

RCA



Reference CCS Architecture

*An initiative of the ERTMS users group and
the EULYNX consortium*

RCA Terms and Abstract Concepts

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1 Preamble

1.1 Release Information

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Support and Feedback:

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1.3 Disclaimer

No disclaimer defined.

1.4 Purpose

This document defines the Data Object Class, Conceptual Drafts , Terms, exchange items and the actors of the System RCA.

2 Version history

Version	Date	Author	Description
0.0.7	2019-11-27	N/A	Joined the general glossary from RCA and the glossary from the RCA specifications.
Gamma.1	2020-01-28	N/A	Integrated review feedback from RCA Core Group.
0.1.1	2020-06-06	N/A	Updated release.
0.1.2	2020-09-10	N/A	Integrated review feedback from RCA Core Group.
0.2 (0.A)	2020-09-11	N/A	Document approved by RCA Core Group.
0.3 (0.A)	2021-07-02	N/A	Migrated content to capella. Updated terms.
0.4	2022-04-26	Dr. Oliver Lemke	Terms updated and abstract concepts added.
1.0	2022-09-30	Dr. Oliver Lemke	Terms updated, abstract concepts updated and renamed to data classes, actors added.
1.1	2022-10-19	Dr. Oliver Lemke	Minor formal changes.

3 Definitions

3.1 Definition of Terms

Terms are defined as expressions that do not have relationships between each other and provide a unique meaning within RCA.

3.2 Definition of Data Object Class

Data Object Classes are defined as expressions that have relationships between each other and provide a unique meaning within RCA. These expressions are used to explain domain specific concepts and their relations. For RCA Baseline 1 Release 0 the primary usage of data object classes is the expression of abstract concepts according to viewpoint AMOD-025.

3.3 Definition of Conceptual Drafts

Conceptual Drafts are defined similar to Data Object Class, but with the only difference that these concepts are in draft status, i.e. not yet approved with all stakeholders. However it is deemed worthwhile publishing them to share on-going work.

3.4 Definition of System Actors

System actors represents the environment the System RCA operates in. Actors are included in this document for an easy to use reference while reading other documents.

3.5 Definition of Exchange Items

Exchange items are used in the model to represent information that is exchanged between functions. The model based content in RCA.Doc.82 and RCA.Doc.81 references the exchange items. This document provides a central definition for exchange items.

4 Terms

- Acquisition Data

Acquisition Data follows the Engineering Data Structure and represents the part of Engineering Data that can be captured on the track for the purpose of comparison in the validation function.

- Advanced Protection System (APS)

A group of subsystems in the RCA interface architecture responsible for safe track usage and for control and supervision of the railway production.

APS assures as a gatekeeper, that the requests of Plan Execution (PE) create a safe traffic flow and then executes them.

It includes the proposed subsystems Safety Logic (SL), Safety Manager (SM), Object Aggregation (OA), Movement Authority Transactor (MT), Mobile Object Transactor (MOT) and Fixed Object Transactor (FOT)

- Advanced Protection System, ATO Execution, Plan Execution, Map (A.P.M.)

A.P.M. stands for "Advanced Protection System" (APS), "ATO Execution" (AE), "Planning System" (PE) and "Map". This term summarises these core subsystems inside RCA (Reference CCS Architecture).

- Automatic Train Operation (ATO)

Automatic Train Operation (ATO) is an operational enhancement used to help automate operations of trains.

- Configuration Data

Configuration Data is the data distributed between the RCA subsystems Device and Configuration Management (DCM) and other RCA subsystems via the Standard Maintenance Interface (SMI) providing configurations that concern different functionalities and applications in the RCA subsystems.

- Digital Map (DM/MAP)

Digital Map (DM/MAP) is a set of functionalities providing track and trackside infrastructure information in the form of structured Map Data. The initial scope of Digital Map ensures the quality criteria of Map Data along with Map management functionalities like Map versioning and download of Map Data for On-Board consuming systems. The extended scope of Digital Map will additionally cover the functionalities associated with the life cycle of the Map Data such as generation, validation, compiling of Map Data along with provisioning of Map Data to the trackside consuming systems.

- Driver Machine Interface (DMI)

The interface to enable direct communication between the on-board equipment and the driver.

- Engineering Data

The Engineering Data is created based on the Infrastructure Manager Data (IM Data). Typically, the data are not adapted to cope with specific views demanded by each consumer. The Engineering Data contains all the base data (i.e. track topology and topography) for deriving the Map Data during the compile process. Besides providing base data for Map Data generation, the Engineering Data should also cover the needs for configuration of systems (e.g. parameter data). The Engineering Data must fulfil engineering rules, that are influenced by requirements of Map Data.

Engineering Data contains only the updated resulting data (i.e. no several variants/versions of the same track) that is needed for the next provisioning and operation at a certain point of time in the consuming systems.

- Field Element

Field Element is a railway fixed equipment on/or adjacent to track, e.g. Light Signal, Point, Level Crossing.

- Grade of Automation (GoA)

Grade of Automation (GoA) refers to the automation level of train operation, in which a train can be operated, resulting from sharing responsibility for given basic functions of train operation between operations staff and system.

- Infrastructure Manager Data

Data from Infrastructure Manager (IM) specific digital sources required for engineering of RCA systems, such as:

- Track layout (nominal geometry of the respective construction phase)
- Objects (points, signals, train detection elements, etc.)
- Properties (speeds, gradients, etc.)
- Structures (platform, tunnel, etc.)
- Logical data such as trackside detection sections (if still available)

- Interlocking (IXL)

In railway signalling, an interlocking is a system composed by a set of signal apparatus that prevents trains from conflicting movements through only allowing trains to receive authority to proceed, when routes have been set, locked and detected in safe combinations.

- Localisation Information

Set of spatial values referenced to the rail network, and kinematic variables referenced to the Train Unit, that enable determining the position of the Train Unit in a specific point of the network and its dynamic behaviour from its speed, acceleration, and orientation values.

- Localisation Sensor Data

Data that responds to some type of input from the physical environment and helps to locate the Vehicle. These data can come from elements deployed on tracks such as Eurobalises or other onboard equipment that can acquire data from the Environment or the kinematic characteristics of the Vehicle itself.

- Map Integrity Data
Suitable information (protection data such as hash) to reveal potential transmission or processing faults.
- Map Reference Data
Unambiguous reference to a certain version and region of Onboard Map information. It includes information containing Map Version Data, Map Id Data and Map Integrity data required to validate Onboard Map Data.
- Open CCS Onboard Reference Architecture (OCORA)
European initiative to define the Control-Command and Signalling (CCS) on-board architecture.
- Railway Undertaking (RU)
Any public or private undertaking licensed according to EU directive 2012/34/EU, the principal business of which is to provide services for the transport of goods and/or passengers by rail with a requirement that the undertaking ensure traction; this also includes undertakings which provide traction only.
- Reference CCS Architecture (RCA)
RCA (Reference CCS Architecture) is a harmonised reference architecture for the future railway CCS, with the main goal to substantially increase the performance/total cost of ownership ratio of CCS.
- Shift2Rail
Shift2Rail is a European initiative which fosters the introduction of better trains to the market (quieter, more comfortable, more dependable, etc.), which operate on an innovative rail network infrastructure reliably from the first day of service introduction, at a lower Life Cycle Cost, with more capacity to cope with growing passenger and freight mobility demand.
- Traffic Management System (TMS)
Traffic Management System (TMS) is part of the Planning System and provides permanent control across the network, automatically plans the movement of trains and logs train movements as well as detects and solves potential operational conflicts.
- Train Integrity Monitoring System (TIMS)
System to monitor and confirm train integrity and safe train length.

5 Data Object Class

Data Object Classes are defined as expressions that have relationships between each other and provide a unique meaning within RCA. These expressions are used to explain domain specific concepts and their relations. For RCA Baseline 1 Release 0 the primary usage of data object classes is the expression of abstract concepts according to viewpoint AMOD-025.

5.1 Area related concepts

The Area domain provides concepts needed by System RCA to represent specific areas.

ToDo: This domain is currently incomplete and will be enhanced in a future release.

5.1.1 Description of Area related concepts

- Warning Area

A Warning Area is described by a TrackArea in which Authorised Trackside Person must be protected while performing trackside works.

The Warning Area is related to a collective Warning Subsystem (light and sound) and/or an individual Warning Subsystem (light, sound, and vibration).

These warning subsystems are activated when a Movement Permission is intersecting with the Warning Area AND the Trackbound Movable Object of the Movement Permission is approaching a defined entry point. These devices are deactivated when the (rear end of) the Trackbound Movable Object has left a defined exit point.

5.2 Localisation related concepts

The Localisation domain provides concepts needed by System RCA to represent localisation information. ToDo: This domain is currently incomplete and will be enhanced in a future release.

5.2.1 Description of Localisation related concepts

- GeoCoordinates

Geo-Coordinates are used to locate topology objects (like Track Nodes and Track Edge Points) on or alongside track. They provide pure absolute positioning. The topology objects are also relatively positioned within respect to Track Edges and Track Nodes.

5.3 Map related concepts

The Map domain provides abstract concepts that will be used to provide reliable and validated topology and topography data in the form of Map Data.

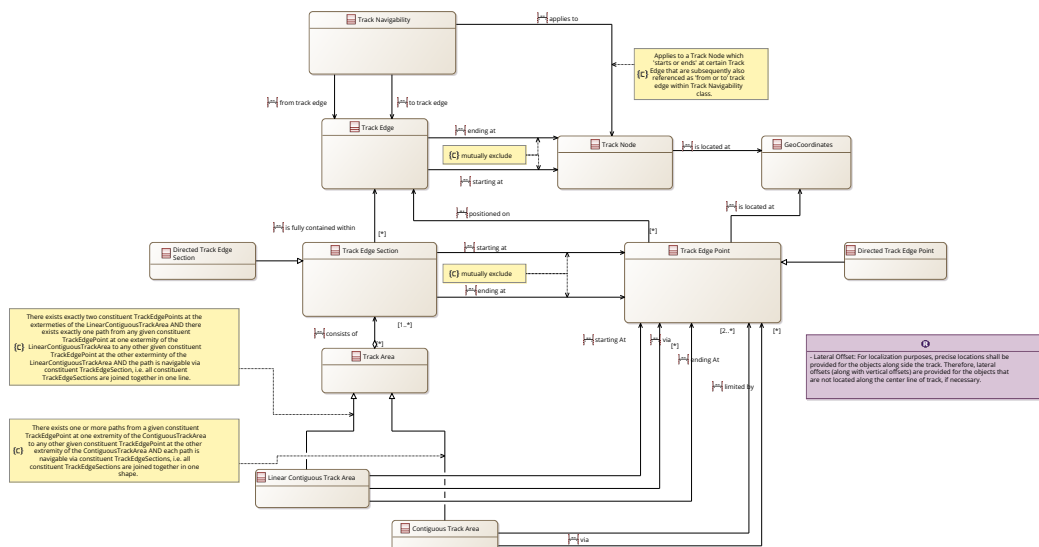


Figure 1: [O.CDB][AMOD-025] Base topology [Abstract concepts]

