RCA

Reference CCS Architecture

An initiative of the ERTMS users group and the EULYNX consortium

APS Concept Operating State and APS Domain Objects

Document ID: RCA.Doc.61

Table of contents

1 Preamble **4**
1.1 Release Information 4
1.2 Imprint 4
1.3 Disclaimer 4
1.4 Purpose 4

2 Version history **5**

3 Introduction **6**
3.1 Type of document 6
3.2 References 6
3.3 Terms and abbreviations 6

4 Problem description **7**
4.1 General need 7
4.2 Current solution 7
4.3 Problems with current solution 8

5 Solution approach **9**
5.1 Operating State in context of RCA 9
5.2 Overall principles of the APS Operating State 11
5.2.1 Fail-safe 11
5.2.2 Real-time 12
5.3 Overall principles of APS Domain Objects 12
5.3.1 Abstraction 12
5.3.2 Geometric representation 13
5.3.3 Aggregation 14
5.4 APS Domain Objects 15
5.4.1 Classification of APS Domain Objects into the MAP Object Model 15
5.4.2 Categories of APS Domain Objects 16
5.4.3 Infrastructure Objects 17
5.4.3.1 Drive Protection Section 17
5.4.3.2 Drive Protection Section Group 19
5.4.3.3 Allocation Section 20
5.4.4 Movable Objects 21
5.4.4.1 Movable Object (MOB) - Overall description 21
5.4.4.2 Non-Trackbound Movable Object (nMOB) 21
5.4.4.3 Trackbound Movable Object (tMOB) - Overall description 22
5.4.4.4 Unresolved Trackbound Movable Object (uMOB) 22
5.4.4.5 Resolved Trackbound Movable Object (rMOB) 22
5.4.5 Control Objects 23
5.4.5.1 Movement Permission (MP) 23
5.4.5.2 Usage Restriction Area (URA) 23

5.4.5.3 Warning Area (WA) 23

6 Closure **25**

1 Preamble

1.1 Release Information

Basic document information:

RCA-Document Number: RCA.Doc.61

Document Name: APS Concept Operating State and APS Domain Objects

Cenelec Phase: 1

Version: 1.0

Approval date: 2022-09-30

1.2 Imprint

Publisher:

RCA (an initiative of the ERTMS Users Group and EULYNX Consortium)

Support and Feedback:

For feedback, or if you have trouble accessing the material, please contact rca@eulynx.eu.

1.3 Disclaimer

No disclaimer defined.

1.4 Purpose

See chapter 'Introduction'.

2 Version history

Version	Date	Author	Description
1.0	2022-09-30	Marius Kunde, Philipp Nicolaus, Martin Kaufmann, Frank Schiffmann	First published version for RCA BL1 R0

3 Introduction

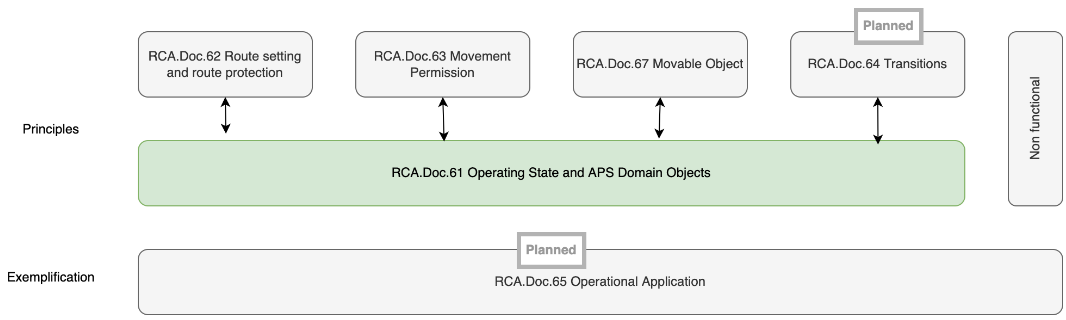
3.1 Type of document

This concept is one of the detailed concepts of the Advanced Protection System (APS). After the introduction of the concept of APS in /RCA.Doc.51/ it offers more details on how the $requirements from it can be fulfilled by further describing the ideas and solution concepts in the problem space.

Notes

- This document is a concept and not a specification;
- This document describes "solutions" in the problem space and rather not in the solution space - it shall not restrict the solution space and vendors' diversity of ideas, nor competition;
- This document includes not only APS specific content but also overall A.P.M. content.

