In this scenario, only the earliest starting Risk Path is required to be considered.
**[**SPT2TRAFFIC-14763 **]**

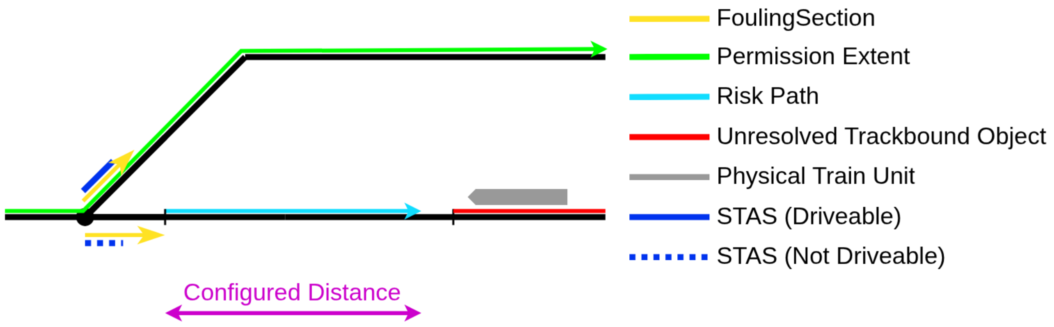
## 9.5 Elements Terminating a Risk Path

This section lists all elements and ways which are able to terminate a *Risk Path.* Termination of *Risk Path*s means that there is a protecting element at the end of the *Risk Path* which sufficiently mitigates the entry of uncontrolled vehicles which could impose the risk of flank collision.
This is mainly either track-enforced (by *Switchable Trackside Assets* in a deflecting position, see section 9.5.2 - STA Sections (track-enforced flank protection)) or by a controlled vehicle itself which will not impose a risk (see section 9.5.4 - Movement Permission and Train Object). If accepted by the risk assessment, also *UTO*s could terminate a *Risk Path* (see section 9.5.5 - Unknown Train Object).
If a *Risk Path* cannot be terminated, i.e. an element is unable to terminate (see section 9.6 - Elements Allowing Risk Path Termination Fail), the *Movement Permission* request (for which the *Risk Path* was searched for completion) will be rejected.
**[**SPT2TRAFFIC-14754 **]**

### 9.5.1 Bounded Risk Path Distance

A Risk Path may, in principle, be short and terminate close to its associated Fouling Section. However, where no track-enforced flank protection is provided i.e. where no Switchable Trackside Asset is available in a protecting position, the project risk analysis may require the application of a bounded Risk Path distance. In such cases, the configuration parameter SPT2TRAFFIC-15310 - Topo.FP.minimumRPLength defines the distance over which a Risk Path shall be searched and assessed. If no element capable of terminating the Risk Path is identified within this distance, the Risk Path may be terminated at the end of the defined length. The value of Topo.FP.minimumRPLength is specified as a project-wide parameter in order to ensure consistent application and to reduce engineering effort. Where justified by local conditions, this value may be overridden for specific locations, as defined in SPT2TRAFFIC-15309. The appropriate value for this distance is expected to depend on the assessed flank-collision risk, balanced against the available track length, operational constraints, and impacts on railway capacity.

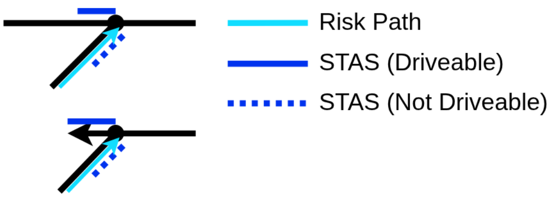
**[**SPT2TRAFFIC-15312 **]**




**[**SPT2TRAFFIC-21105 **]**

### 9.5.2 STA Sections (track-enforced flank protection)

#### 9.5.2.1 Point from trailing side, derailer/catch point

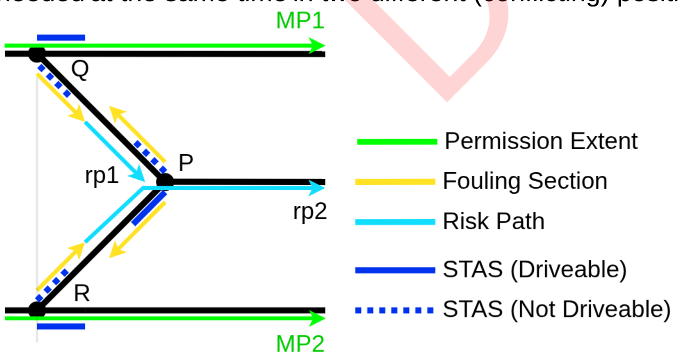



These are the 'classical' elements to provide (track-enforced) flank protection by preventing the movement into the Risk Path. **[**SPT2TRAFFIC-14742 **]**



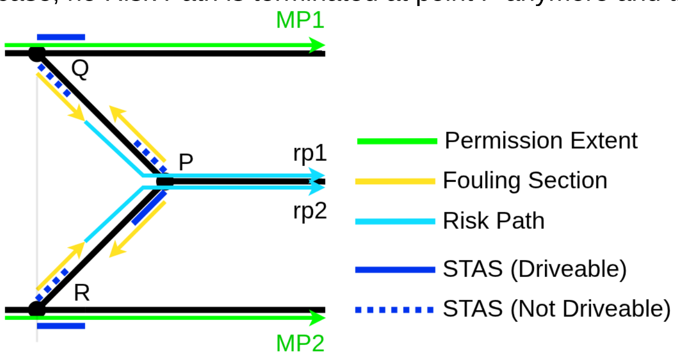
##### 9.5.2.1.1 Special cases: Selective protective point and self-selective protective point

**Selective protective point**: In this special case, a Point P potentially providing flank protection would be needed at the same time in two different (conflicting) positions:




In this case, *MP1* as first granted MP could use *P* as terminating element for its *Risk Path rp1*. MP2 cannot, so - like today - the search is continued. **[**SPT2TRAFFIC-14744 **]**

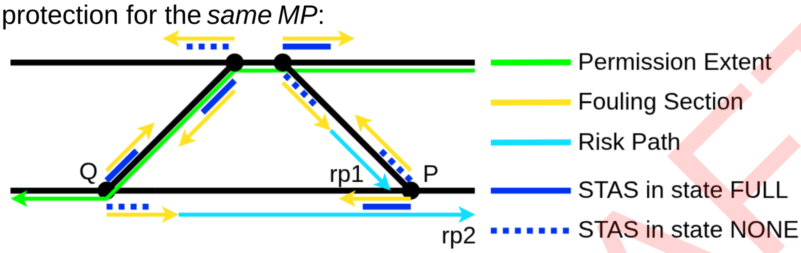
If point P shall be moveable, point P can be marked as not to be used for flank protection by MP1 and MP2 according to *9.8 - Elements which should not terminate Risk Paths for Operational Reasons*. In that case, no Risk Path is terminated at point P anymore and the point is moveable.




[SPT2TRAFFIC-21206]

[SPT2TRAFFIC-21205]

**Self-selective protective point**: A *Point* P is needed in two different positions for providing flank protection for the *same MP*:

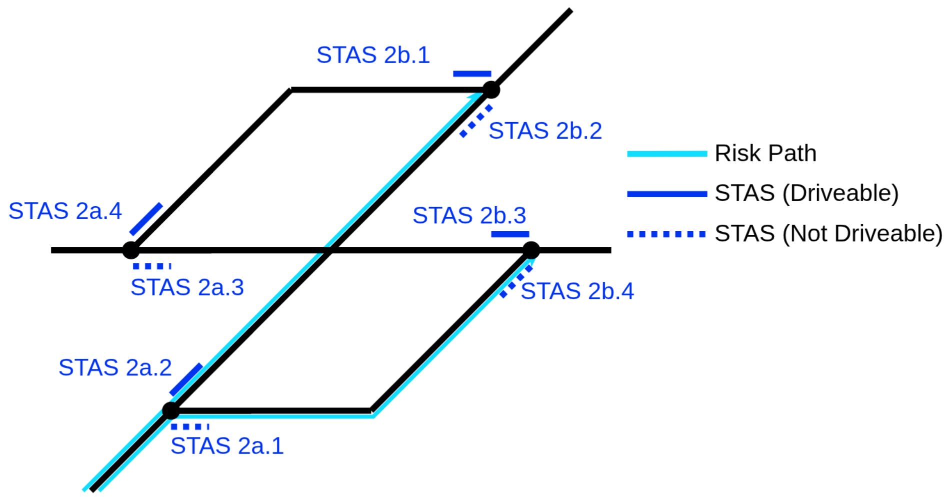



*PES* has the choice which position of *P* would be least restrictive. In the example, *rp1* as the nearest *Risk Path* would provide best protection, and rp2 would be needed to be searched for beyond (left to) *P*. When the train has passed (fully or partially), the position of *P* could now requested to be changed, and *rp2* would now terminate at *P*. This makes sense if the first *rp2* imposes a restriction at *Q* (lesser speed). [SPT2TRAFFIC-21219]

### 9.5.2.1.2 Slip Points

#### 9.5.2.1.2.1 Double Slip

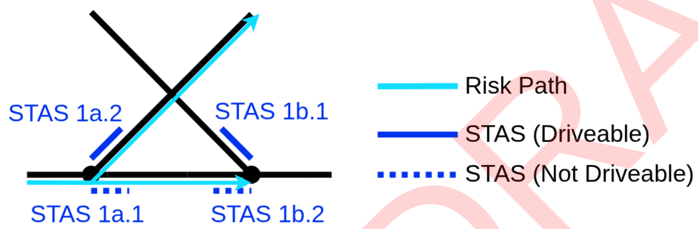
A double slip has one Point Machine on each side which is controlled by one Object Controller. Instead of two blades as with simple points, each Point Machine is connected to four blades that are moved together. The whole double slip is modelled by four "simple points" and one diamond crossing. When a Risk Path search is incoming from the 2a.1/2a.2 side, it is split according to SPT2TRAFFIC-14627 - Splitting of Risk Paths and then is terminated at the "b" side of the slip. please note that 2b.1 and 2b.3 as well as 2b.2 and 2b.4 always have the same driveability state as they are representing the physical blades.