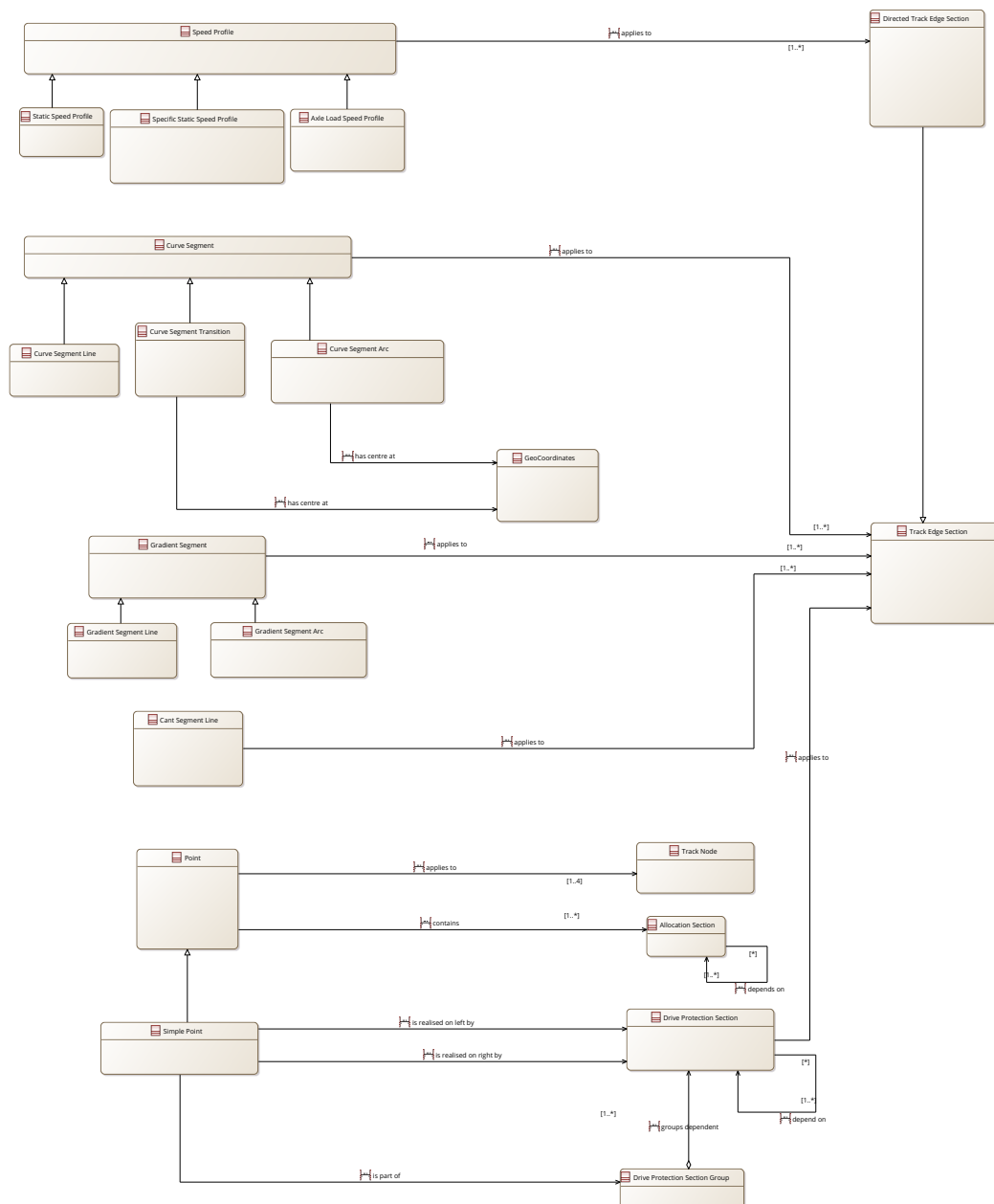
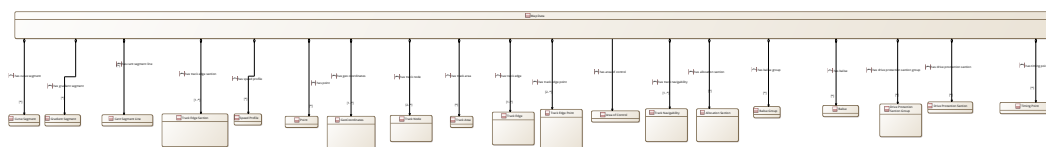


Figure 2: [O.CDB][AMOD-025] Taxonomy for map objects [Abstract concepts]



5.3.1 Description of Map related concepts

- Adjacent Area of Control

The adjacent Area of Control is used to link one Area of Control at the system borders with its neighbours.

- Area of Control

The Area of Control (AoC) is a special subclass of Track Area to define the common topologically limited area of control of the subsystems (the system borders).

- Axle Load Speed Profile

Defines speed profile based on axle load categories.

- Balise

Balises (Eurobalises in the context of ETCS) are technical devices in the railway track bed that store information (telegram) and transmit it to rail vehicles passing the location of the balise.

- Balise Group

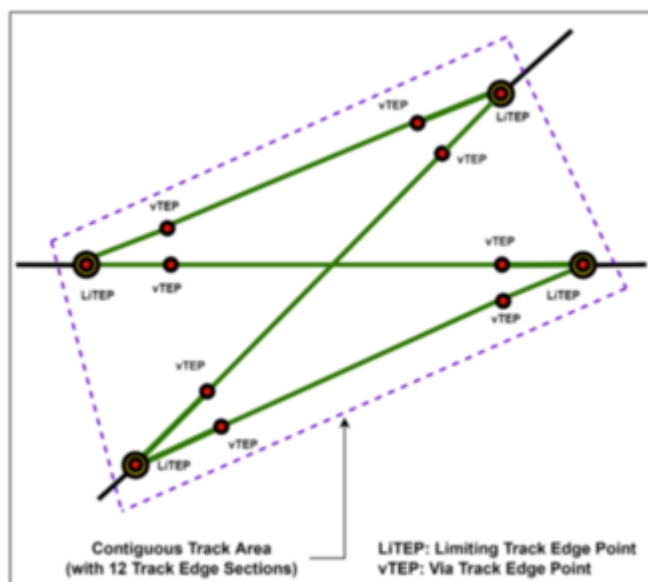
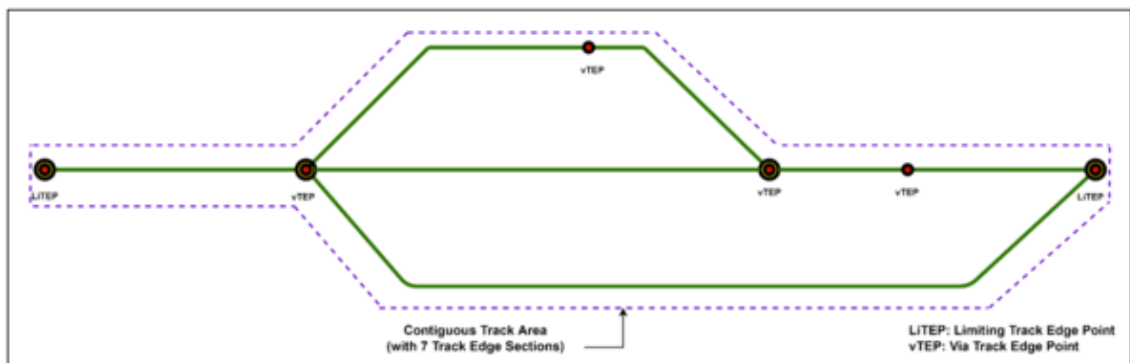
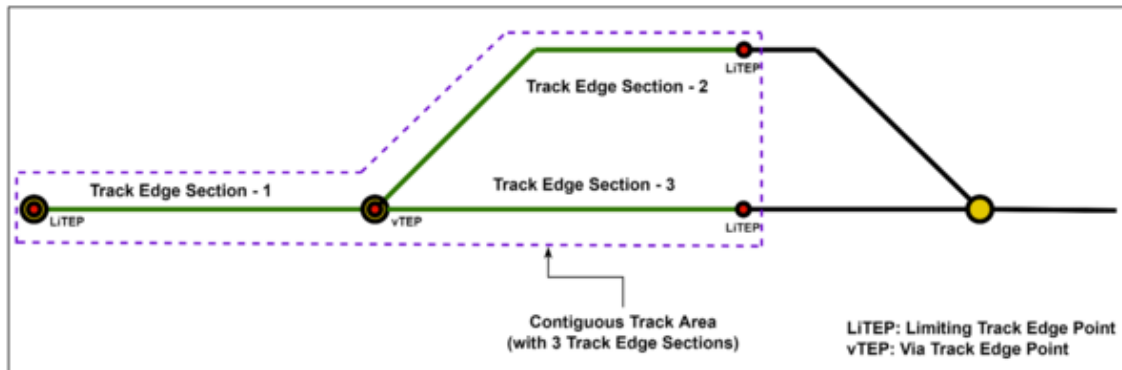
One or more balises to which the same reference position is assigned in the track.

- Cant Segment Line

Base definition of cant with properties. The Cant Segment Line defines both constant cant segments and transitions between constant cant segments.

- Contiguous Track Area

The Contiguous Track Area is a specialised class of Track Area to group a number of Track Edge Sections, which are topologically connected to each other such that they form one or more paths.



- Curve Segment

Base definition of a curve with properties, which are applicable to all derived elements of the curve. The specific elements of a curve are defined as an extension to this base object.

- Curve Segment Arc

The Curve Segment Arc defines the curved parts of a Track Edge with a constant radius over the whole curve.

- Curve Segment Line

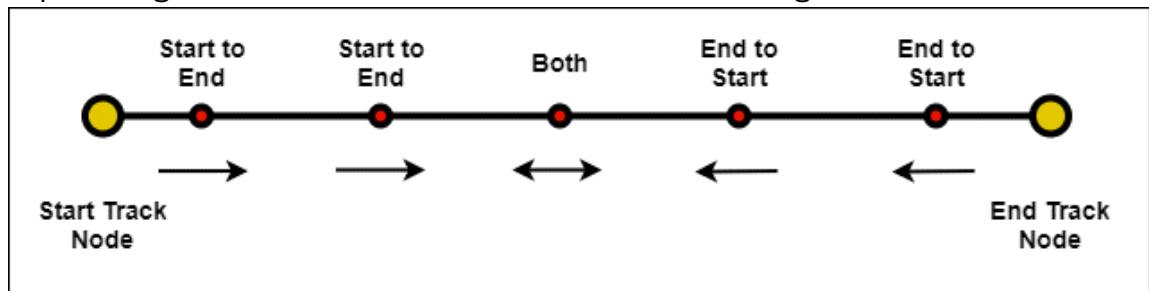
The Curve Segment Line defines the straight parts of a Track Edge.

- Curve Segment Transition

The Curve Segment Transition defines the transitions from the straight to the curved (circle) sections. Currently only clothoids are supported as transition elements.

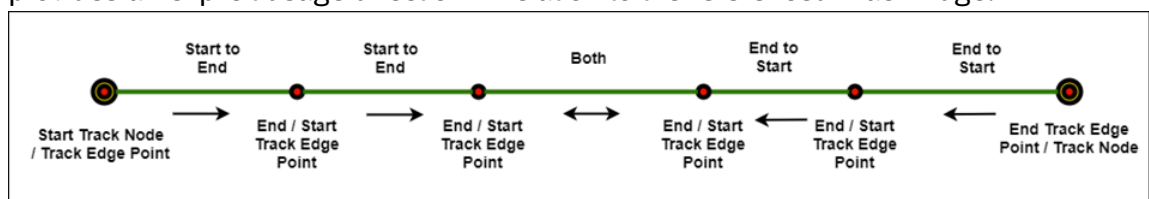
- Directed Track Edge Point

Directed Track Edge Point is a specialized class of Track Edge Point which provides an explicit usage direction in relation to the referenced Track Edge.