This document is a fundamental APS concept specifically providing a base for all other APS concepts. It describes the overall principles of the Operating State including its abstract objects from APS point of view, also defined as APS Domain Objects, with all its attributes. The application and single use cases of those APS Domain Objects will be considered in the following concepts (e.g. /RCA.Doc.62/), see the figure below.



3.2 References

Please refer to the references listed in /RCA.Doc.52/ APS Detailed concepts overview and / RCA.Doc.6/ RCA documentation plan.

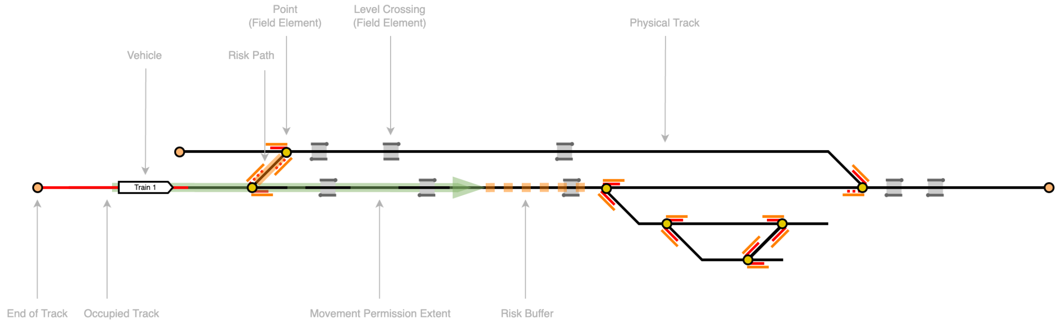
3.3 Terms and abbreviations

Please refer to the abbreviations listed in /RCA.Doc.52/ and /RCA.Doc.14/.

4 Problem description

4.1 General need

In general, productive railway systems need centralised CCS systems exchanging constantly data with trains, trackside assets and persons in the physical railway system to control the railway operation. To enable CCS to do its job, a representation of the actual state of the physical railway system inside the CCS system is needed. This representation is called the Operating State. Within this document the Operating State from viewpoint of APS - called APS Operating State - is considered. Following graphic illustrates a generic sample of an APS Operating State.



Operating States are used in different manners and for different purposes in different domains of a CCS system. There are for example Operating States to plan the railway operation but also Operating States for safety purposes.

In context of safety purposes, a set of conditions are checked by a safety system, before granting any request to change a switchable field element or authorise any permission to move a train. Each safety check must result in either true or false - false leading to rejection of the related request. Each safety check requires the knowledge of the APS Operating State.

4.2 Current solution

In legacy CCS application information of the Operating States already exist. These kind of information are present in interlocking systems like electronic interlockings. In case of application uses radio-based ETCS for train control purposes, information of the Operating State are also given in Radio Block Centre (RBC) based on received information of the supervised trains. Since train control functions for supervision (e.g. ETCS) were specified and developed much later than interlocking technologies, there is a functional split that results in inherent challenges for the operation of today's railways.

In most applications the object information isn't exchanged, so that there is no common representation. No overall aggregation (see chapter 4.3.3) takes place. Representations are processed and stored within each subsystem.

From an operational point of view, an interlocking is designed according to the legacy approach ensuring safe train movements (block centric approach, see /RCA.Doc.63/ for further details). The usage of the Operating States is concentrated on requesting and supervising train movements in normal operation according the definition in /TSI OPE/. The representation of the physical railway system is limited to currently set track routes and the currently monitored occupancies. The RBC covers the derived operational information given by trackside and the specific information received from on-board. This leads to the fact, that the view on a train movement is not the same in interlocking and RBC. Interlocking mapped the location of the train based on Trackside Train Detection, while an RBC determines the location based on cyclic received position reports.

From the technical point of view, legacy Operating States are closely connected to the interfaced devices/technologies of the physical railway system. By defining fixed routes the devices are 'hard-coded' within the safety logic of the interlocking systems. For the RBC the sequence of receiving information on location is determined to specific values configured. No data exchange or aggregation between both systems concerning an aggregated Operating State is present. In most cases this is performed on the level of operational installations like Traffic Management Systems.

4.3 Problems with current solution

A core problem of legacy Operating States is the merging of operational functionalities and functionalities for safe rail operation in a complex way in present products. This inflates the safety requirements as a whole and leads to higher costs, due to the safety target which is also considered for non-safety-related functionalities in system design.