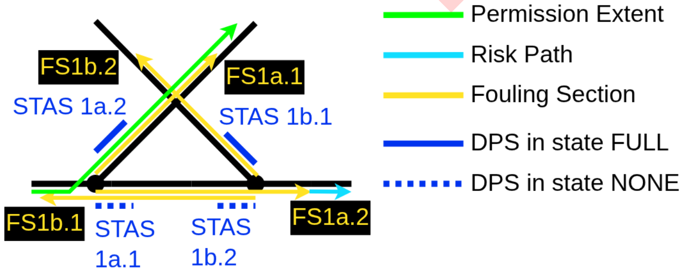

**[**SPT2TRAFFIC-21232 **]**

#### 9.5.2.1.2.2 Single Slip

A single slip has - similar to a double slip - one Point Machine on each side controlled by one Object Controller each. Different to a double slip, only two blades are moved. Thus a single slip can be modelled by two "simple" points and a diamond crossing. When a Flank Path search is incoming through 1a.1/1a.2, it is split according to SPT2TRAFFIC-14627 - Splitting of Risk Paths. One part is terminated on STAS 1b.1 (Driveable) and STAS ab.2 (Not Driveable), for the other part another termination option must be found.




In case a Movement Permission lies over the left branch of 1a (initiating a Risk Path search on the right branch), the Fouling Section must be modelled so that the search begins after STAS 1b.2. Otherwise 1b.1/1b.2 would serve as flank protection although it is not suitable.

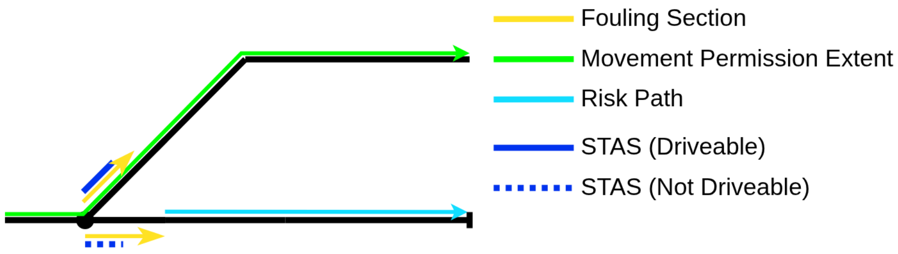



**[**SPT2TRAFFIC-21237 **]**

### 9.5.2.2 Non-suitable STA Sections

Only *STA Section*s can physically deflect a potentially conflicting movement away from a protected movement. That means that *STA Sections* (*Switchable Trackside Asset*) which express parallel tracks cannot terminate *Risk Path*s - see also section *9.11.1.5 - Level Crossings, Gates, and Movable Bridges*.
**[**SPT2TRAFFIC-14768 **]**

### 9.5.3 Bufferstop or end of tracknet

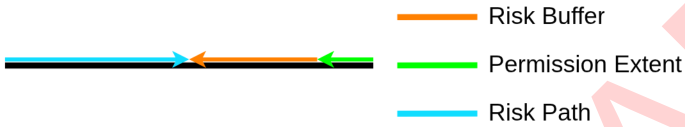



A *Bufferstop* or an end of tracknet marks the last location of potential endangering risks and is therefore limiting the *Risk Path* search.
Note: A *Switchable Bufferstop* is for this aspect similar to a *Derailer*. **[**SPT2TRAFFIC-14770 **]**

### 9.5.4 Movement Permission and Train Object

#### 9.5.4.1 Movement Permission

**Front of *MP***
The *Risk Buffer* of a facing *MP* can delimit the *Risk Path*:




**[**SPT2TRAFFIC-14736 **]**



#### 9.5.4.2 Train Object without Movement Permission

A *Train Object* without an *MP* cannot move because it is supervised for standstill by the *OBU* according to the accepted risk level; it can therefore delimit the *Risk Path*.

**Front of *Train Object***


**Rear of *Train Object***


**[**SPT2TRAFFIC-14738 **]**

### 9.5.5 Unknown Train Object


Where the harmonised operational rules restrict the stabling or shunting of vehicles to specific tracks (potentially along with other measures like drag shoes or prohibition boards). Or explicit prohibitions of stabling and shunting, then occupied tracks maybe accepted as providing adequate protection. The applicability and reliability of such operational measures are not assumed implicitly. Instead, whether these

measures can be relied upon is explicitly configured (SPT2TRAFFIC-14673 - Config.FP.UTOAcceptedAsRP. This ensures that the acceptance of occupied tracks as a mitigating measure is based on declared, enforceable rules rather than on implicit or informal operating practices.
[SPT2TRAFFIC-14740]

## 9.6 Elements Allowing Risk Path Termination Fail

If an element encountered during Risk Path evaluation cannot terminate a Risk Path, the system shall apply one of the following rules:

1. Continuation of Risk Path search:
   If the encountered element: does not terminate the Risk Path, and does not itself constitute an unacceptable risk, the Risk Path search may continue beyond that element, including delegation to an adjacent Area of Control in accordance with *9.12 - Delegation of Flank Protection*.
2. Failure of Risk Path termination:
   If the encountered element: does not terminate the Risk Path, constitutes a risk in its own right, and cannot be accepted as a mitigating condition by configuration, the Risk Path search shall not continue beyond that element. The Risk Path termination shall be considered to have failed.
3. Elements causing Risk Path termination failure
   The following element shall cause Risk Path termination to fail: an Unknown Train Object (UTO), where the configuration parameter SPT2TRAFFIC-14673 - Config.FP.UTOAcceptedAsRPis set to false.
4. Consequence of termination failure:
   Where Risk Path termination fails for any Risk Path associated with a Movement Permission, the Risk Path shall be considered non-mitigated, and the corresponding Movement Permission shall not be granted.

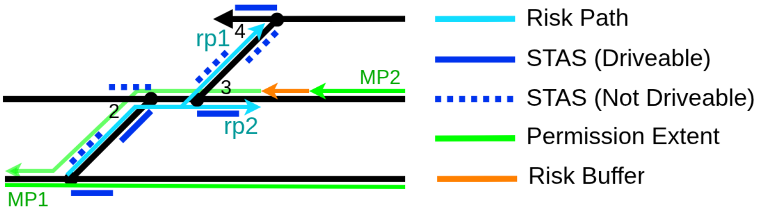
[SPT2TRAFFIC-14758]

## 9.7 Enforced Speed Restriction

Where the project risk analysis determines that the residual risk of a flank collision is acceptable, a failure to terminate a Risk Path shall not necessarily result in rejection of a Movement Permission, provided that the passing speed at the relevant Fouling Section is sufficiently low. In such cases, a Movement Permission results in a train passing the Fouling Section at or below a predefined speed threshold, ETPS may accept the Movement Permission despite the absence of a terminated Risk Path. This represents an alternative mitigation measure to track-enforced flank protection. The maximum permissible speed for this case is specified by configuration parameter SPT2TRAFFIC-14676 - Config.FP.SpeedRestrWhenNoRP i.e. the maximum speed at the Fouling Section at which a Movement Permission may be accepted when no Risk Path can be terminated. If Config.FP.SpeedRestrWhenNoRP is set to 0, no enforced-speed mitigation shall be permitted, and the Movement Permission shall be rejected if the associated Risk Path cannot be terminated. This mechanism reflects common operational practice, where restricted speeds (typically in the order of 40 km/h) are accepted as providing sufficient mitigation of flank-collision risk under defined conditions.
[SPT2TRAFFIC-14743]

## 9.8 Elements which should not terminate Risk Paths for Operational Reasons

In many situations, more than one element may be capable of terminating a Risk Path. In general, using the nearest eligible terminating element is beneficial, as it minimises the extent of the flank-protection area. However, there may be operational reasons to deliberately deviate from this principle. Such deviations are justified where maintaining the nearest element in a flexible and changeable state, is required to support current or future operational needs, for example to enable subsequent Movement Permissions or alternative train movements. In these cases, flank protection may be intentionally provided by elements located further along the Risk Path, including through *9.12 - Delegation of Flank Protection*. The intended effect is that elements identified as operationally flexible are not fixed in a protecting position, but remain available to be moved or reused as required by the operational plan. By contrast, elements selected to terminate a Risk Path are expected to remain in their protecting state for the duration of the associated Movement Permission.