- Directed Track Edge Section

Directed Track Edge Section is a specialised class of Track Edge Section which provides an explicit usage direction in relation to the referenced Track Edge.



- Gradient Segment

Base definition of a gradient with properties, which are applicable to all derived elements of the gradient. The specific elements of a gradient are defined as an extension to this base object.

- Gradient Segment Arc

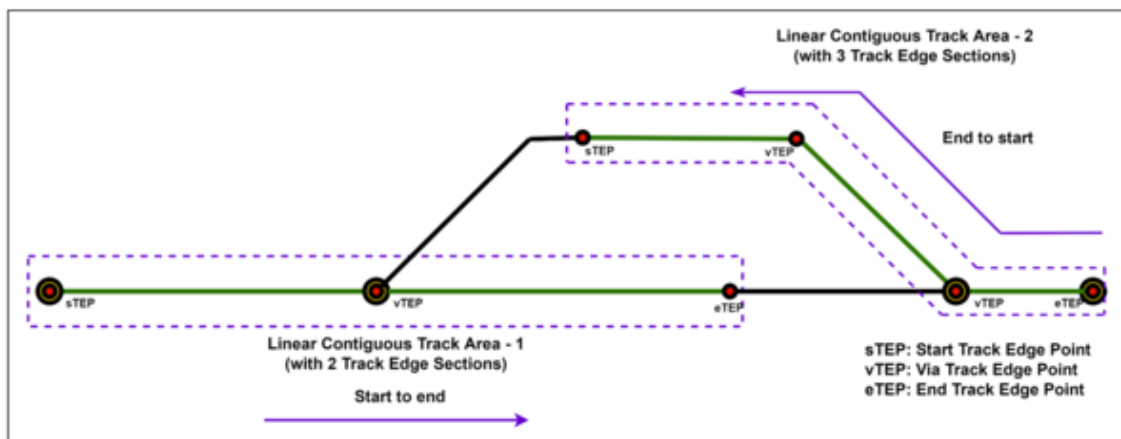
The Gradient Segment Arc defines the transitions between different line sections.

- Gradient Segment Line

The Gradient Segment Line defines the ramps or flat track sections of a gradient section.

- Linear Contiguous Track Area

The Linear Contiguous Track Area is a specialized class of Track Area to group an ordered and directional number of topologically connected Track Edge Sections such that they form exactly one path. The sequence of sections needs to be unambiguously navigable along the track network. Meaning that, each end of a Track Edge Section coincides with the start / end of the immediately succeeding section in the sequence.



- Map Data

Map Data contains a very detailed microscopic digital representation of the railway network that contains all information necessary for planning and performing railway operations, such as infrastructure characteristics, location and details of Field Elements, etc. The Map Data remain unchanged until the next provisioning of Map Data.

- Point

A Point is an item of movable infrastructure with two possible drivable paths. A point enables navigability between one Track Edge and only one of two possible Track Edges.

- Simple Point

Base definition of the physical track asset / filed element point.

- Specific Static Speed Profile

The specific SSP categories are decomposed into two types:

- The "Cant Deficiency" SSP categories: the cant deficiency value assigned to one category shall define the maximum speed, determined by suspension design, at which a particular train can traverse a curve and thus can be used to set a specific speed limit in a curve with regards to this category.
- The "other specific" SSP categories: it groups all other specific SSP categories corresponding to the other international train categories.

- Speed Profile

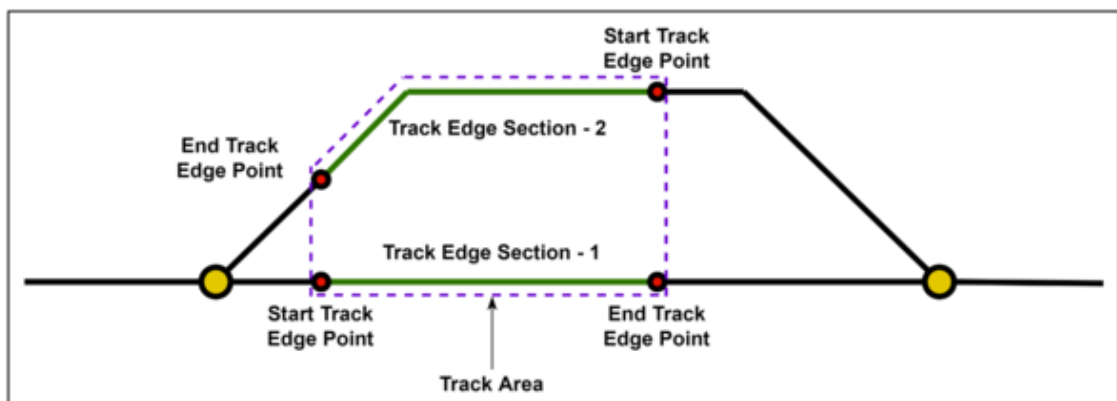
Base definition of a speed profile. Specific speed profiles are defined as an extension to this base object.

- Static Speed Profile

The Static Speed Profile (SSP) is a description of the fixed speed restrictions of a given piece of track. The speed restrictions can be related to e.g. maximum line speed, curves, points, tunnel profiles, bridges (As defined in Subset 026-3.11.3.1.1).

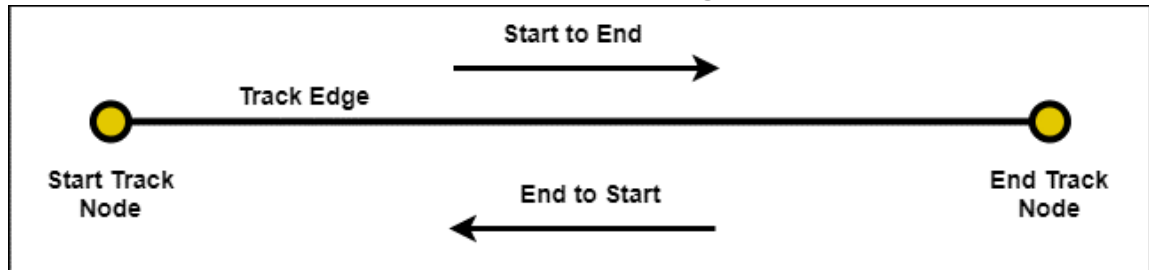
- Track Area

A Track Area groups an arbitrary number of Track Edge Sections. 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.



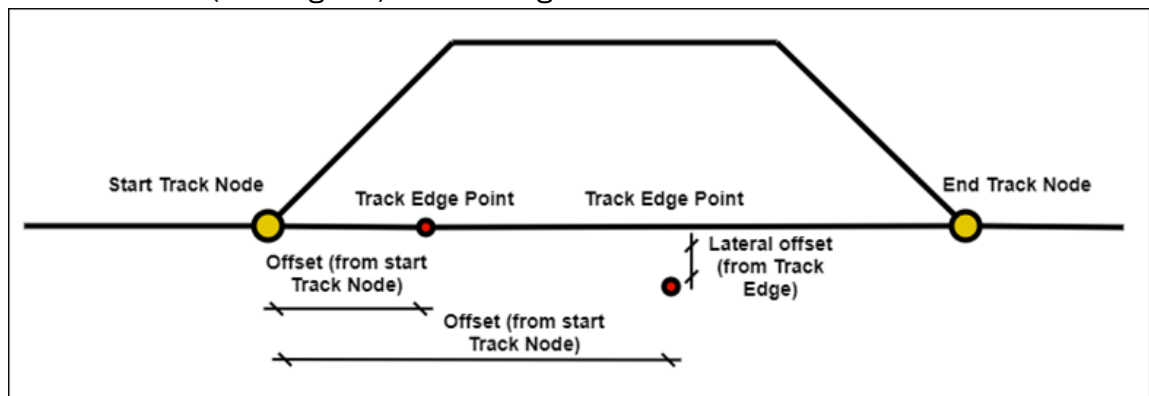
- Track Edge

A Track Edge is a linear object that connects exactly two Track Nodes. One of these Track Nodes is defined as the Start Track Node, the other is defined as the End Track Node, which gives an implicit direction to the Track Edge. The implicit Track Edge direction does not specify the drivability of a Track Edge.



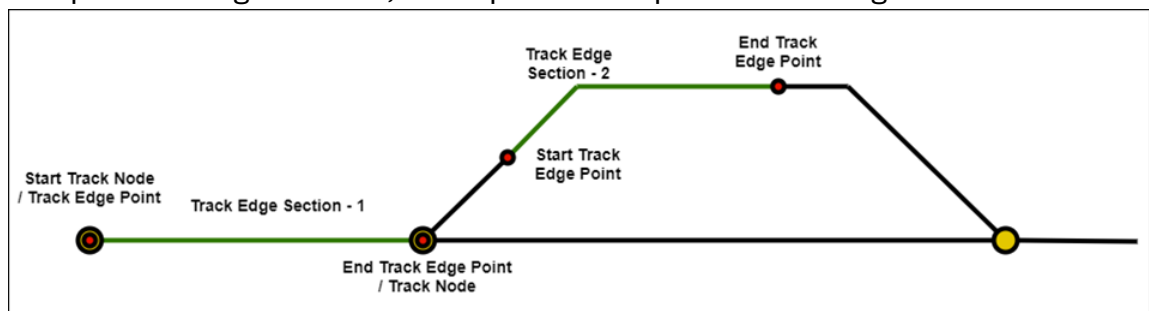
- Track Edge Point

Base-element to describe non-directed spot objects (without spatial expansion) and to locate them on (or alongside) a Track Edge with additional attributes.



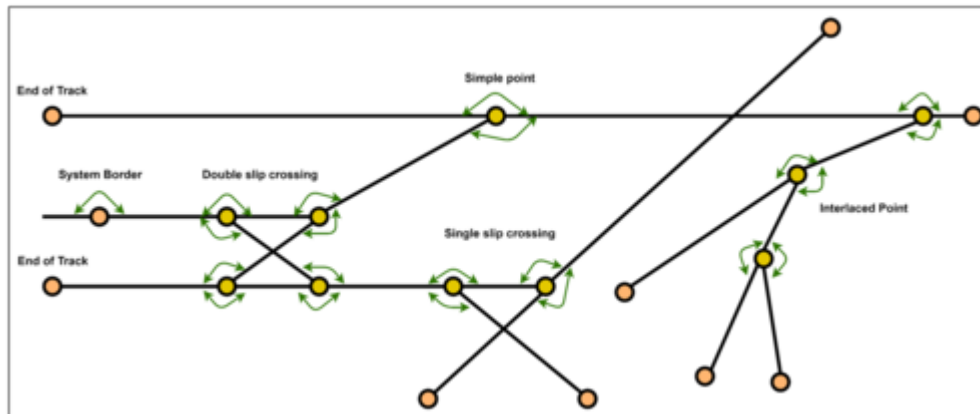
- Track Edge Section

Base-element to describe non-directed linear objects (with a linear extension) and to place them on (or at the side of) a Track Edge. A Track Edge Section can only refer to exactly one Track Edge. Sections across multiple Track Edges must be defined as multiple Track Edge Sections, each specific to respective Track Edge.