Another core problem is the 'hard-coding' of the interfaced devices. When changing something at the interfaced devices, the core of the safety system must often be adapted accordingly. This leads to a high engineering effort when changing the topology or the location of a field element.

Furthermore, some entities of the physical railway system such as persons, construction sites and vehicles as well as degraded scenarios are not automatically represented in the legacy Operating State. This leads to a higher involvement of human actors as operational rules have to be executed manually. The result is higher effort and lower safety.

In general, the functionalities of legacy Operating States are limited to the block centric approach from interlocking perspective, additional information of the train control part and less aggregation of the different data sources for getting a common overview. There are only minor solutions, where e.g. information from an RBC are used for optimising the handling of interlocking functions. An information flow from RBC towards interlocking is realised for optimising route protection functions in some applications only. But no aggregation of data towards a single Operating State is performed.

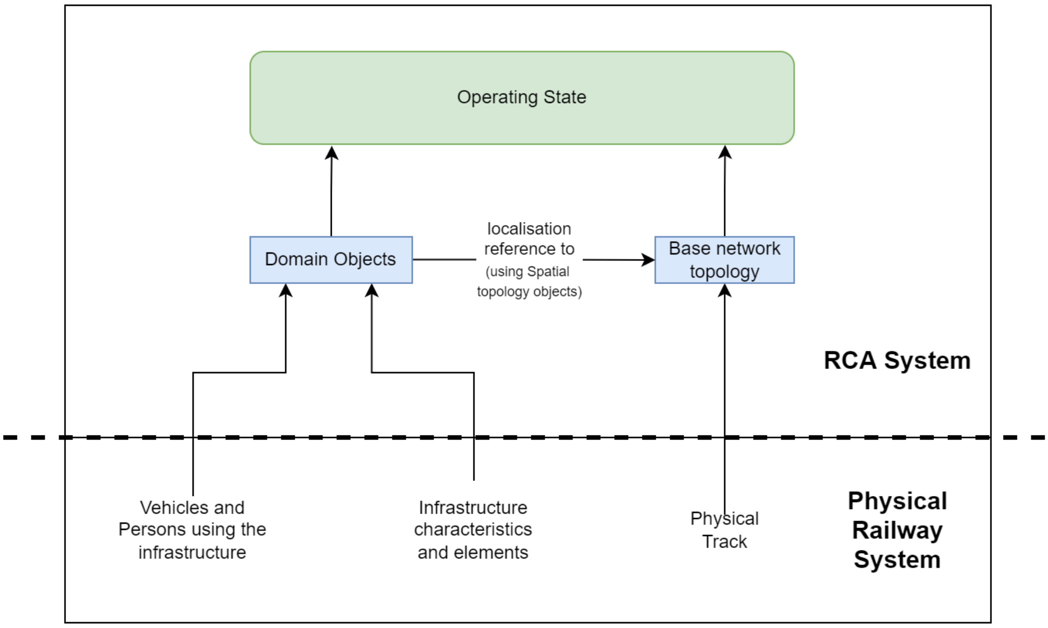
There is no representation of track worker and non-trackbound (railway) vehicles or machinery in the technical system at all. Sometimes this is performed indirectly by usage of operational measures like closing of sections. The grade of correct and exact information on the real Operating State is in case of constructions less compared to normal operation. This limits operational flexibility.

With introducing RCA based on radio-based train control systems like ETCS, the technology ensuring safe train movements follows a different approach. This approach focuses on the protection of the mobile objects (e.g. persons, train) themselves on a train-centric approach (see /RCA.Doc.63/ for further details) combined with more possibilities of representation on track workers and equipement.

5 Solution approach

5.1 Operating State in context of RCA

In context of RCA, the Operating State consists of the Base network topology as part of the Map Data and Domain Objects. Both represent a part of the physical railway system inside the RCA system (see graphic below).
The Base network topology represents the physical track layout. It is modeled by nodes and edges and serves for positioning the Domain Objects.
The Domain Objects represent relevant infrastructure characteristics and elements (e.g. curve radius, speed profiles, field elements) as well as vehicles and persons using the infrastructure. Furthermore, Domain Objects are used inside the RCA System to describe logical information controlling the railway operation (e.g. Movement Permission). All Domain Objects are positioned on the Base network topology using a location reference.
Domain Objects can have static and/or dynamic attributes. Those attributes describe generic information like the extent of an object or specific values like velocity or a state.