In the illustrated example above, Movement Permission MP1 is requested. Point P2 would normally be the nearest element suitable for terminating the associated Risk Path. However, if P2 must remain flexible for later operational use (for example, to support a subsequent Movement Permission MP2), PES shall indicate this requirement in the Movement Permission request. In response, ETPS shall continue the Risk Path search beyond P2, rather than using P2 as a terminating element, and shall identify alternative Risk Paths (labelled *a* and *b* in the example) that can provide flank protection.

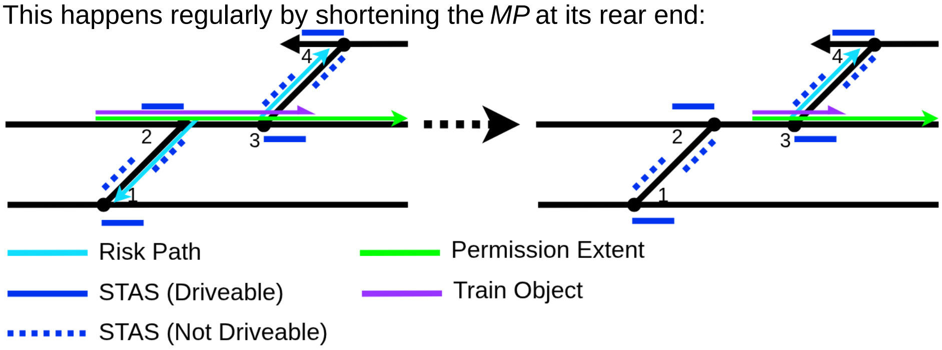
To support this behaviour, the interface between PES and ETPS shall allow the explicit identification of flexible elements. Where operational flexibility is required, the relevant element or list of elements shall be included as a parameter in the ETPS request. Where no such flexibility is required, an PES shall provide and empty parameter to ETPS. The inclusion or omission of this parameter therefore determines whether operational flexibility is applied. Where no flexible elements are indicated—for example, that do not require this capability, ETPS shall treat the nearest eligible element (such as P2 in the example) as required to provide track-enforced flank protection.
**[**SPT2TRAFFIC-14760 **]**

### 9.9 Waived Risk Paths

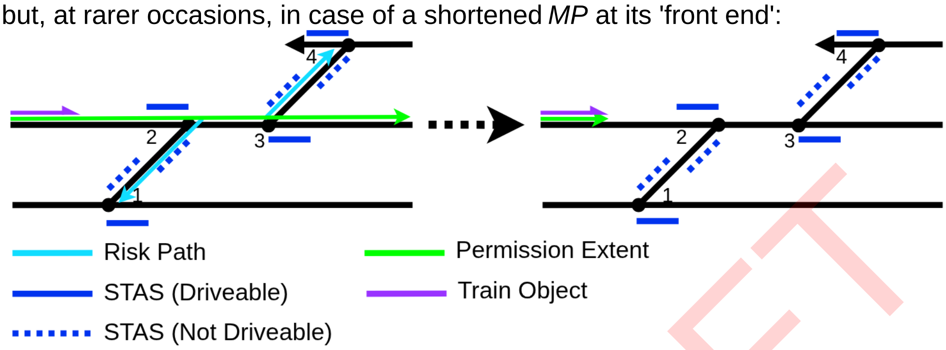
For certain train movements, the Infrastructure Manager may accept a higher residual risk of flank collision, for example on secondary or low-risk lines where operational and traffic conditions significantly limit the likelihood and consequences of conflicting movements. In such cases, flank protection may be explicitly waived. Waiving flank protection means that Risk Paths are neither constructed nor required to be terminated for the affected Fouling Section. This behaviour is enabled through the configuration parameter SPT2TRAFFIC-14668 - Topo.FP.waivesFlankProtectionWhen this parameter is set for a given Fouling Section, ETPS shall not generate Risk Paths for that Fouling Section as part of Movement Permission evaluation. The application of this configuration is subject to the explicit acceptance of the risks i.e. shall only be applied where the associated flank-collision risk has been assessed a deemed acceptable within the overall safety framework. **[**SPT2TRAFFIC-14750 **]**

### 9.10 Release of Risk Paths

This happens regularly by shortening the *MP* at its rear end:




but, at rarer occasions, in case of a shortened *MP* at its 'front end':




A *Risk Path* will be removed when the originating *Fouling Section* no more intersects the *MP*.
Rationale: if a *Fouling Section* no longer applies to a *MP*, the related flank collision risk for this location no longer exists. **[**SPT2TRAFFIC-14757 **]**

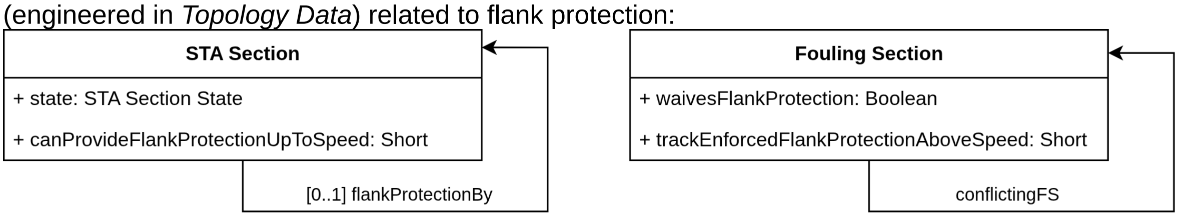


### 9.11 Risk Path Termination Capability

#### 9.11.1 Switchable Trackside Assets

##### 9.11.1.1 Flank protection related properties in Topology Data

*Switchable Trackside Asset*s are modelled by the *STA Section* abstraction which contains information (engineered in *Topology Data*) related to flank protection:




**[**SPT2TRAFFIC-14762 **]**

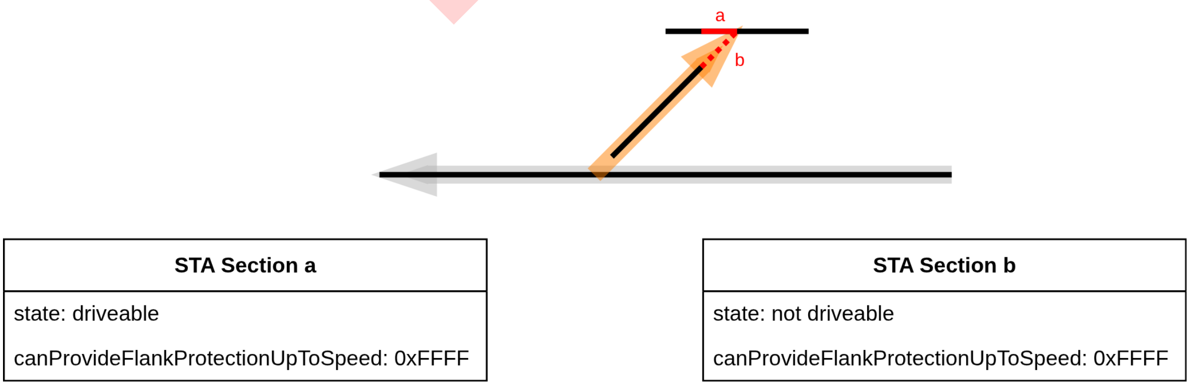
| Property | Description |
|---|---|
| *STA Section* | |
| `state` | The STA Section State is the current operating state of a Switchable Trackside Asset (STA) Section, indicating whether the corresponding section of track is in a position and condition |

| Property | Description |
|---|---|
| | that allows it to be safely used as part of a Movement Permission or as a terminating element for a Risk Path. |
| `canProvideFlankProtectionUpToSpeed` | Describes whether the *STA Section* altogether can provide flank protection by its physical capabilities. Example: A *Simple Point* can while a *Level Crossing* can not.<br>Additionally, a speed up to it can provide flank protection can be specified.<br><br>See configuration value SPT2TRAFFIC-14672 - Topo.FP.canProvideFlankProtectionUpToSpeed |
| `flankProtectionBy` | Reference to *another STA Section* in the *STA* which protects *this STA Section*. The other *STA Section* has the property `canProvideFlankProtectionUpToSpeed` set to a value greater 0. |
| *Fouling Section* | |
| `waivesFlankProtection` | (Default: false) Some Infrastructure Managers allow to waive flank protection when the operational conditions are 'simple'. In this case, for such a *Fouling Section* no *Risk Path*s are even needed (to build)! |
| `trackEnforcedFlankProtectionAboveSpeed` | Some rules of Infrastructure Managers require track-enforced flank protection in several situations. That means, *ETPS* can only chose *Switchable Trackside Asset* type elements to terminate *Risk Path*s. Example: loading tracks around the *Fouling Point*.<br>Additionally, a speed from which on track-enforced flank protection is required can be specified.<br><br>See configuration value SPT2TRAFFIC-14666 - Topo.FP.trackEnforcedFlankProtectionAboveSpeed. |
| `conflictingFS` | A conflicting Fouling Section is the Fouling Section that represents the potentially conflicting track path relative to an authorised Movement Permission, from which a Risk Path originates and through which a flank collision could occur if not adequately mitigated. |

**[**SPT2TRAFFIC-14764 **]**



### 9.11.1.2 Simple points




**[**SPT2TRAFFIC-18524 **]**

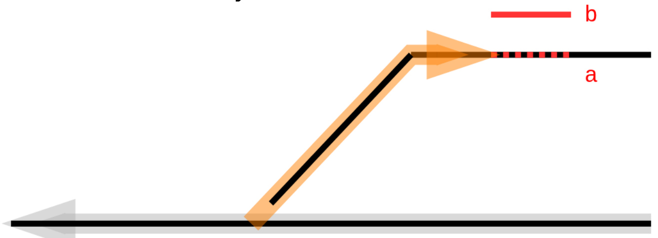
### 9.11.1.3 Derailers

It might not appear obvious why *Derailer*s have two *STA Section*s as there is no *Track Node*.
But it has to be assured, that the deflector is *fully* attached (in an end position) to provide flank protection.