- Track Navigability

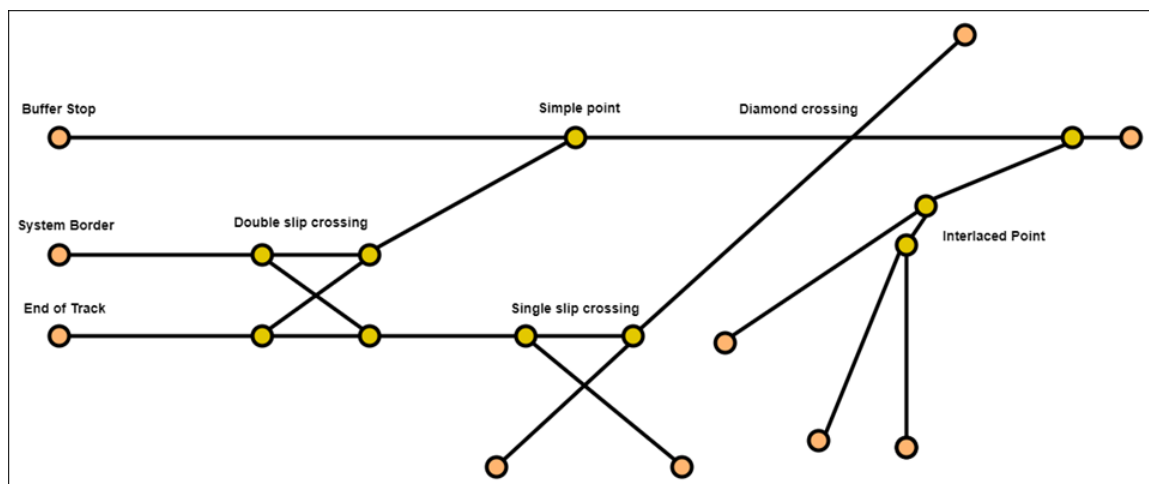
Information on a Track Node, whether a Physical Train Unit is able to pass from one Track Edge to another over a Track Node (valid movement path). Track Navigability represents ordered pairs of navigable Track Edges, referenced by Track Edge attributes. The Track Navigability always refers to one direction only, meaning if navigation between two Track Edge A and B in both directions is possible, two navigabilities ("from Track Edge A to Track Edge B" and "from Track Edge B to Track Edge A") have to be defined.



- Track Node

A Track Node is a position on the topological model of the track network where a Track Edge begins or ends. There are several situations where a Track Edge begins or ends, and all are modelled as Track Node (list is not exhaustive):

- Points - It is a location of the track network where trains coming from one direction and have more than one possible Track Edge to continue driving. Note: Even if one Track Edge begins while another passes through the point, the Track Node that represents the point splits the passing track into two Track Edges
- End Of Track - The position on the track network where the physical track ends or a Buffer Stop is located.
- System borders - The position defining a system border (i.e. between two infrastructure operators, between two areas of control or between a controlled and a non-controlled area. Note: Even if the physical track continues, on this location one track edge ends and another begins.



5.4 Mission related concepts

The Mission domain provides abstract concepts that will be used to plan the movement of rolling stock from an origin to a destination.

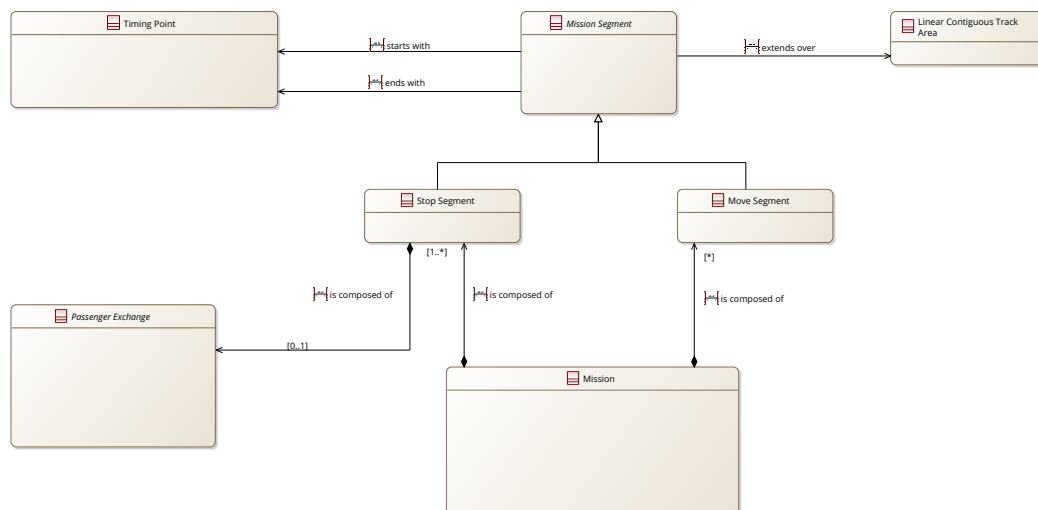


Figure 4: [O.CDB][AMOD-025] Mission [Abstract concepts]

5.4.1 Description of Mission related concepts

- Mission

A movement of rolling stock from an origin to a destination. It is described by a continuous sequence of Mission Segments from origin to destination, without gaps and branches and is operated on each Mission Segment by exactly one Train Unit, with possibly different Train Units on individual Mission Segments.

- Mission Segment

A part of a Mission that is either a Move Segment or a Stop Segment.

- Move Segment

A part of a Mission that represents the movement of a Train Unit from start of wheel movement at one planned Stopping Point to stop of wheel movement at the next planned Stopping Point.

- Passenger Exchange

Passenger Exchange is a part of Stop Segment specific to a situation in which Passengers move from Platform Area to Train Unit Area or vice versa.

- Stop Segment

A part of a Train Unit's Mission, in which the Train Unit is planned to stop at a planned Stopping Point, from the stop of wheel movement (arrival) to the start of wheel movement (departure), usually to carry out specific activities such as perform Passenger Exchange.

- Timing Point

A scheduled location of a train unit where a specific time is identified. This time may be an arrival time, departure time or in the case of a train unit not scheduled to stop at that location the passing time. (according to TSI (EU) 2019/773 Appendix J, small adaptations made)

6 Conceptual Drafts

Conceptual Drafts are defined similar to Data Object Class, but with the only difference that these concepts are in draft status, i.e. not yet approved with all stakeholders. However it is deemed worthwhile publishing them to share on-going work.

6.1 Incident

The Incident domain provides concepts for the management of incident events in System RCA. **ToDo:** This domain is currently incomplete and will be enhanced in a future release.

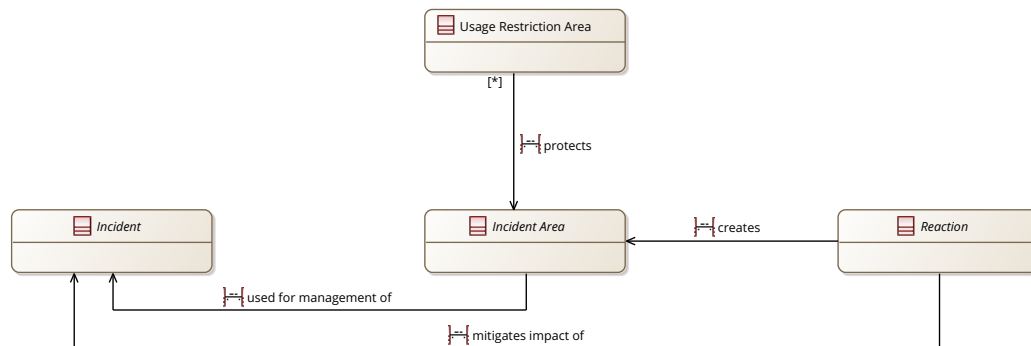


Figure 5: [O.CDB][AMOD-025] Incident domain [Abstract concepts]

6.1.1 Description of Incident

- Incident
An event that has an impact concerning safety, security or performance of the railway.
- Incident Area
A specific area around an Incident to prevent or mitigate the potential impact of the Incident. An Incident Area is not limited to space near the track. For example, an Incident Area can be defined on a station platform or concourse, completely independently of the track.
- Reaction
A Reaction is defined as the triggering or execution of a measure to prevent or mitigate the impact of an Incident.

6.2 Localisation

The Localisation domain provides concepts needed by System RCA to represent localisation information. **ToDo:** This domain is currently incomplete and will be enhanced in a future release.

6.2.1 Description of Localisation

- Max Safe Front End (maxSFE)
The Maximum Safe Front End position differs from the estimated position by the under-reading error of the localisation system.
- Min Safe Front End (minSFE)
The Minimum Safe Front End position differs from the estimated position by the over-reading error of the localisation system.
- Max Safe Rear End (maxSRE)
The Maximum Safe Rear End position differs from the estimated position by the under-reading error of the localisation system.
- Min Safe Rear End (minSRE)
The Minimum Safe Rear End position differs from the estimated position by the over-reading error of the localisation system.

6.3 Maintenance and Monitoring

The Maintenance and Monitoring domain provides the concepts needed for the maintaining and monitoring systems of RCA. ToDo: This domain is currently incomplete and will be enhanced in a future release.

6.4 Operational Plan

The Operational Plan domain provides concepts for Operational Movements, Operational Warning Measures and Operational Restrictions, as well as for reporting the PE Operating State and the Operational Plan Execution progress.

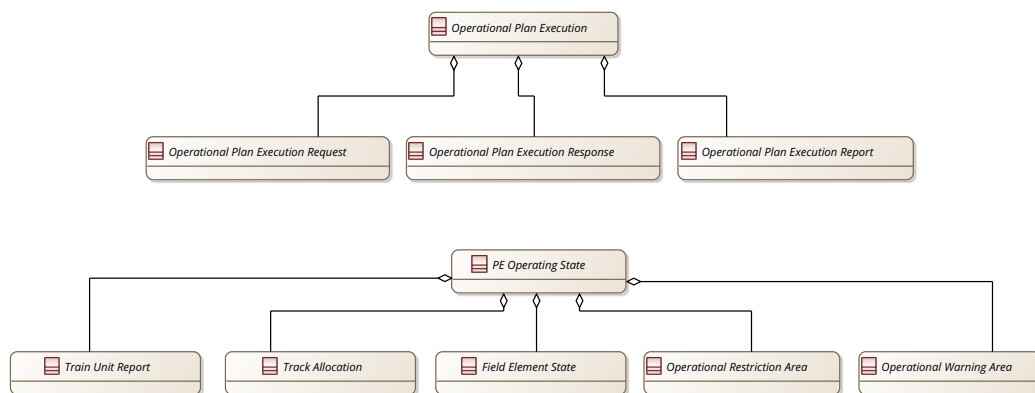


Figure 6: [O.CDB][AMOD-025] Operating State and Operational Plan Execution [Abstract concepts]

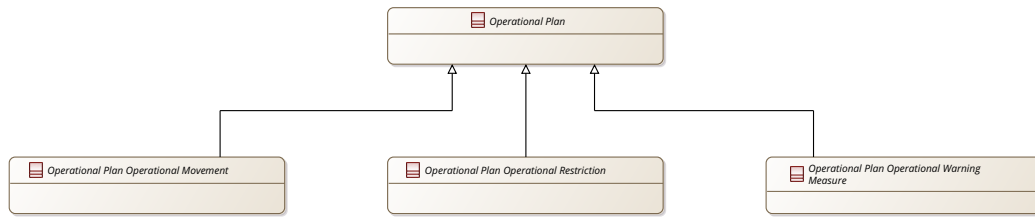


Figure 7: [O.CDB][AMOD-025] Operational plan domain [Abstract concepts]