Regarding the RCA system and the Planning System (PAS), there exist several Operating States. APS, PE (as representatives of RCA) and PAS - each of them has its own characteristic of Operating State. The architecture of the overall system is given by the approach of splitting operational and safety-related functions. This shall keep the safety core as slim as possible. The APS Operating State distinguishes itself by complying higher safety measurements than the other ones. (It is explicitly not the intention of this concept to quantify any safety-related issues.)

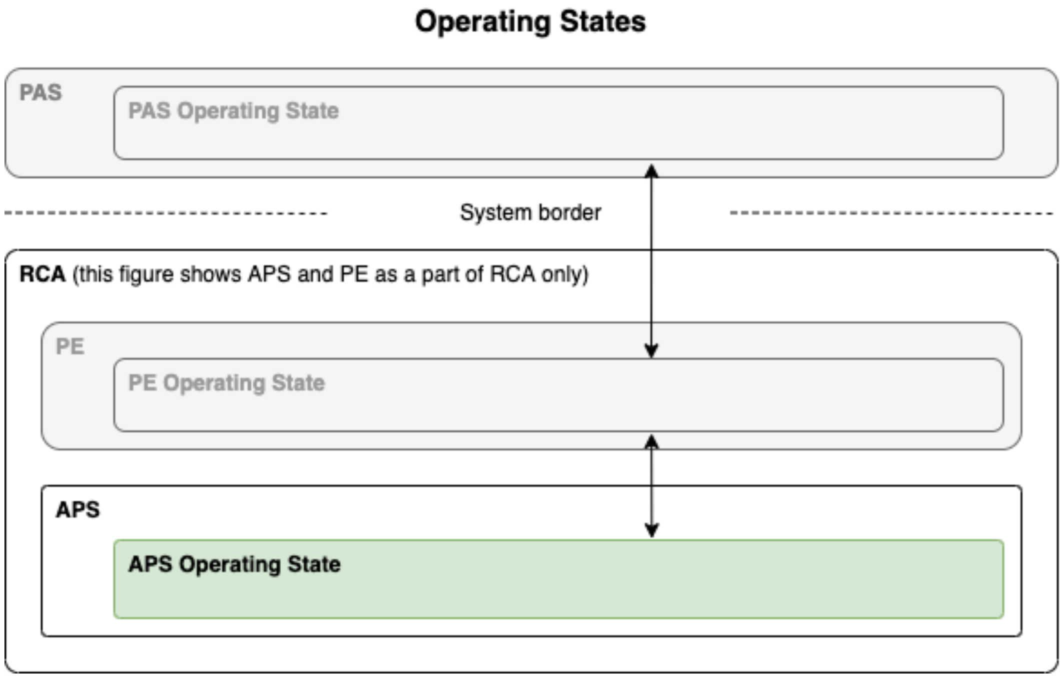
The different Operating States of PAS, PE and APS use Domain Objects of different domains. The origin of the Domain Objects can be associated towards a leading part of the architecture (e.g. PAS, PE, APS). All so-called APS Domain Objects represent the relevant objects for executing APS functions. The definition of these Domain Objects is under the responsibility of APS in context of the full development of the RCA system.

The so-called APS Domain Objects are a comparable artefact like the defined "abstract concepts" in /RCA.Doc.31/ for the Operational Plan Execution and the Operating State in terms of SCI-OP.

The linking of Domain Objects towards an entity (e.g. PAS, PE, APS) does not limit the exchange of certain Domain Objects between the systems. Each entity can use same objects' attributes or properties. Any enrichment of specific information is possible too.

Example of differences between different Operating States are named in the following table:

<table>
<tr><th>Entity</th><th>Typical characteristics of specific Operating State</th></tr>
<tr><td>PAS</td><td>Railway network representation of e.g. an entire country;
Consideration of plan of operation short-term, mid-term and long-term as kind of prognostic view on Operating State, e.g.:
Timely representation of all planned train runs;
Forecasts of the specific planned operation;
Short-term resolving in case of deviation to planned operation;
Knowledge of information of past movements for optimisation if similar situation in the future.
Preperation of Operational Plans.</td></tr>
<tr><td>PE</td><td>Timely representation of planned train runs (Operational Plans) on short-term;
Segmentation of Operational Plans under consideration of current and short-term forecast of Operating State (deriving specific MP requests);
Usage of PE Domain Objects;
Usage of APS Domain Objects.</td></tr>
<tr><td>APS</td><td>Current states at APS runtime;
Solely occupancy claims which block a track path from usage. This includes e.g. (this list is not exhaustive):
Track occupancies (caused by tMOB) - derived from trackside and on-board train detection technologies;
Track path claims/reservations (MP);
Track path restrictions (URA, WA).
Current switchable field element representation.</td></tr>
</table>



This concept focuses on the APS Operating State and on the APS Domain Objects. Nevertheless the APS Operating State uses also Domain Objects belonging to the MAP Domain. Those MAP Domain Objects as well as the Base network topology are considered in /RCA.Doc.69/. To step further into the APS Domain, overall principles of the APS Operating State and of the APS Domain Objects are explained in the following chapters.