SCI-P is used anyway for *Derailer*s, and if it would be reduced to only one *STA Section*, a notified *unreached* end position corresponding needed to the blocking a conflicting movement would not be recognised. Therefore, both end positions have to be mapped - like for *Simple Point*s - also for a *Derailer*. With this, both checks for flank protection:

1. The terminating *STA Section* is not in driveable state (*a* in the figure); and
2. The protecting *STA Section* (`flankProtectionBy`, *b* in the figure) is in driveable state

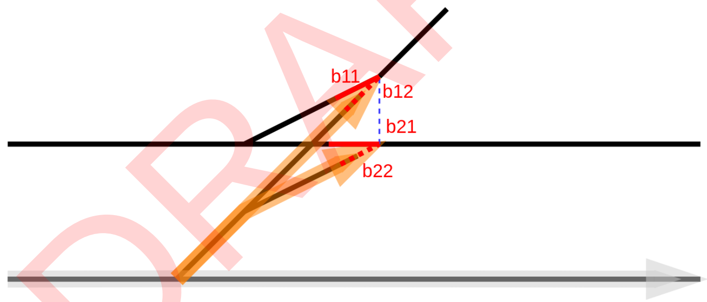
can be made and only if successful, the *Risk Path* can be terminated:




Another benefit is, that there is no different handling required for *Catch Point*s and *Trap Point*s. **[**SPT2TRAFFIC-14746 **]**

### 9.11.1.4 Compositions of Simple Points (e.g. Slip Points)

A *Slip Point*, as usual, can be composed of four *Simple Points*. However, as the two *Point*s of the 'a side' (as well as those of the 'b side') are moved together (coupled switch rod = dashed blue line), the related *Domain Objects* are (only shown for the 'b side'):






| STA Section b11 |
| --- |
| state: driveable |
| canProvideFlankProtectionUpToSpeed: 0xFFFF |

| STA Section b12 |
| --- |
| state: not driveable |
| canProvideFlankProtectionUpToSpeed: 0xFFFF |

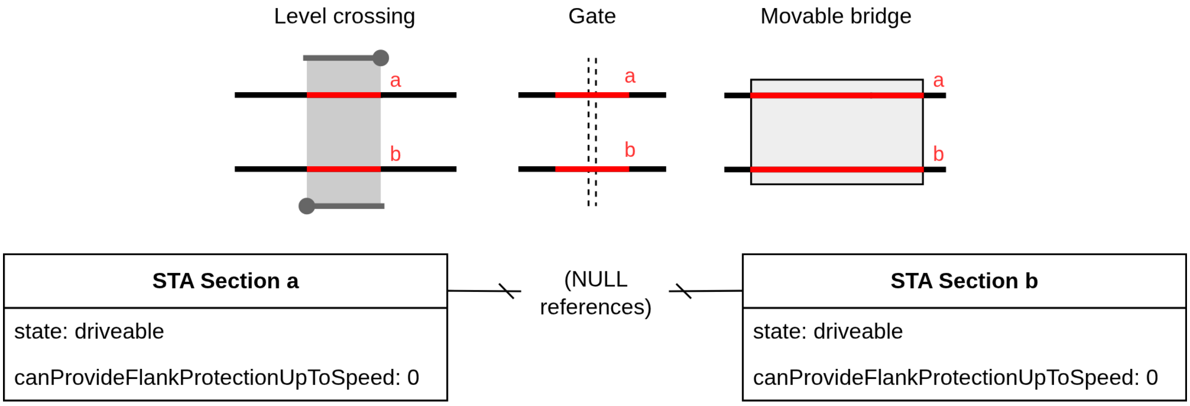
| STA Section b21 |
| --- |
| state: driveable |
| canProvideFlankProtectionUpToSpeed: 0xFFFF |

| STA Section b22 |
| --- |
| state: not driveable |
| canProvideFlankProtectionUpToSpeed: 0xFFFF |

(For simple *Slip Points*, only one pair is needed = not more specific than just information for a *Simple Point*.) **[**SPT2TRAFFIC-14747 **]**

### 9.11.1.5 Level Crossings, Gates, and Movable Bridges

All *STA Section*s are there always in the same state. Therefore, there cannot be a *STA Section* in driveable state which protects another *STA Section* not in driveable state:




**[**SPT2TRAFFIC-14748 **]**

### 9.11.2 Other types of elements terminating a Risk Path

It is also possible - but not yet foreseen - that other elements impose restrictions on the protected speed, potentially depending on national requirements if not harmonised. Once this is needed, it can be further elaborated. **[**SPT2TRAFFIC-14735 **]**

## 9.12 Delegation of Flank Protection

If any of the aforementioned (potential) flank protection providing elements is found during building the *Risk Path* and it is not in the protecting state, it cannot be used as a flank protection providing element. The search is not terminated and will continue until a (next) (potential) flank protection providing element is found or the search fails when reaching the search depth limit. Continue searching may split the *Risk Path*. A search could reach the limit of the *AoC* and would need to be continued beyond it. As the area beyond is not known to *ETPS*, searching for *Risk Paths* has to be done in cooperation with an adjacent *CCS* system. This will be investigated later in the course of the *ETPS* handover to/from another *AoC*. **[**SPT2TRAFFIC-14737 **]**



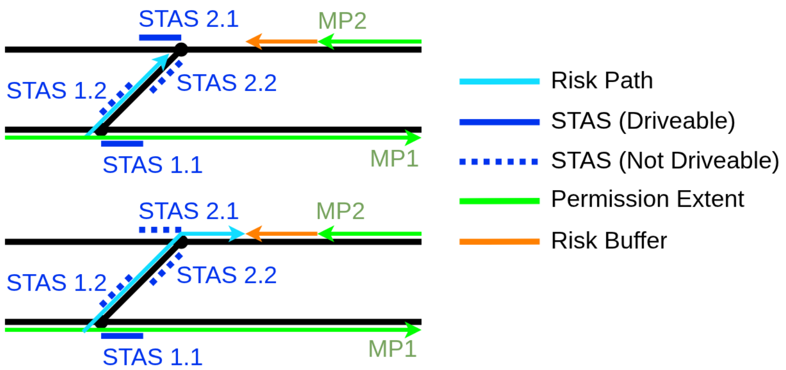
## 9.13 Risk Path Status

*Risk Path*s assure that the flank collision risk is sufficiently mitigated. ETPS shall continuously monitor the conditions that mitigate a Risk Path remain valid for the duration of the Movement Permission. To maintain this assurance, ETPS shall prevent any system action that would invalidate an active Risk Path. For example, ETPS shall reject any request to change the state of a Switchable Trackside Asset if that asset is currently being used to terminate a Risk Path. The Risk Path status may depend on the presence or absence of Train Objects or other Movement Permissions on the conflicting track. In particular, a Risk Path may initially be established based on the current topology and protection elements, even if no Train Object or Movement Permission exists on the conflicting track at the time the Movement Permission is granted. If, after a Movement Permission has been accepted, a new Movement Permission is requested on a conflicting track, ETPS shall re-evaluate the affected Risk Paths. ETPS shall only accept the new Movement Permission if the existing Risk Paths remain valid or can be re-established without reducing the level of flank-collision protection for any authorised movement. In this way, ETPS ensures that changes in train or Movement Permission status do not introduce unmitigated flank-collision risks, and that the safety assumptions underlying existing Risk Paths are preserved throughout system operation. **[**SPT2TRAFFIC-14745 **]**

### 9.13.1 Changed STA Section state

If the terminating element is an STA Section (2.1 driveable, 2.2 not driveable) and it changes its state, the Risk Path is no more terminated. ETPS must search a new Risk Path reaching beyond the changed STA Section. The old Risk Path is removed and (a) new one(s) is (are) built according to the introduced rules.

In this example:




a new Risk Path terminating at the Risk Buffer of MP2 will be created (and the old removed).