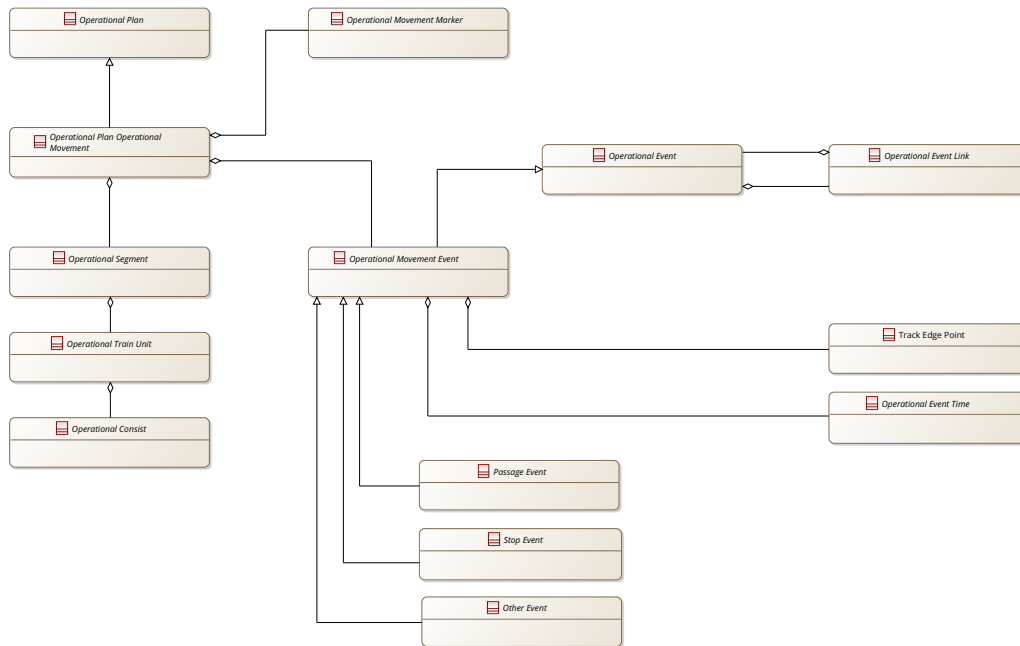
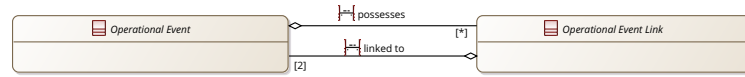


Figure 8: [O.CDB][AMOD-025] Operational plan for operational movements [Abstract concepts]

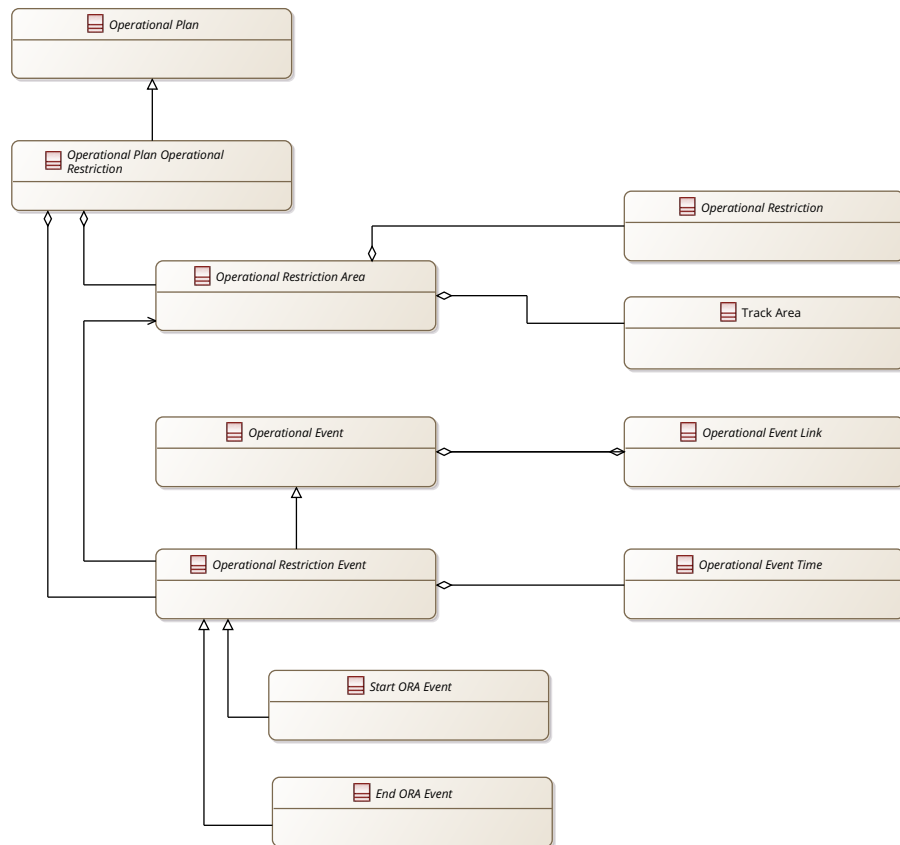


Figure 9: [O.CDB][AMOD-025] Operational plan for operational restrictions [Abstract concepts]

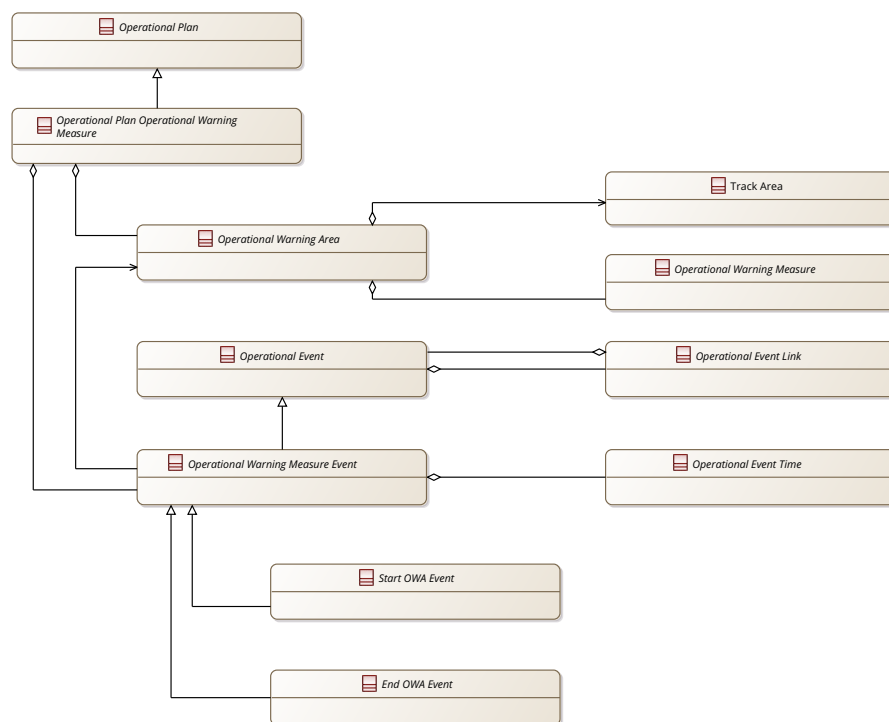


Figure 10: [O.CDB][AMOD-025] Operational plan for operational warnings [Abstract concepts]

6.4.1 Description of Operational Plan

- End ORA Event

The End ORA Event describes the planned time at which an Operational Restriction Area and all its containing Operational Restrictions shall become inactive.

- End OWA Event

The End OWA Event describes the planned temporal end of an Operational Warning Area.

- Execution Failure

An Execution Failure describes that at least one step for the execution of an Operational Event cannot be successfully implemented by the executing RCA subsystem. The Execution Failure, detected by Subsystem Plan Execution PE or Subsystem ATO Execution AE during the execution of an Operational Event, cannot be resolved by the corresponding subsystem and is therefore reported as an Operational Plan Execution Report via SCI-OP to the Planning System.

- Execution Warning

An Execution Warning describes that at least one step for the execution of an Operational Event cannot be implemented as planned by the executing RCA subsystem. The Execution Warning, detected by Subsystem Plan Execution PE or Subsystem ATO Execution AE during the execution of an Operational Event, can be neglected by the corresponding subsystem but is reported as an Operational Plan Execution Report via SCI-OP to the Planning System.

- Field Element State

The Field Element State is an entity of the PE Operating State. It describes the state of any Field Element in the Area of Control.

- Map Data Activation Time

The Map Data Activation Time defines a time window, defined by the Planning System and transmitted to SubSys Plan Execution and SubSys ATO Execution, in which the activation of the distributed Map Data for all RCA trackside systems in the Area of Control should take place. This time window is optimal for the activation of Map Data from an operational point of view.

- Map Data Activation Time Request

The Map Data Activation Time Request is the request to implement the activation of the distributed Map Data for all trackside systems in the Area of Control within the specified time window. It is sent by the Planning System to SubSys Plan Execution and SubSys ATO Execution via SCI-OP.

- Operational Consist

The Operational Consist describes a sequence of the Physical Vehicles and the operating parameters of the Physical Consist planned to be operated.

- Operational Event

An Operational Event is a description of a single planned action (e.g. stop/passage of a Physical Train Unit, start/end of an Operational Restriction Area, start/end of an Operational Warning Area) defined in the Operational Plan.

- Operational Event Link

An Operational Event Link is a dependency on place and/or time between two Operational Events of the same or of two different Operational Plans.

- Operational Event Time

The Operational Event Time provides the type and the actual time assigned to an Operational Event.

- Operational Movement

An Operational Movement is a Train Run of a certain train, at defined times, along a defined Track Path within the Area of Control.

- Operational Movement Event

Operational Movement Events are Operational Events specified in the Operational Plan Operational Movement. They describe an ordered sequence of actions to take place at a certain position on the Track Path at a certain time.

- Operational Movement Marker

An Operational Movement Marker describes the start or end of a temporary infrastructure restriction that affects an Operational Movement. The described restriction is of a defined extent, whereas its start and end are represented by an Operational Movement Marker, each, as well as a reference to the affected Track Edge.

- Operational Plan

The Operational Plan is the result of the planning process performed by the Planning System. It describes either a planned Operational Movement, Operational Restriction or Operational Warning Measure through a temporal sequence of Operational Events to be implemented by Subsystem ATO Execution (AE) and/or Subsystem Plan Execution (PE) in the Area of Control.

- Operational Plan Event Reference

An Operational Plan Event Reference is a marker on one Operational Movement Event of an Operational Plan Operational Movement. It serves as a reference between two successive versions of the same Operational Plan Operational Movement to assure gap-free and unambiguous transition to the new version of an Operational Plan Operational Movement.

- Operational Plan Execution

The Operational Plan Execution is the logical representation of all messages concerning the execution of Operational Plans in the Area of Control. This includes the Operational Plan Execution Request, the Operational Plan Execution Response, the Operational Plan Execution Report and the Operational Plan Execution Forecast.

- Operational Plan Execution Forecast

The Operational Plan Execution Forecast describes the execution forecast of the Operational Plan. It is provided by Subsystem ATO Execution AE via SCI-OP.