5.2 Overall principles of the APS Operating State

APS needs a safe representation of the physical railway system. That encompasses besides others the aspects of 'real-time' and 'fail-safe'. Both principles are explained in the following.

5.2.1 Fail-safe

The aspect fail-safe is considered by APS covering the three main aspects:

- Failure disclosure and safe reaction of APS (e.g. two information contradict). APS shall disclose internal failures as well as failures from interfaced systems;
- Fail-safe in relation to a (partial) outage of a subsystem (APS intern or extern subsystem);
- Fail-safe as a result of the Aggregation principle (see more details in chapter 'Aggregation').

APS must handle all three meanings of Fail-safe. In case of a disclosed failure or missing information, APS must consider this in the representation of the Operating State taking safety measures into account. Therefore APS can intervene the APS Operating State directly and independently from other RCA subsystems. This can be done by manipulating certain Domain Objects to represent the most restrictive scenario possible or by setting certain Control Objects to block or restrict certain track areas.

5.2.2 Real-time

Real-time focuses on Movable Objects and Infrastructure Objects (both objects will be explained in the chapter 'Categories of APS Domain Objects'). For those objects, changes in the physical railway system must be represented in the Operating State within a very short time frame. 'Very short' means here a 'reasonable' amount of time to assure safe reactions. (Changes of the physical track are excluded here. In general, the provision of a reliable Base network topology including the update process is under responsibility of MAP). Control Objects (see chapter 'Categories of APS Domain Objects') are represented when their life cycle begins.

5.3 Overall principles of APS Domain Objects

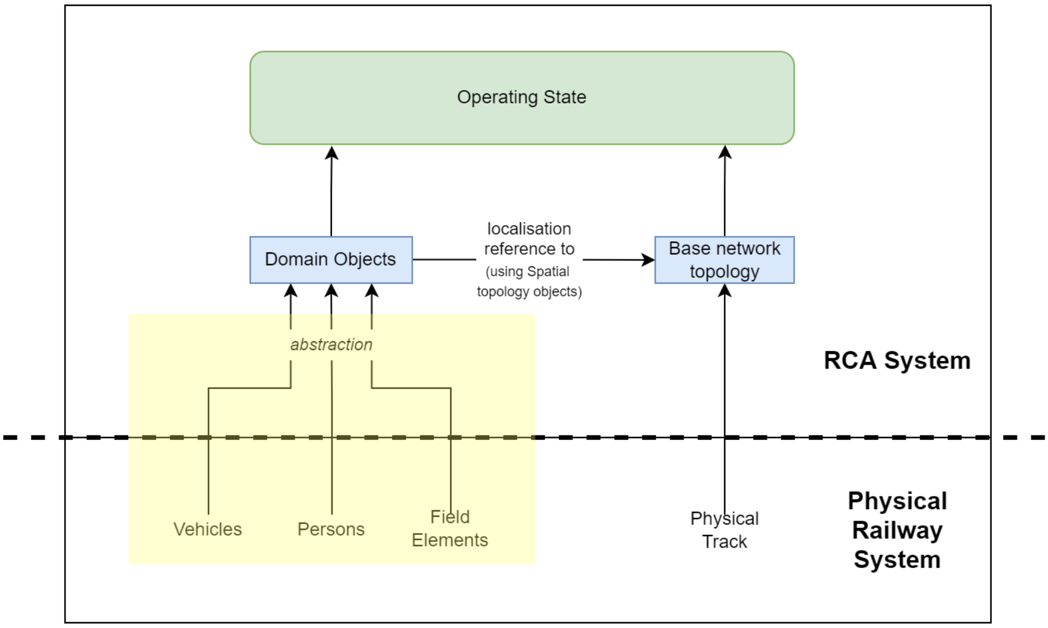
What makes the APS Operating State stand out in comparison to legacy Operating States are the principles of the APS Domain Objects. They are key principles ensuring the realisation of the APS System requirements (see /RCA.Doc.51/) and will be explained in the following subchapters.