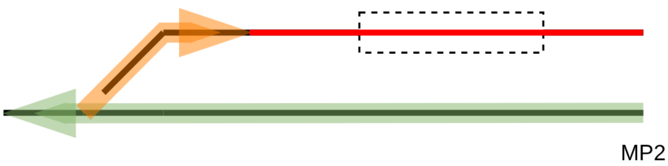
If thereby occurs at least one unterminated Risk Path, a safety reaction has to be applied. **[**SPT2TRAFFIC-21231 **]**

### 9.13.2 Changed MP/Train object state

If the terminating element is an *MP* or *Train Object*, there is a similar consideration as above (combined risk is deemed acceptable). Consider this example where an MP2 was granted because already granted MP1 provides flank protection. In the next step the terminating element MP1 changes its state (arrival of the train and End of Mission (EoM) performed - thus a *UTO* was created):


**[**SPT2TRAFFIC-18523 **]**






an appropriate speed restriction would need to be present over the *Fouling Section* in the straight part of the *Point* within MP2 (SPT2TRAFFIC-14669 - Config.FP.SpeedRestrUTOasRP).
**[**SPT2TRAFFIC-15730 **]**

For the depicted situation SPT2TRAFFIC-15730, similar to section *9.13.1 - Changed STA Section state*, with argumentation for the combined risk, no reaction will be foreseen. (An alternative could be a co-operative shortening for MP2.) **[**SPT2TRAFFIC-18527 **]**

## 9.14 Configurability

In the long term, operational harmonisation is expected to enable a uniform approach to flank protection, with no differing requirements between Infrastructure Managers. In practice, however, such harmonisation cannot be assumed in the short term, and differences in operational rules, risk acceptance, and legacy constraints will continue to exist across networks. For this reason, ETPS provides a structured configurability concept to accommodate justified variations in flank protection behaviour while maintaining a common product. Configurability is expressed at two distinct levels:

- Feature level
  At a higher level, a feature determines whether a specific capability, or variant of a capability, is supported or not. Features are Boolean in nature and are either enabled (true) or disabled (false). Features may be interdependent.
- Configuration-value level
  At a lower level, configuration values define the detailed behaviour of enabled features. These values typically specify thresholds, limits, or parameters (for example numerical values) that may legitimately differ between projects or Infrastructure Managers.

Features and configuration values are provided to ETPS through engineering data, either as:

- Application-level configuration data (for features and non-topology-dependent configuration values), or
- Topology Data (for configuration values that are specific to Fouling Sections, STA Sections, or other topological elements).

[SPT2TRAFFIC-14756 ]

### 9.14.1 Application-wide

**Config.FP.SpeedRestrWhenNoRP**
*ETPS* provides the configurability of the value for the accepted maximum speed at a *Fouling Section* where - from its conflicting *Fouling Section* - a *Risk Path* exists but this cannot be terminated.

- **Configuration category**: Application
- **Level**: *AoC*
- **Type**: Integer
- **Value**: Maximum permissible speed at the *Fouling Section* of the *MP*

[SPT2TRAFFIC-14676 ]

**Config.FP.UTOAcceptedAsRP**
*ETPS* provides the configurability of the value if an *Unresolved Train Object* is acceptable to terminate a *Risk Path*.

- **Configuration category**: Application
- **Level**: *AoC*
- **Type**: Boolean
- **Value**:
    - true: acceptable (in this case, SPT2TRAFFIC-14669 - Config.FP.SpeedRestrUTOasRP limits the speed) in the *Fouling Section*
    - false: not acceptable

[SPT2TRAFFIC-14673 ]

**Config.FP.SpeedRestrUTOasRP**
*ETPS* provides the configurability of the value for the accepted maximum speed at a *Fouling Section* if an *Unresolved Train Object* is acceptable to terminate a *Risk Path*.

- **Configuration category**: Application

- **Level**: *AoC*
- **Type**: Integer
- **Value**: Maximum permissable speed at the *Fouling Section* of the *MP* (value > 0)

**[**SPT2TRAFFIC-14669 **]**

**Feat.FP.fpForRiskBuffer**
*ETPS* provides the configurability to enable or disable the feature to provide/check flank protection also for *Fouling Point*s in the *Risk Buffer*, e.g. beyond the EoA.

- **Configuration category**: Config
- **Level**: *AoC*
- **Type**: Boolean
- **Value**: true/false if feature is enabled/disable

**[**SPT2TRAFFIC-14665 **]**

### 9.14.2 Location-specific (Fouling Section)

General note: Even if there is the possibility to provide a configuration value location-specific, it can be beneficial to provide the value globally (like described in section *9.14.1 - Application-wide*). Only for those locations where this application-wide default is to be replaced by a location-specific value, it needs then to be supplied. This reduces engineering efforts. **[**SPT2TRAFFIC-15309 **]**

**Topo.FP.trackEnforcedFlankProtectionAboveSpeed**
*ETPS* provides the configurability of the speed from which on (higher values) track-enforced flank protection is needed.

- **Configuration category**: Topo
- **Level**: Topo Element
- **Type**: Integer
- **Value**:
  - 0: Track-enforced flank protection is needed in any case
  - 0 < n < 0xFFFF: Track-enforced flank protection is only needed above speed *n*
  - 0xFFFF: No track-enforced flank protection

**[**SPT2TRAFFIC-14666 **]**

**Topo.FP.waivesFlankProtection**
*ETPS* provides the configurability for *Fouling Section*s whether the risk of flank collision at this *Fouling Section* is considered as negligible.

- **Configuration category**: Topo
- **Level**: Topo Element
- **Type**: Boolean
- **Value**:
  - true: The risk is negligible, no *Risk Path* termination is needed
  - false: else

**[**SPT2TRAFFIC-14668 **]**

**Topo.FP.minimumRPLength**
*ETPS* provides the configurability for *Fouling Section*s whether the *Risk Path* originating has a minimum length.

- **Configuration category**: Topo
- **Level**: Topo Element
- **Type**: Integer

- **Default**: 0

[SPT2TRAFFIC-15310 ]

### 9.14.3 Location-specific (STA Section)

Please consider the hint SPT2TRAFFIC-15309.

**Topo.FP.canProvideFlankProtectionUpToSpeed**
*ETPS* provides the configurability for a *STA Section* which can provide track-enforced flank protection but only up to a certain speed.

- **Configuration category**: Topo
- **Level**: Topo Element
- **Type**: Integer
- **Value**:
    - 0: The element cannot provide track-enforced flank protection
    - 0 < n < 0xFFFF: the element can provide track-enforced flank protection up to speed *n*
    - 0xFFFF: The element can provide track-enforced flank protection for any speed

[SPT2TRAFFIC-14672 ]

**Topo.FP.sufficientDistance**
*ETPS* provides the configurability of an attribute SPT2TRAFFIC-14674 - Topo.FP.sufficientDistance for a *STA Section* from which on (in *Risk Path* direction) the search for *Risk Path* termination can be finished if no terminating element is found before.

- **Configuration category**: Topo
- **Level**: Topo Element
- **Type**: Integer
- **Value**: Distance

[SPT2TRAFFIC-14674 ]

## 10 Switchable Trackside Assets

**The Approving members agree with the content of the following chapter as captured below to be used as a basis for future specification work**
Approval Baseline for transparency: Traffic CS Technical Design Decisions

| | |
|---|---|
| Approvals | Roman Treydel : Approved , Ghielmetti Cirillo (I-NAT-GST-CCS) : Approved , Golebniak, Udo (SMO RI ML ADC I&C) : Approved , Adomeit, Sven (SMO RI R&D TC PE) : Approved , EVANGELISTI CLAUDIO : Approved , Philipp Nienheysen : Approved , Schöni Ulrich (I-NAT-GST-CCS) : Approved , Schmidt Steffen (I-NAT-GST-ERTM) : Approved , LOEFFLER Christian : Approved , Smit Srivastava : Approved , CIUCCI Paolo : Approved , Domínguez Fernández, Silvia : Approved , Konstantinos Emmanouil : Approved , Morman Bettina (I-NAT-GST-CCS) : Approved |

| | |
|---|---|
| Comments | **#1 Approval comment** by **LOEFFLER Christian** on 2026-05-07 13:36<br>Conditional Approval with the following conditions given:<br>1. Only Points are analysed in more detail to be compliant with STA concept. Other trackside assets still need to be analysed - until such an analysis has confirmed the compliance of the STA concept to the specific trackside asset type, the chapter shall not give the impression that STA concept can be applied to the specific trackside asset type (e.g. Level Crossing). For actively Traffic CS controlled Gates and Bridges STA concept seems to be ok - if Traffic CS receives pure status information from these devices, application of STA concept seems to be questionable, needs to be analysed in detail and adapted if necessary.<br><br>**#2 (reply to #1 Approval comment)** by **LOEFFLER Christian** on 2026-05-07 14:23<br>Detailed comments are given in the actual working document. |