- Operational Plan Execution Report

The Operational Plan Execution Report describes the execution progress of the Operational Plan. It is provided by SubSys ATO Execution and SubSys Plan Execution via SCI-OP.

- Operational Plan Execution Request

The Operational Plan Execution Request is the request to implement an Operational Plan. It is sent by the Planning System to Subsystem ATO Execution AE and Subsystem Plan Execution PE via SCI-OP.

- Operational Plan Execution Response

The Operational Plan Execution Response is the response (acceptance or rejection) to an Operational Plan Execution Request. It is provided by Subsystem ATO Execution (AE) and Subsystem Plan Execution (PE) via SCI-OP.

- **Operational Plan Operational Movement**
The Operational Plan Operational Movement defines the parameters for the implementation of an Operational Movement.

- **Operational Plan Operational Restriction**
The Operational Plan Operational Restrictions defines the parameters for the implementation of Operational Restriction Area(s) and the Operational Restriction(s) therein.

- **Operational Plan Operational Warning Measure**
The Operational Plan Operational Warning Measure defines the parameters for the implementation of Operational Warning Area(s) and the Operational Warning Measure(s) therein.

- **Operational Plan Reference**
Unique reference to an Operational Plan. Used to refer to the corresponding Operational Plan in upstream messages of SCI-OP.

- **Operational Restriction**
An Operational Restriction is a usage limitation on the railway network.

- **Operational Restriction Area**
The Operational Restriction Area is an entity of the Operational Plan Operational Restriction and the PE Operating State. It describes the spatial dimensions of a planned or already implemented Operational Plan Operational Restriction within the Area of Control.

- **Operational Restriction Event**
Operational Restriction Events are Operational Events specified in the Operational Plan Operational Restriction.

- **Operational Segment**
The Operational Segment divides an Operational Movement into several parts in order to represent different train compositions within the Operational Movement.

- Operational Train Unit

The Operational Train Unit describes a sequence of Physical Consists and the operating parameters of the Physical Train Unit planned to be operated.

- Operational Warning Area

The Operational Warning Area is an entity of the Operational Plan Operational Warning Measure and the PE Operating State. It describes the spatial dimensions of a planned or already implemented Operational Plan Operational Warning Measure within the Area of Control.

- Operational Warning Measure

An Operational Warning Measure is a measure to warn people about dangers on the railway network.

- Operational Warning Measure Event

Operational Warning Measure Events are Operational Events specified in the Operational Plan Operational Warning Measure.

- Other Event

Other Event provides an extension point in the Operational Plan Operational Movement. The extension point can be used to add proprietary information to the Operational Plan.

- Passage Event

The Passage Event describes the planned passage of a Physical Train Unit. The Passage Event shall specify at least the position on the track and the time range (upper and lower bound) for the planned passage.

- PE Operating State

The PE Operating State is the logical real-time representation of the actual state of the physical railway system in the Area of Control.

- Start ORA Event

The Start ORA Event describes the planned time at which an Operational Restriction Area and all its containing Operational Restrictions shall become active.

- Start OWA Event

The Start OWA Event describes the planned temporal start of an Operational Warning Area.

- Stop Event

The Stop Event describes the planned stop of a Physical Train Unit as well as all relevant planned actions to be carried out at a planned stop of a Physical Train Unit.

- Track Allocation

The Track Allocation describes the assignment of an extent on the railway network to either a movement, derived from a Movement Permission, or an occupancy, derived from an Unresolved Trackbound Movable Object.

- Track Path

The Track Path is a gap-free and track-specific route on the railway network. It is used for describing the path of Operational Movements in the Operational Plan Operational Movement.

- Train Unit Report

The Train Unit Report is an entity of the PE Operating State. It describes the position, properties, and state of any identified Physical Train Unit in the Area of Control.

- MP Limit Marker

A MP Limit Marker defines the maximum position on the Track Path to which the next MP can be extended upon request. A MP Limit Marker is defined by one-to-many MP Limit Marker Constraints and is active until all its MP Limit Marker Constraints are resolved.

- MP Limit Marker Constraint

A MP Limit Marker Constraint describes one constraint to be resolved before dissolving a MP Limit Marker.

- Request Trigger

A Request Trigger describes a point in time when a request should be sent via SCI-CMD from SubSys Plan Execution to the SubSys Safety Logic. A Request Trigger is described by one-to-many Request Trigger Constraints and is performed when all Request Trigger Constraints are resolved.

- Request Trigger Constraint

A Request Trigger Constraint describes one constraint to be fulfilled before executing a Request Trigger.

- Request Trigger Position

The Request Trigger Position defines the position where a Field Element State must be requested by SubSys Plan Execution at the latest in order for a Train Unit to receive a MP over the Field Element without driving into the current MPs braking curve.

- Earliest Request Trigger Time

The Earliest Request Trigger Time defines the time before a Field Element may not be requested.

6.5 Other

This concepts will be later on allocated to a domain. At the moment it is incomplete and will be enhanced in a future release.

6.5.1 Description of Other

- Advanced Protection System Area of Control

The Advanced Protection System Area of Control (APS AoC) is the topologically limited extent of the Advanced Protection System with its technical components covering the specific infrastructural track assets in this area. The term is used here for defining the technical and operational responsibility of one Advanced Protection System (APS). Please note: 1..n APS AoC might be mapped to 1 AoC.

- Journey Profile

The Journey Profile contains the set of dynamic infrastructure data and operational data required by the Subsystem ATO-OB in order to drive the Train Unit. The operational data contains the list of Timing Points to be traversed by the Train Unit along its journey. This list is defined in real time on the basis of the scheduled timetable and on-line traffic regulation. The Journey Profile may be updated during the journey.

Source: ATO over ETCS Glossary, EUG Reference: 13E154, V1.6

- Onboard Train Detection

Onboard Train Detection (OTD) is the abstract term for detection of rolling stock on a track where the detection technology is placed onboard.

- Onboard Train Detection Area

Contiguous Track Area where OTD is used. A TTD is either not present at all or non-contiguous (for support of OTD) only.

→ Non-OTD equipped rolling stock cannot be detected in all tracks and will usually not be admitted to an OTD area.

- Trackside Train Detection

Trackside Train Detection (TTD) is the abstract term for detection of rolling stock on a track, where the detection technology is placed trackside. Trackside Train Detection is provided in the scope of RCA by EULYNX Train Detection System

- Trackside Train Detection Area

Contiguous Track Area where a Trackside Train Detection is contiguously present and used.

→ Non-OTD equipped as well as OTD equipped rolling stock can be detected in all tracks and therefore will be admitted to a Trackside Train Detection area.

6.6 Rolling Stock

The Rolling Stock domain provides concepts needed by System RCA for the representation of rolling stock. ToDo: This domain is currently incomplete and will be enhanced in a future release.

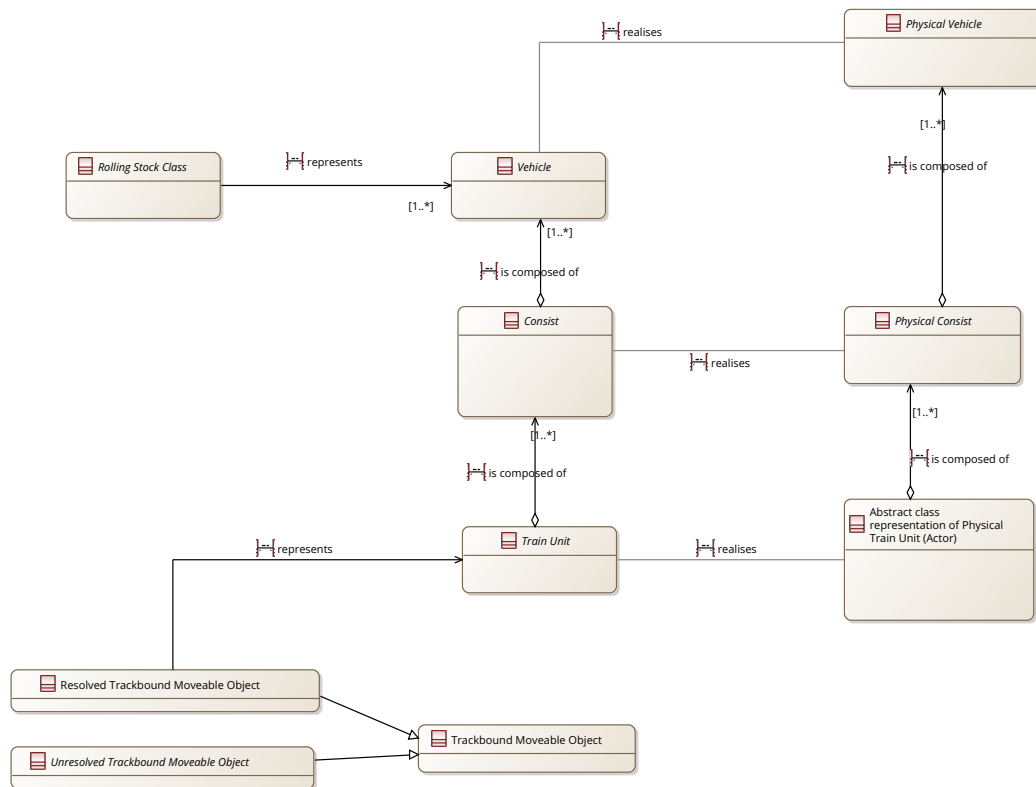


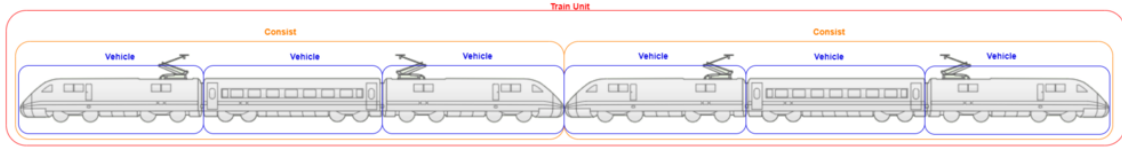
Figure 11: [O.CDB][AMOD-025] Rolling Stock [Abstract concepts]

6.6.1 Description of Rolling Stock

- **Abstract class representation of Physical Train Unit (Actor)**
This class is a data representation of the system actor Physical Train Unit.
- **Consist**
A Consist is an abstract object representing a Physical Consist and an independent item of rolling stock, comprising one or more mechanically connected Vehicles.
- **Physical Consist**
Physical Consist is a physically existent, independent item of rolling stock, comprising one or more mechanically connected Physical Vehicles, whose composition cannot be changed within System RCA System Borders.
- **Physical Vehicle**
Physical Vehicle is a physically existent, single item of rolling stock which is registered in the National Vehicle Register.
- **Rolling Stock Class**
A group of rolling stock built to a common design sharing the same technical and operational properties.
- **Train Run**
A planned movement of Train Unit from an origin to a destination. It is described by a continuous sequence of segments from origin to destination, without gaps and branches and is operated on each segment by exactly one Train Unit, with possibly different Train Units on individual segments. The Train Run is as a whole identified by a common identifier Train Running Number.
- **Train Running Number**
A number which, within certain limits, defines the type of train, the traffic relationship and the direction of travel and enables the unambiguous identification of the moving unit.

- Train Unit

A Train Unit is an abstract object representing a Physical Train Unit and made up of a single or an ordered sequence of Consists coupled together.