5.3.1 Abstraction

Basic principle

As well as other subsystems, APS follows the principle of **Abstraction** by using generic representations for processing of information. Entities of the physical railway system (e.g. vehicles, persons, field elements) are abstracted to the RCA system in form of Domain Objects.

Those Domain Objects show precisely defined semantic and attributes (see also chapter 'APS Domain Objects'). The basic principle is shown in the figure below (yellow area).



By abstraction, the safety logic can be truely generic and only be working on Domain Objects, not knowing their concrete type. Only the lower layers in the architecture need to know this and thus, an adaptation of concrete railway entities will only affect subsystems in the lower layers but keep the safety logic stable and untouched.

Applying a generic abstraction of entities of the physical railway system, the processing of information within RCA becomes heavily independent of the interfaced devices/technologies outside of RCA. On the one hand, this allows an Engineering Data independent approval of APS. This means, there is only one approval needed for APS when implementing the system. If the Engineering Data changes over the years, no further approval of APS is needed but only for the Engineering Data itself. On the other hand, this allows the exchange of interfaced RCA external subsystems with reduced impact on operation, without affecting the RAMS conditions of APS and without a need to restart any other RCA subsystem (except for the affected object controllers). By adding or removing Domain Objects, RCA is able to cope with those situations. By that, high availability of RCA can be ensured. Using standardised interfaces to the physical railway system, existing subsystems as well as a variety of future subsystems of the physical railway system will be supported by receiving the same semantics. In consequence this enables every Infrastructure Manager to use RCA for their individual infrastructure. For example, RCA supports a variety of different localisation systems and there is no need to install a specific one (see more details in chapter 'Aggregation').

Furthermore, the approach of Domain Objects enables a route protection in RCA which is object orientated, taking only the measures into account, which are necessary (individual route protection for each train instead of fixed engineered routes). For further details see /RCA.Doc.62/.

5.3.2 Geometric representation

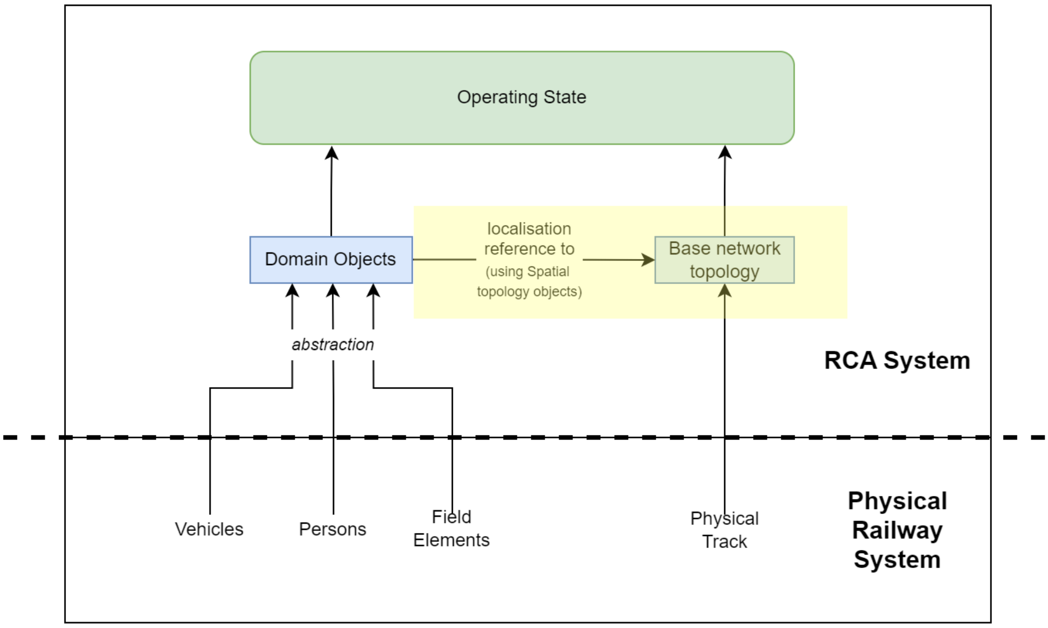
Basic principle

By following the principle of **Geometric representation**, Domain Objects can always be mapped to the Base network topology (see /RCA.Doc.69/) with

- a unique spot location OR
- a geometric extent.