## 10.1 Introduction

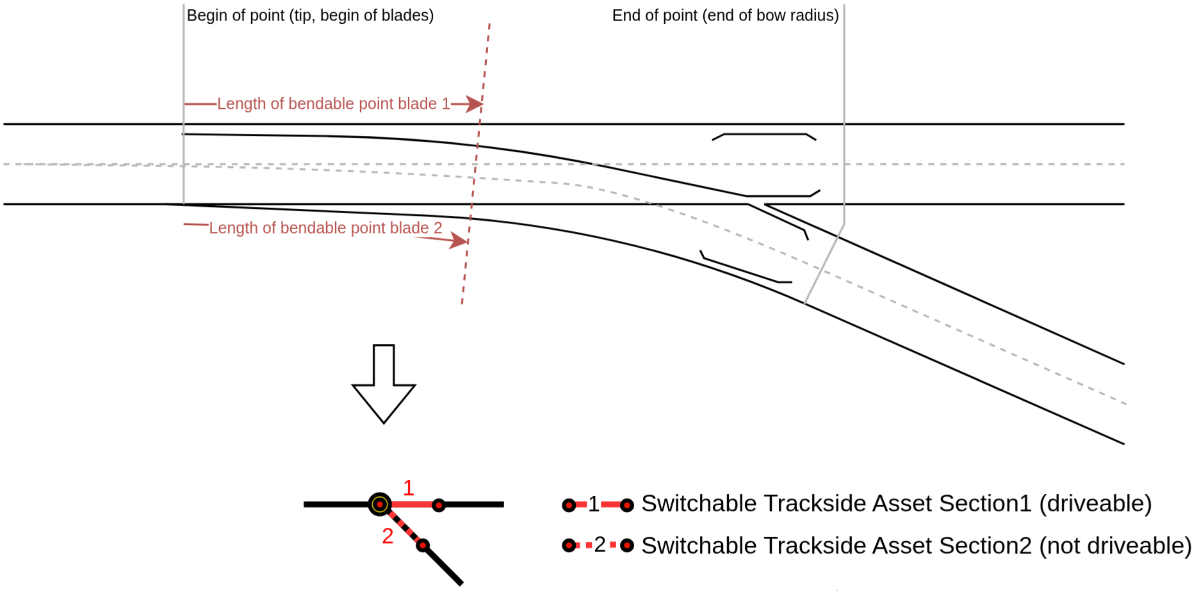
*Switchable Trackside Asset*s (STA) in the railway network can provide the continuity or discontinuity of the track path and/or can supply the possibility to join/diverge tracks. The most prominent examples are (simple) *Points*. They can be switched to provide continuity of the track path in one or the other direction while at the same time interrupting the track path in the non-chosen direction. *Point*s appear in several combinations (e.g. double/interlaced *Point*s, simple/double slip *Point*s with an inner crossing). While the primary purpose of Points is to provide continuity, its possible discontinuity can also be used to mitigate the risk of a flank collision. This mitigation is also the main purpose of derailers. Finally, there can be obstacles in the way: Movable bridges or (flood) gates. **[**SPT2TRAFFIC-20431 **]**

With the *STA* concept, the following basic needs can be fulfilled:

1. Determination of the position (status) of an *STA*;
   - Safety check before accepting a position of an *STA* for a Movement Permission (cf. section *10.4 - Safety checks*);
2. Move an *STA* to the needed position;
   - Safety check before accepting a request to change an *STA* (cf. section *10.4 - Safety checks*)

**[**SPT2TRAFFIC-13880 **]**

To reach a generic and easy-to-maintain Safety Logic, it is beneficial to abstract the concrete *STA* to the core characteristics which are needed for the Safety Logic. For the example of a simple *Point* below: **[**SPT2TRAFFIC-20429 **]**




**[**SPT2TRAFFIC-20439 **]**

There are two movable parts (point blades - 'the points'). They can be moved such that they provide one position or the other, and give continuity for one or the other. Translated to the railway topology node/edge model, the *STA* of type *Point* forms a *Net Relation*. Either of the ways is represented by a *Linear Element Section* (*LES*). These *LES* will be called *STA Sections* and are engineered in the *Topology Data* with an extent that covers the movable parts of their *STA* (for a *Point* as shown above, for a movable bridge for the length of the bridge).

This means, that the **core aspect** of an *STA*, the **driveability**, is handled by *STA*/*STA Section*s. There are two more aspects

- Potential **structure gauge conflict**: please refer to chapter *8 - Clearance Conflicts*;
- Degraded situations (e.g. trailed *Point*): this will be done by the *UR* concept. As mentioned already there, the restriction imposed by a malfunction/unintended state of an *STA* leads to the (automatic) creation of a *UR*. This ensures that any (existing or later requested) *Movement Permission* obeys that restriction. Please refer to chapter *7 - Usage Restrictions*.

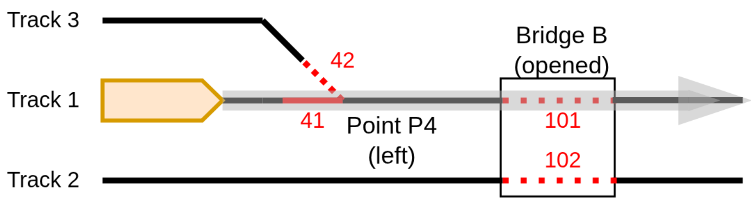
This separation into three aspects adheres to a core architectural principle: separation of concerns. **[**SPT2TRAFFIC-13819 **]**

## 10.2 Introductory example

With the help of this example it should be easy to understand the concept of *STA Section*s. It is explained mainly by describing the *Point*, the most prominent *STA*. The mentioned principle is applicable to other types of *STA* which are listed in the *10.6 - Applications* for further reference. **[**SPT2TRAFFIC-13816 **]**

### 10.2.1 Layout

Consider this simplified track layout with a *Point* and a *Movable Bridge*: **[**SPT2TRAFFIC-20433 **]**



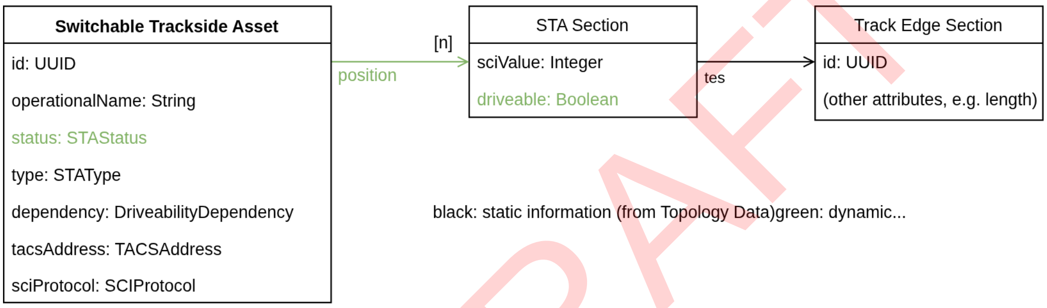

[SPT2TRAFFIC-13810 ]

A *Movement Permission* (grey arrow) is requested for the train to reach beyond the *Point* and the bridge. Before that could happen, *PES* had requested to set both *Switchable Trackside Assets* to the needed position. When now requesting the *Movement Permission*, the Safety Logic of *ETPS* checks if all *STA*s are in the needed position (which is not the case for the bridge). [SPT2TRAFFIC-20437 ]

### 10.2.2 Domain Model

It is helpful to understand how *STA*s are modelled conceptually (only used for concept/specification purpose; the actually used *Domain Model* and *Domain Objects* can be supplier-specific, see also Concept: ETPS Specification patterns - Detail, Domain Model, Safety Rules).

The conceptual *Domain Model* of the analysis model is [SPT2TRAFFIC-13804 ]




[SPT2TRAFFIC-20443 ]



where *n* is the number of 'affected ways' (2 for a simple *Point*, 3 for a *Movable Bridge* with 3 tracks, ...), using these types [SPT2TRAFFIC-20434 ]

| <<enumeration>> **STAType** |
|---|
| POINT |
| DERAILER |
| SWITCHED_DIAMOND_CROSSING |
| GATE |
| MOVABLE_BRIDGE |
| (LEVEL CROSSING *) |
| (SIGNAL *) |

| <<enumeration>> **STAStatus** |
|---|
| DISTURBED |
| TRAILED |
| PROCESSING |
| READY |

| <<enumeration>> **SCIProtocol** |
|---|
| SCI-P |
| SCI-LS |
| SCI-LX |
| SCI-IO |

| <<enumeration>> **DriveabilityDependence** |
|---|
| EXCLUSIVE |
| EQUAL |

* see appendix of this chapter

[SPT2TRAFFIC-20444 ]

The *Switchable Trackside Asset* has a **type**. This type is not needed for the Safety Logic (see below) but can be used to provide non-abstract, concrete diagnosis and user information (e.g. "Point 4 is disturbed" rather than "STA 4 is disturbed").

It has a number *n* of related *STA Sections* which represent the *n* different ways to pass beyond the *STA*. Each *STA Section* references a linear stretch on the topology (*Linear Element Section*). By this, any traversal algorithm will find the *STA Section*, e.g. when checking for safety conditions for the granting of a *Movement Permission*. These *1* to *n STA Section*s are referenced by the **position** attribute. Each of the *STA Section*s has the information if it is actually **driveable**.