- Vehicle

A single item of rolling stock of a given Rolling Stock Class

6.7 Safety Logic

The Safety Logic domain provides concepts needed by System RCA to ensure safe movements of Trackbound Movable Objects and support safety of Non Trackbound Movable Objects in the Track Area (e.g. construction sites).

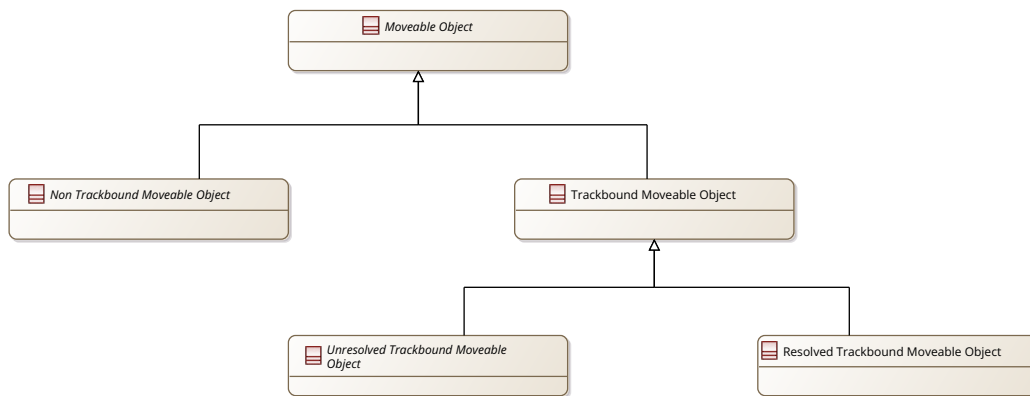


Figure 12: [O.CDB][AMOD-025] Moveable object taxonomy [Abstract concepts]

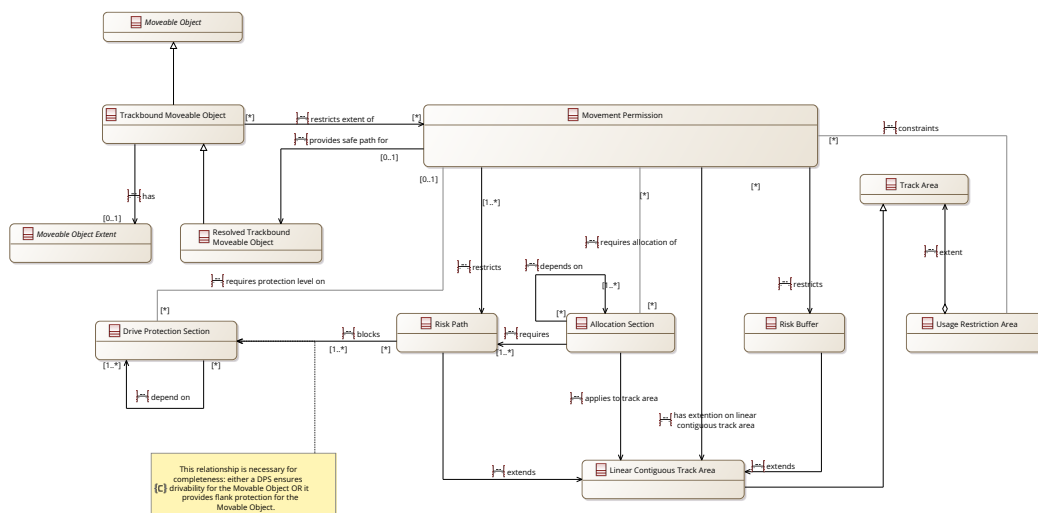


Figure 13: [O.CDB][AMOD-025] Safety Logic [Abstract concepts]

6.7.1 Description of Safety Logic

- Allocation Section

An Allocation Section (AS) is defined as a directed Linear Contiguous Track Area of 1...n Track Edge Sections and 1..n exclusive dependencies as additional information. The direction always leads away from the dependent Allocation Section (from conflict area to non-conflict area of clearance gauge).

Allocation sections are located in Track Areas where one or more clearance gauge conflicts between different tracks arise.

The conflict arises when the clearance gauges of different tracks overlap each other. Out of this conflict an exclusive, symmetric interdependency between two or more Allocation Sections has to be deduced.

Exclusive dependency means that if one allocation section is fully or partially occupied by a Movable Object or if it is fully or partially contained in a granted Movement Permission Extent, no Movement Permission may be granted over any dependent Allocation Section.

Allocation Sections may overlap each other. In this case there must not be an exclusive dependency between the overlapping Allocation Section.

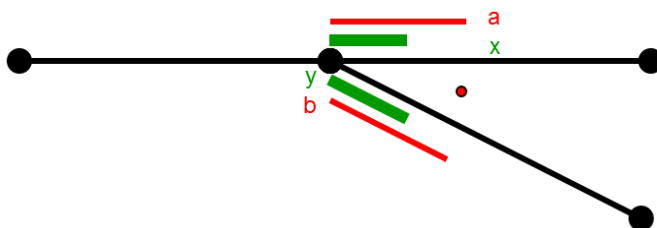
A non-complete list of usages is: points, diamond crossings, single and double slips, turnouts and gauntlet tracks.

All use cases and the according modelling principles can be affiliated to three basic assets: a diverging of Track Edges in a Track Node (point), a crossing of Track Edges (diamond crossing) and an interlacing track edges or there clearance profile (gauntlet).

Note: In the following figures, red and brown denotes an Allocation Section and green denotes a Drive Protection Section.

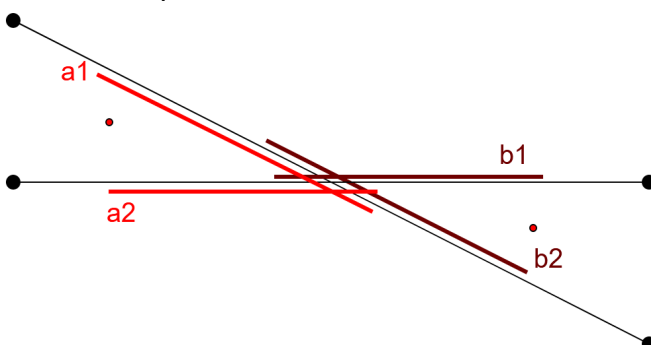
Example of a point

exclusive dependency: $a \Leftrightarrow b$



Example of a diamond crossing

exclusive dependencies: $a1 \Leftrightarrow a2$, $b1 \Leftrightarrow b2$



- Drive Protection Section

A Drive Protection Section (DPS) is defined through an extent on the track. It represents a part of a trackside asset that changes drivability. A Drive Protection Section is typically represented as one Track Edge Section where, for Physical Train Units to pass safely, a switchable field element has to be set to and secured in a specific position.

Note that the Drive Protection Section does not represent the switchable element itself but rather a part of the track, which - depending on the state of the switchable field element - is fully drivable (Full), limited drivable (Limited) or not drivable (None).

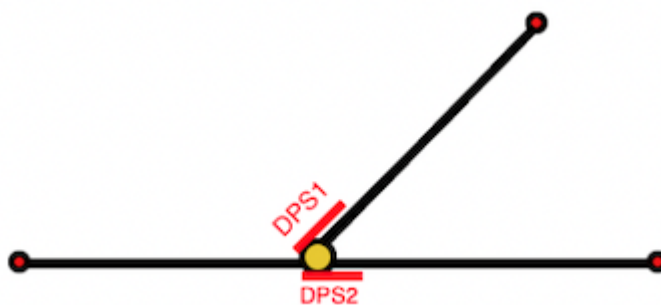
Therefore one switchable field element may affect several Drive Protection Sections. A simple point has two Drive Protection Sections for the two branching tracks and a level crossing has as many Drive Protection Section as tracks are passing through the level crossing. Common switchable field elements that require Drive Protection Sections are (non-complete list): Points, Level Crossings, derailleurs, movable bridges, gates, turntables.

Drive Protection Sections of the same physical elements have interdependencies - e.g. the two Drive Protection Sections of a simple point can not both be drivable at the same time. To indicate an interdependency, several DPS are grouped in one DPS Group (compare 'Drive Protection Section Group').

The following picture shows a simple point as an example of a switchable field element.



The following drawing shows the representation of the single tracks that are passing through the simple point as Drive Protection Sections. In addition, topology objects are shown to increase the understanding.



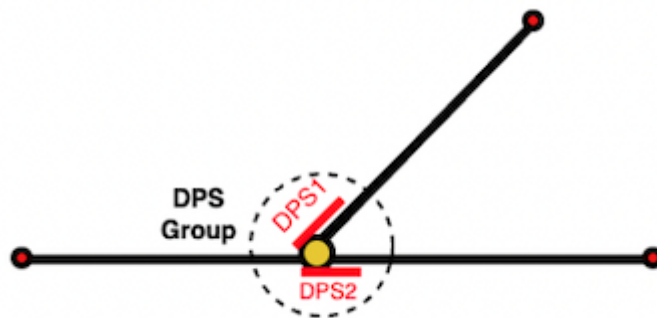
- Drive Protection Section Group

A Drive Protection Section Group (DPS Group) groups 1..n Drive Protection Sections which belong to the same switchable field element. DPS in one DPS Group might be dependent from each other. Furthermore, the DPS Group indicates the state of the switchable field element. Please note: a switchable field element (e.g. a slip point) might be represented by more than one DPS Group.

The following picture shows a simple point for which a Drive Protection Section Group is used as the Domain Object for representation.



The following drawing shows the representation of a simple point as a Drive Protection Section Group.



- End of Movement Permission

The End of a Movement Permission (EoP) describes the position up to which a Train Unit is allowed to move. The Risk Buffer connects gap-free behind to it.

- Moveable Object

A Movable Object (MOB) is a representation of a real-world object as part of the physical railway system that moves. Such Movable Objects can be trackbound (such as Physical Train Units) or non-trackbound (such as Authorised Trackside Persons). Any real-world movable object which is detected as such by a person or system with safety responsibility will be represented as a Movable Object in System RCA.

- **Moveable Object Extent**

The Movable Object Extent (MOB Extent) represents the safe extent of the corresponding object in the Topology. It consists of the navigable gap-free and overlap-free path between two Track Edge Points. For determination of the MOB Extent, different sources of information are used. For Resolved Trackbound Movable Object it results for example from a combination of Train Detection System information with reported front and rear end position as well as the path in between under consideration of inaccuracy of the localisation technology.

- **Movement Authority**

Permission for a train unit to run to a specific location within the constraints of the infrastructure and supervision of speed.

- **Movement Permission**

A Movement Permission (MP) is an authorisation for a particular Trackbound Movable Object to move in a defined direction, with a defined maximum speed profile, along a defined path (a Linear Contiguous Track Area) on the track network represented as so-called Movement Permission Extent plus safety margins (Risk Path(s) and Risk Buffer). A Movement Permission includes all conditions under which the movement of the Movable Object can be performed safely. A Movement Permission always refers to exactly one Movable Object.

Example of a Movement Permission:



- **Movement Permission Extent**

The Movement Permission Extent (MP Extent) is a Linear Contiguous Track Area in a defined direction. It describes the topological extent of the running path of the Movement Permission.

- Non Trackbound Moveable Object

Identified and localised objects such as Contruction Equipment or Authorised Trackside Persons are represented as Non-Trackbound Movable Objects. The movement of these objects is not constrained along the paths defined in the railway network Topology domain.