The Base network topology is the abstraction of the physical track network. It consists of Track Nodes, Track Edges and Track Navigability. For further details, see /RCA.Doc.69/.

The location reference of the Domain Objects is built by using Spatial topology objects (see Tier 2 as described in /RCA.Doc.69/) such as e.g. Track Edge Sections. The Spatial topology objects can be understood as a defined language to describe certain spots or areas on the Base network topology. The basic principle is shown in the figure below (yellow area).



The geometric representation of entities of the physical railway system is essential in order to perform certain safety checks by determining geometrical overlap of different Domain Objects. Therefore Map Data and its semantics shall be unambiguously specified in order to be supported by APS. As an example, track occupancies are being represented with an arbitrary location and an arbitrary geometric extent, independent of fixed routes. When a train movement shall be safely granted by APS the geometric extent of the requested movement can be mapped to the Operating State and

a) the existence of the requested geometric extent can be validated and

b) eventual geometric overlaps with domain objects identified in order to either reject or grant such a request.

Furthermore, the geometric representation enables APS to perform route checking for any point A to any point B (see /RCA.Doc.63/). The start and end of a Movement Permission are not restricted to a limited amount of fixed locations.

APS is allowed to create, change and delete geometric extents of APS Domain Objects like Movement Permission in its Operating State.

5.3.3 Aggregation

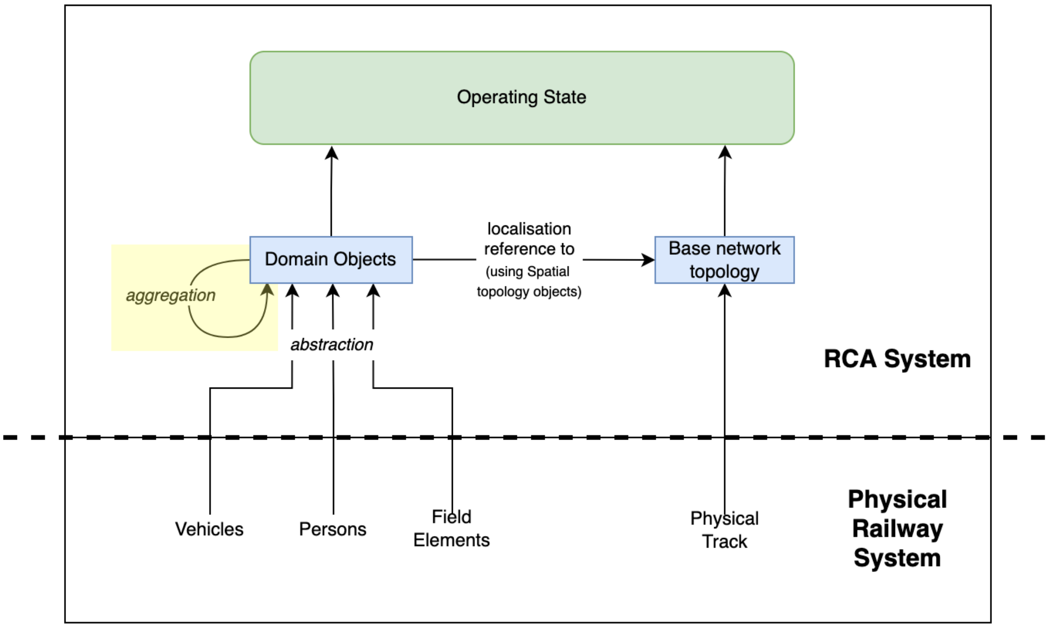
Basic principle

By following the principle of **Aggregation**, different data are considered by subsystems like APS to create one Domain Object. Aggregation is used for two purposes:

1.) Provide an Operating State which represents the physical railway system as precise as possible and as needed. This enables a higher capacity of the line. It is achieved by combining the data from different data sources from the physical railway system to one aggregated Domain Object.

2.) Derive a safe representation in the Operating State. That means, if one of several information (sources) is not available, APS will build up the Domain Object out of available information. In that case APS ensures the same safety level by considering mitigating measures. This enables a higher availability of the line. The case, that no information is available (e.g. because of an outage of a subsystem), is considered in the chapter 'Fail-Safe' below.

The basic principle of Object Aggregation is highlighted in the figure below (yellow area).