Some information is needed to make the translation between the abstract *STA*/*STA Section* notion and the concrete *Trackside Asset* (e.g. a Point). For this, the used SCI Protocol (**sciProtocol**) is retrievable, together with the communication address of the related trackside object (*ObjectController,* **ObjectControllerAddress**). From this, it will be known that e.g. for a point (SCI-P) the attribute to be evaluated is *Reported Point Position*. From **sciValue** it is known which value means left (0x02) or right (0x01). The dynamic state **driveable** can then be simply retrieved from the report

driveable := (<reported value> == sciValue)

or translated to the SCI parameter value to set the point

*Commanded Point Position* := sciValue

Example: the P4 is in left position (= 0x02) so position[0].driveable for STA Section 41 is *true* as it matches position[0].sciValue, and position[1].driveable is *false* as it does not match position[1].sciValue. **[**SPT2TRAFFIC-20436 **]**

While accepting any reported value, not every combination of *STA Section* positions can be accepted. As an example for *Point* 4, *STA Section* 41 and *STA Section* 42 cannot be both set to driveable but only either of them. This is expressed by the **dependency**:

- EXCLUSIVE: exactly one *STA Section* can be requested driveable, any other request is non-driveable. A *Point* is an obvious example.
- EQUAL: all *STA Section*s are requested with equal driveability. A *Movable Bridge* or *Gate* are examples: all the tracks (*STA Section*s) is driveable (bridge closed, gate opened) or all non-driveable (bridge opened, gate closed).

Finally, the *Switchable Trackside Asset* has an overall status so it is clear how it can be used by *ETPS*:

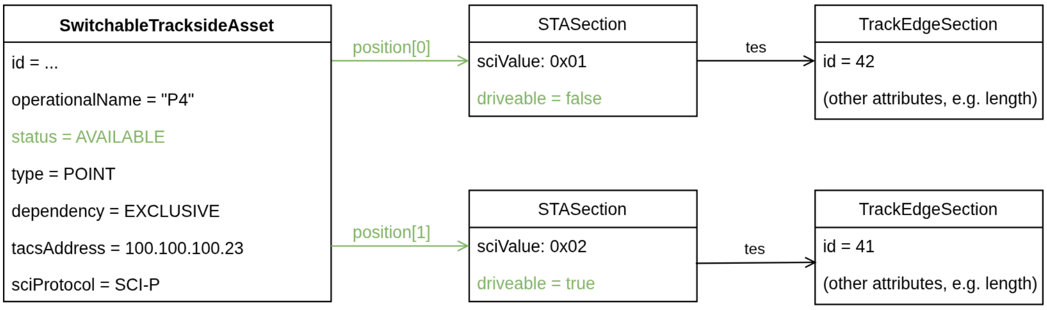
- AVAILABLE (regular state): The *STA* can be operated; it is ready to receive commands;
- PROCESSING: The *STA* is switching. A new command (for an immediate reversal) will be still accepted;
- DISTURBED: The *STA* cannot be operated. One example is a disturbed communication link.

This information is used to determine if switch requests are possible, but also to know if *ETPS* can trust the reported state: if the communication is broken, *ETPS* cannot guarantee the (previously) reported state is (still) correct and will have to consider all *STA Section*s (of the related *STA*) to be non-driveable. **[**SPT2TRAFFIC-20438 **]**

### 10.2.3 Instantiated Domain Objects

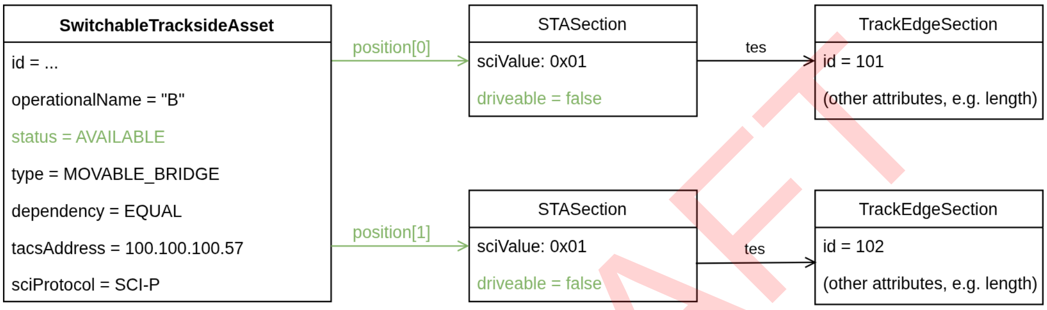
Referring to the next figure, all static information (shown in black) is built at *ETPS* startup from the static *Topology Data* and all dynamic information (shown in green) is initialised to the respective safe value. In effect, *Domain Object*s are created from the *Domain Model*'s object model. Please note again that this is still a conceptual view only used for concept/specification purpose; the actually used *Domain Model* and *Domain Objects* are implementation-specific. **[**SPT2TRAFFIC-20440 **]**

For the sketched simplified layout, the instantiated *Domain Object*s, including their synchronised dynamic state, are **[**SPT2TRAFFIC-20430 **]**




[SPT2TRAFFIC-20441 ]

for the Point and assuming that for the bridge, the 0x01 value ('right') corresponds to closed position but the bridge is actually opened (0x02 value), the dynamic state is [SPT2TRAFFIC-20432 ]




[SPT2TRAFFIC-20442 ]

## 10.3 Interface for STA

### 10.3.1 Retrieve position of an STA

By standard EULYNX SCI-XX interfaces, trackside elements (synonym for *Object Controller*) provide information about the status of *STA*. The provided concrete protocol (e.g. SCI-P) is known by the **sciProtocol** attribute of an STA and each **position** attribute (*STA Section*) maps the state value of the related SCI-P protocol. [SPT2TRAFFIC-18529 ]

When there is no connection to a trackside element, the **status** of the *STA* is set accordingly, and a safe value is taken for the **position** of the related *STA Section*s. [SPT2TRAFFIC-18531 ]

### 10.3.2 Change position of an STA

By the same standard SCI-XX interfaces, an *STA* can be actuated to change its position. This is an asynchronous operation: After the actuation, control returns. Asynchronous status updates provide the actual position which is first undetermined (e.g. while the point blades are moving). [SPT2TRAFFIC-18533 ]

While an STA change state command is processing, the corresponding STA sections driveable status are set to false. [SPT2TRAFFIC-18534 ]

This will prevent that safety checks would allow a *Movement Permission* (extension) using the *STA*. After the needed time, the final state will be reported and thus updated in the *Operating State*. [SPT2TRAFFIC-18535 ]

### 10.4 Safety checks

The checks of the Safety Logic (simplified) are:

- A request for a *Movement Permission* is rejected if the *Movement Permission* would intersect with an *STA Section* which is not in the needed position (plus similar checks for *Risk Buffer* and *Risk Paths*);
- A request to change an *STA* is rejected if any of the *STA Section*s of it is *claimed* (by an occupation or by a *Movement Permission*).

All *STA*s (with their *STA Section*s and dependencies) are engineered with the static information mentioned afore.
**[**SPT2TRAFFIC-13383 **]**

### 10.5 Engineering

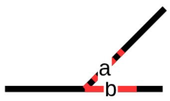
The engineering configuration contains the information mentioned in the aforementioned Object Model. Amongst other specifically the information is needed to identify the trackside elements (object controller) responsible for the *STA* and to both generate the switch command (e.g. *Move Point* on *SCI-P*) and derive the *STA Section* state from the received status report (e.g. *Point Report* on *SCI-P*).
**[**SPT2TRAFFIC-13757 **]**



### 10.6 Applications

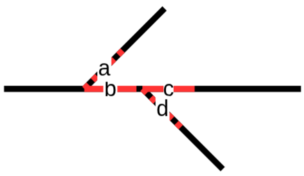
All information has so far mostly been given by the example of the simple *Point*. Handling other types of *STA* is by no means different. For this, all relevant *STA* types are listed in this section to show how they are included. For some of them, the notion '[excluded]' is already appended to the headline to show that these are either not reasonably manageable or are not likely to appear at least in a first rollout stage.
**[**SPT2TRAFFIC-13808 **]**

#### 10.6.1 Simple Point

| | |
|---|---|
| **Schematics** |  |
| ***STA Sections*** | 1 x 2 |
| **Dependency** | EXCLUSIVE |
| **SCI-XX** | SCI-P |

**[**SPT2TRAFFIC-13811 **]**

#### 10.6.2 Interlaced (double) Point

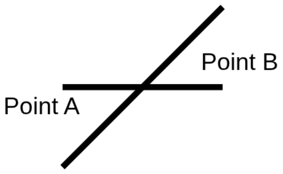
| | |
|---|---|
| **Schematics** |  |
| ***STA Sections*** | 2 x 2 |

| | |
|---|---|
| **Dependency** | EXCLUSIVE (each pair {a, b} and {c, d} itself) |
| **SCI-XX** | SCI-P |

**[**SPT2TRAFFIC-13814 **]**

### 10.6.3 Slip Point

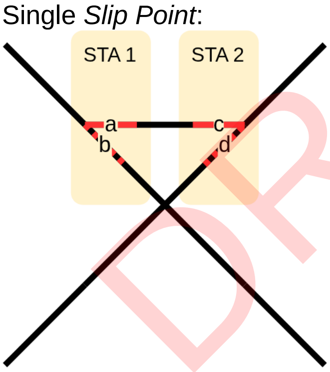
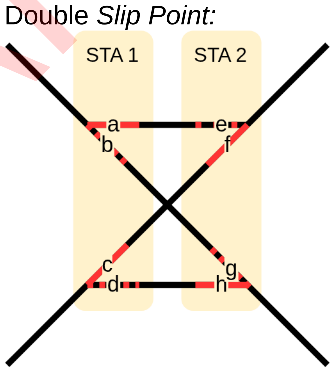
First, it has to be noted that the slip *Point* is no track element on its own. The first idea could be to represent it by two simple *Points*: **[**SPT2TRAFFIC-13820 **]**