- Permitted Movement Mode

The Permitted Movement Mode describes the Movement Modes allowed for a certain Track Area on the topology to be used by the Automatic Train Protection (ATP) system. The set of Permitted Movement Mode implies the split of responsibility between Safety Actors, e. g. the on-board ATP system and the train driver itself.

- Resolved Trackbound Moveable Object

A Resolved Trackbound Movable Object (rMOB) is a Trackbound Movable Object which is identified, i.e. there is a 1:1 mapping between the virtual object in the model and a Physical Train Unit.

Note: A Resolved Trackbound Movable Object represents an object which is known to the Advanced Protection System (identified), independent of the availability of localisation information, i.e. both objects with valid but also with unknown or invalid position are represented as rMOBs.

- Risk Buffer

The Risk Buffer connects gap-free to the End of a Movement Permission (EoP) and describes the extent on the Topology that could potentially be occupied by the Resolved Trackbound Movable Object, if the risk mitigation achieved by the Automatic Train Protection is insufficient to keep the Resolved Trackbound Movable Object within its Movement Permission Extent.

The Risk Buffer is part of a Movement Permission.

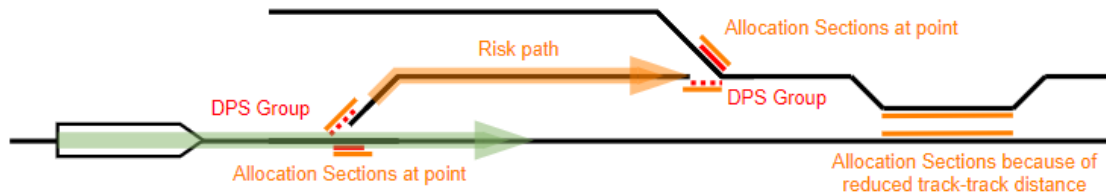
- Risk Buffer Extent

The Risk Buffer Extent describes the extent of a navigable gap-free and overlap-free Track Area of the Risk Buffer on the Topology in a defined direction.

- Risk Path

The 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 Movement Permission extent. The Risk Path starts at each end of the relevant Allocation Section in the extent of the Movement Permission (including the Risk Buffer, if not opted out by other configuration) and is limited through a sufficient method for providing flank protection. For instance, a Drive Protection Section Group or Movement Permission could be used for limiting the Risk Path.

The Risk Path is defined as a Contiguous Track Area.



- Trackbound Moveable Object

A Movable Object whose movement is strictly bound to the paths defined by the railway network Topology domain (that is, a Movable Object that is guided by the rails).

Trackbound Movable Objects are distinguished between Unresolved Trackbound Movable Objects and Resolved Trackbound Movable Objects.

- Unresolved Trackbound Moveable Object

Represents Trackbound Movable Objects which is not (yet) identified, i.e. there is no 1:1 mapping between the virtual object in the model and Physical Train Units (PTUs).

In case of using a Train Detection System this occurs when a track section is occupied.

An Unresolved Trackbound Movable Object may in reality represent zero up to several separate unregistered PTUs in the same Track Vacancy Proving Section (TVPS).

In areas without a Train Detection System installed, this can occur as a consequence of degraded situations. APS defines then an occupation extent by performing an internal calculation.

Notes:

- A track section can also be occupied in case there is no PTU located, but a disturbance of Train Detection System is given.
- Strictly speaking, an Unresolved Trackbound Movable Object therefore only exists in case of missing knowledge that cannot be resolved by APS itself.

- Usage Restriction Area

A Usage Restriction Area (URA) limits or constrains movements on an area described by an overlapping free but not necessarily connected set of Track Edge Sections. Usage Restriction Areas 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). Various limitations are possible for Usage Restriction Areas e.g. speed reduction or full track closure.

Under certain conditions, a Movement Permission may overlap a Usage Restriction Area (e.g. construction vehicle must enter a construction site). Usage Restriction Areas can overlap, for example when multiple construction sites overlap or specific limitations apply to the same location.

7 System Actors

In this chapter, all actors of the RCA system are described below.

- Physical Train Unit Operation Systems (PTU-OS)

Physical Train Unit Operation Systems represents all on-board subsystems not in RCA and OCORA scope, including the Train Control and Management System (TCMS) and hard-wired electrical and electronical components that are necessary for the operation of the Physical Train Unit, but are not likely to change due to the development of System RCA or OCORA.

- Point Machine

Point Machine is a device, which can drive movable parts of field elements (e.g. point blades) to a required position. Such a field element may be equipped with more than one Point Machine.

- Infrastructure Manager (IM)

Infrastructure Manager means any body or firm responsible for establishing, operating, and maintaining railway infrastructure, including the management of all relevant infrastructure data, traffic management, and control-command and signalling in alignment with key term definition in Directive 2012/34/EU. The functions of the Infrastructure Manager on a network or part of a network may be allocated to different bodies or firms.

- Collective Warning System

Collective Warning System represents the devices which actuate the required warning state provided by System RCA to the track workers. Warnings are given audibly and optically. The warning devices are located at the track and are forming one collective warning system to cover the respective warning area.

- Physical Train Unit (PTU)

Physical Train Unit (PTU) is physically existent, driveable and made up of a single or an ordered sequence of Physical Consists coupled together.

- Planning System

Planning System provides functionality for preparing and optimising the entire schedule within an Area of Control. This schedule will be represented by Missions for Train Units. Missions are provided to System RCA where they enable command and control of traffic operations. System RCA provides the current operation state to the Planning System as feedback.

- Date Time Reference

Date Time Reference is the system/organisation that provides reference of date and time to System RCA.

- Environment

Environment represents the external physical environment the System RCA operates in. It is a source for environmental conditions, localisation references like landmarks or dedicated electromagnetic signals and also for possible obstacles impeding the railway operation.

- Eurobalise (EUB)

A transponder, mounted on the track, which can communicate with a train passing over it, compliant to the ERTMS/ETCS specifications.

8 Exchange Items

In this chapter, all exchange items defined in the model are described below.

8.1 movement_authority_indication

Type: FLOW

Elements:

Indicates the movement authority as defined in specification ERA_ERTMS_015560.

8.2 automatic_driving_state_indication

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
indicatedAutomaticDrivingState	AutomaticDrivingDisplayState	Enumeration	- ATO ready for engagement - ATO engaged - ATO selected

8.3 remaining_dwell_time_indication

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
IndicatedRemainingDwellTime	DurationTime	PhysicalQuantity	-

8.4 door_operation_state_indication

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
indicatedDoorsState	DoorDriverInformation	Enumeration	- Doors are open - Request driver to close doors - Doors are closed - Doors are being closed by ATO

8.5 DMI_engage_event

Type: EVENT

Elements:

Attribute	Type	BaseType	Values
requiredState	EngagementState	Enumeration	- Engaged - Disengaged

8.6 map_data_authorisation_command

Type: EVENT

Elements:

Attribute	Type	BaseType	Values
commandedMapDataVersion	UUID	StringType	-

8.7 map_data_state_indication**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
indicatedMapDataState	MapDataVersionState	Enumeration	- Activated - Ready - Deactivated
indicatedMapDataVersion	UUID	StringType	-

8.8 point_position_indication**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
indicatedPosition	EndPositionState	Enumeration	- Right end position - Left end position - No end position

8.9 warning_area_warning_requirement**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
requiredWarningState	WarningState	BooleanType	- True - False
affectedWarningArea	Warning Area	Class	-

8.10 date_and_time_definition**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
definedDateAndTime	DateTime	Class	-

8.11 physical_dimensions_and_limits_presence**Type:** FLOW**Elements:**

This exchange item represents the real physical environment dimensions and limits.

8.12 physical_objects_presence**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
presentAbstractObject	PhysicalObject	Enumeration	<ul style="list-style-type: none"> - Adult - Agriculture machine - Animal - Authorised machinery - Authorised person - Bicycle - Buffer stop - Bus - Cab car - Car - Catenary pole - Fallen tree - Fire - Freight wagon - Heavy construction vehicle - Kid - Landslide - Locomotive - Lost cargo - Motorbike - Other infrastructure element - Other pole - Passenger car - Platform - Pram - Rock - Shopping cart - Signal pole - Smoke cloud - Track - Truck - Unlisted object - Walls or fences - Flood - Avalanche - Wheelchair

8.13 eurobalise_telegram

Type: EVENT

Elements:

Eurobalise telegram as specified in ERTMS/ETCS SUBSET-036 and ERTMS/ETCS SUBSET-026.

8.14 physical_train_unit_behaviour_presence

Type: FLOW

Elements:

The actual physical behaviour of the train unit, e.g. the movement of the Train Unit in space over time.

8.15 emergency_brake_requirement

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
requiredActivationState	EmergencyBrakeActivation	BooleanType	- True - False

8.16 audible_warning_device_requirement**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
requiredState	WarningState	BooleanType	- True - False
requiredTone	ToneType	Enumeration	- High tone - Low tone

8.17 all_doors_state_observation**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
observedDoorsState	DoorsState	Enumeration	- All closed and locked - Not all closed and locked

8.18 relative_traction_braking_effort_level_requirement**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
requiredPercentageLevel	TractionBrakingPercentage	NumericType	-

8.19 train_unit_integrity_state_estimation**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
estimatedIntegrityState	TrainIntegrityState	Enumeration	- Confirmed - Lost - No information

8.20 door_operation_state_requirement**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
requiredDoorsState	DoorOperationState	Enumeration	- No required state - Closed

8.21 train_unit_front_end_movement_direction_intention**Type:** FLOW**Elements:**

Attribute	Type	BaseType	Values
intendedMovementDirection	DirectionControllerPosition	Enumeration	- Forward - Neutral - Backward

8.22 mission_requirement

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
requiredMissions	Mission	Class	-

8.23 point_position_estimation

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
estimatedPosition	EndPositionState	Enumeration	- Right end position - Left end position - No end position

8.24 warning_area_requirement

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
plannedWarningArea	Warning Area	Class	-
plannedCreationTime	DateTime	Class	-
plannedRemovalTime	DateTime	Class	-

8.25 train_unit_navigation_data_estimation

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
estimatedMotionState	TrainUnitTrackboundMotionState	Class	-

8.26 map_data_state_observation

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
observedMapDataVersion	UUID	StringType	-
observedMapDataState	MapDataVersionState	Enumeration	- Activated - Ready - Deactivated

8.27 motion_state_over_time_plan

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
missionExecutionTrackEdgePoint			-
relatedMissionId	UUID	StringType	-
calculatedArrivalTime	DateTime	Class	-

8.28 warning_area_actual_definition

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
definedActualState	WarningAreaState	Enumeration	- Created
definedWarningArea	Warning Area	Class	-
creationTimestamp	DateTime	Class	-

8.29 restriction_area_requirement_STUB

Type: UNSET

Elements:

None

8.30 restriction_area_actual_definition_STUB

Type: UNSET

Elements:

None

8.31 point_machine_actuation_requirement

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
requiredMachineActuation	PointMachineActuationState	Enumeration	- Move left - Move right - Stop moving

8.32 point_machine_position_estimation

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
estimatedMachinePosition	EndPositionState	Enumeration	- Right end position - Left end position - No end position

8.33 map_data_definition

Type: FLOW

Elements:

Attribute	Type	BaseType	Values
mapDataVersion	UUID	StringType	-

Attribute	Type	BaseType	Values
currentMapDataState	MapDataVersionState	Enumeration	- Activated - Ready - Deactivated
definedMapData	Map Data	Class	-