**[**SPT2TRAFFIC-13817 **]**

While this is the usual operational view on the Signaller's GUI, it is not its true topological notion: a slip *Point* can be entered at least until its mid without derailment which is not the case with the above representation (it requires the 'entry *Point*' to be set correctly. Further, it cannot represent the difference between single and double *Slip Points*. Therefore, it can only be represented by four (two) simple *Points* and a *Diamond Crossing* which in fact reflects the true physical situation (which is strongly interlaced). **[**SPT2TRAFFIC-13796 **]**

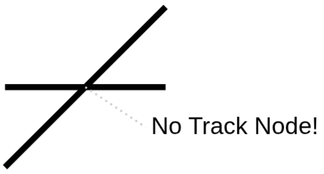


| | | |
|---|---|---|
| **Schematics** | Single *Slip Point*:   | Double *Slip Point:*   |
| ***STA Sections*** | 2 x 2 | 2 x 4 (coupled: a=c, b=d, e=g, f=h) |
| **Dependency** | EXCLUSIVE | |
| **SCI-XX** | SCI-P | |

**[**SPT2TRAFFIC-13797 **]**

### 10.6.4 Diamond Crossing

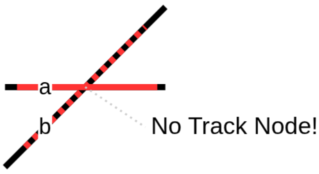
A *Diamond Crossing* has no settable parts and has therefore no relation to an *STA*. It is neither represented by a *Track Node*. Hint: The interlocking of the two conflicting routes will be achieved by *Fouling Sections*. **[**SPT2TRAFFIC-13798 **]**




[SPT2TRAFFIC-13799 ]

### 10.6.5 Switched Diamond Crossing

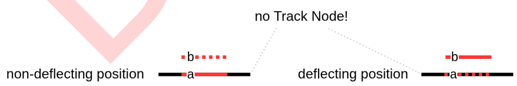
If, because of a flat angle, movable frogs are needed, *Diamond Crossing*s need to be switched. They are still no *Track Node* but *STA Section*s would exist: [SPT2TRAFFIC-13785 ]

| | |
|---|---|
| **Schematics** |   |
| ***STA Sections*** | 1 x 2 |
| **Dependency** | EXCLUSIVE |
| **SCI-XX** | SCI-P |

[SPT2TRAFFIC-13786 ]

### 10.6.6 Catch Point, Trap Point, Derailer

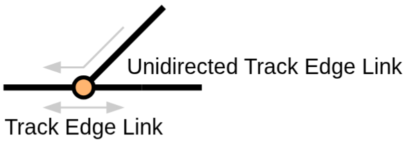
Catch/Trap *Point*s can be handled like *Point*s. The *Derailer* is different: it, again, is not represented by a *Track Node*. While one could think that one *STA Section* would be enough, indeed two are needed to accept a *Derailer* as flank protection providing element: It is needed to have proof of the *driveable* state of the other *STA Section b* (fully attached onto rail)- only then it can fully provide flank protection. [SPT2TRAFFIC-13788 ]

| | |
|---|---|
| **Schematics** |   |
| ***STA Sections*** | 1 x 2 |
| **Dependency** | EXCLUSIVE |
| **SCI-XX** | SCI-P |

[SPT2TRAFFIC-13791 ]

### 10.6.7 Resetting Trailable Point

Sprung *Point*s play an important role in some secondary lines to save costs. To cost-effectively upgrade those lines to *ETPS* they still could be re-used. However, they are not strictly (remotely) switchable as they are 'operated' by the train itself. Their representation in the *Topology Data* would be [SPT2TRAFFIC-13793 ]




[SPT2TRAFFIC-13795 ]

and thus, no need for an *STA* would exist. [SPT2TRAFFIC-13823 ]

### 10.6.8 Keylock [excluded]

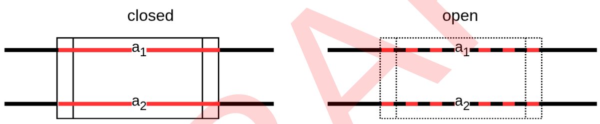
*Point*s (or *Derailer*s) controlled by keylocks are likely not included in an *ETPS* controlled environment. It can rather be foreseen that the related *Point*s (*Derailer*s) would be replaced by remotely controlled ones. [SPT2TRAFFIC-13825 ]

### 10.6.9 Switchable Bufferstop [excluded]

They are used to only temporarily terminate a track (when industry sidings are protected from traffic while there is no active service to/from the siding). Theoretically, they can be handled like a *Derailer*. [SPT2TRAFFIC-13827 ]

### 10.6.10 Movable Bridge

(*n*: number of tracks on the bridge)

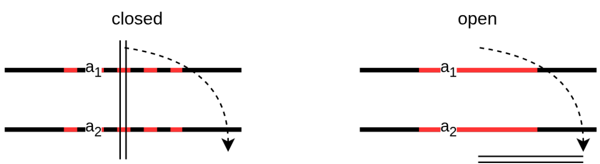
| | |
|---|---|
| **Schematics** |  |
| ***STA* Sections** | 1 x n |
| **Dependency** | EQUAL |
| **SCI-XX** | SCI-IO or SCI-P |

[SPT2TRAFFIC-13802 ]



### 10.6.11 Gate

(*n*: number of tracks through the gate)

| | |
|---|---|
| **Schematics** |  |
| ***STA* Sections** | 1 x n |
| **Dependency** | EQUAL |
| **SCI-XX** | SCI-IO or SCI-P |

[SPT2TRAFFIC-13803 ]

### 10.6.12 Traverser and Turntable [excluded]

There is a significant difference between *Traverser*s/*Turntable*s on the one hand side and other *STA*s on the other hand side: While the latter are not allowed to be occupied when setting (moving) them, the first's nature is to move vehicles which means they can be occupied while moving.

Additionally, *Turntable*s can turn the orientation of the vehicle by 180° and have no "left" and "right" side. It is assumed that neither *Traverser*s nor *Turntable*s, present in uncontrolled areas, would be subject to *ETPS* control. **[**SPT2TRAFFIC-13806 **]**

### 10.6.13 Level Crossing [postponed]

At this stage of the concept, *Level Crossing*s need further investigation. They are *STA*s in principle, but have other characteristics. One important difference is the need of activation (activation time; pre-warning) which makes them more similar to *Working Area*s (construction sites with warning devices for track worker safety). **[**SPT2TRAFFIC-13809 **]**

### 10.6.14 (Light) Signal [postponed]

*Signal*s are inherently related to route-based systems but even there, lineside signalling can be replaced by cab signalling. For *ETPS*, there are still potential areas of application:

- Protection of the entry route into a neighbour class B system (exit transition from *ETPS*). Such a signal (including its distance signal) is under exclusive control of the neighbour system so ETPS does not need to control this signal. However, it needs information about the status of the related route to convey a proper authorisation to the train which either ends at this signal or includes information about the signal's authorisation beyond it (speed, mode).
- The protection of the entry (transition into *ETPS*) is under exclusive control of ETPS. As ETCS level 2 is a mandatory precondition, neither signals are needed as cab signalling by the *Movement Authority* is used.
- Shunting signals are widely used to control shunting movements. As long as there is no mature solution for shunting in ETCS level 2 (ETCS mode *Supervised Manoeuvre* which requires OBU on shunting units and safe train length determination), shunting signals may still play a role and potentially need to be interfaced by *ETPS*.

**[**SPT2TRAFFIC-13812 **]**



### 10.6.15 Further [excluded]

This section lists - for reason of completeness - further trackside assets influencing the continuity of a railpath which could be theoretically considered. **[**SPT2TRAFFIC-13815 **]**

**Cranes**
There can be equipment near the track which can violate the structure gauge when in a certain position. Examples are loading cranes and water cranes. There is little point in remotely setting them, so they are no *STA*s. It is not realistic either to observe their position. The main reason is the lack of sensors. This equipment can be considered if the need really occurs; an alternative way to handle them would be (switchable) *UR*s (de-/activated by an external system, which again requires sensors). **[**SPT2TRAFFIC-13818 **]**

**Brakes in hump yards**
There is a number of brake types used in hump yards: de-coupled waggon (group)s are pushed by the loco downhill, roll with individual (weight dependent) speeds and need to reach a certain target speed to give time for *Point* moving and/or to reduce drive-up speed when bumping into the wagon(s) in the target track

They either work directly depending on the wagon's weight or need to be actuated to reach their effect. There are two potential influences on *ETPS*:

- switch/observe brakes which can be actuated (in the meaning of an *STA*)
- save locos not to pass activated brakes
    - permanent *UR*s of total closure type if they cannot be folded away; or
    - switchable *UR*s of total closure type if they can be folded away (activated/deactivated depending on the state)

As it is very unlikely (even excluded?) that such hump yards are supervised by *ETPS* (major reason: wagons rolling downhill are not supervised at all), these brakes will be excluded. **[**SPT2TRAFFIC-13821 **]**

## 11 Open Points