APS implements a strict object aggregation, based on its Domain Objects. As an example, APS can receive for one Physical Train Unit various localisation information from different localisation devices. Those information are then aggregated by APS to derive one Domain Object with the most precise geometric extent possible of the abstracted Physical Train Unit.

Further details on the aggregation of Movable Objects are given in /RCA.Doc.67/.

5.4 APS Domain Objects

The following chapters give an overview about the APS Domain Objects. First of all the APS Domain Objects will be classified within the MAP Object Model. Afterwards a categorisation is given and at the end each APS Domain Object is explained.

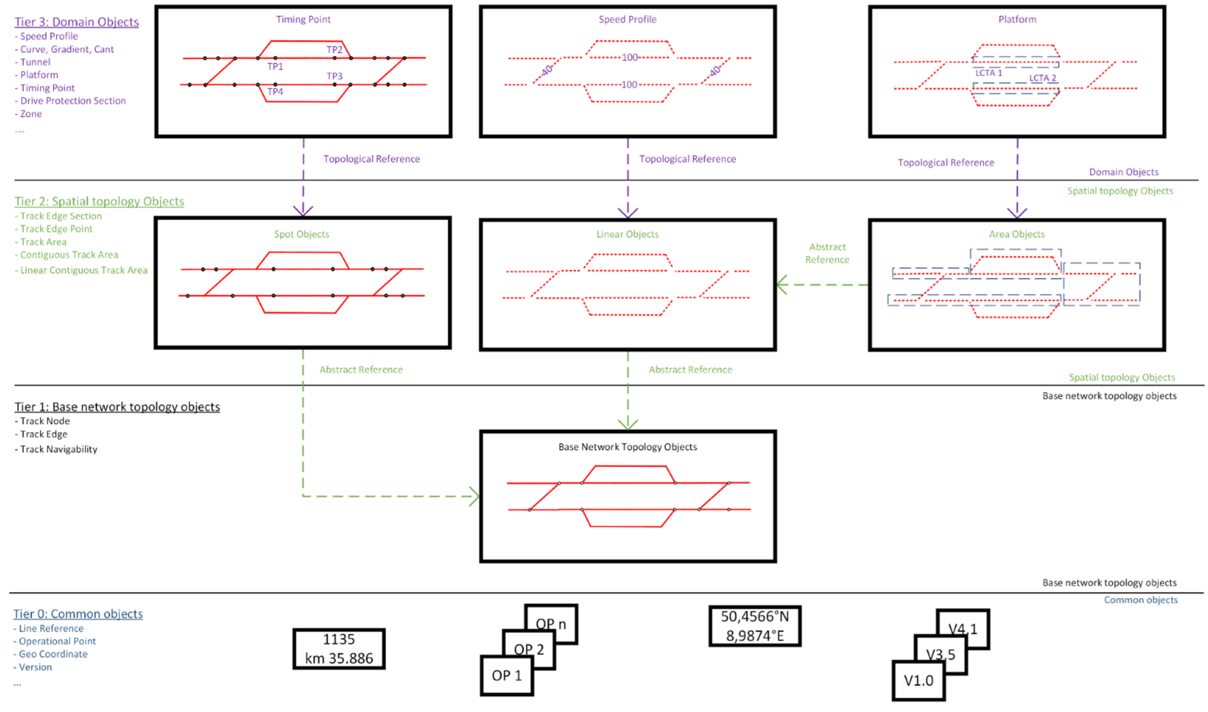
5.4.1 Classification of APS Domain Objects into the MAP Object Model

In /RCA.Doc.69/, the MAP Object Model is introduced. This model structures the Abstract Objects under responsibility of MAP into 4 tiers (see graphic below). Objects in each tier are referencing the objects either within them or the underlying tier(s).

The tiers 1 up to 3 represent the already known objects

- Base network topology objects (tier 1)
- Spatial topology objects (tier 2)
- Domain objects (tier 3)

Tier 0 is not relevant for this concept.



APS supports and makes use of this object model following the approach of the referencing tiers. First of all, this means the APS Domain Objects can be classified within the Tier 3. Secondly, APS describes the location and/or extent of its Domain Objects by giving a reference to a certain Spatial topology object defined by MAP (compare also chapter 'Geometric representation').

In the chapters below, the location and extent of APS Domain Objects are referenced by the attribute 'appliesTo<Spatial topology object>' (e.g. 'appliesToTrackEdgeSection'). For an explanation of each Spatial topology object please refer to /RCA.Doc.69/.

Note: The current defined APS Domain Objects considers only a subset of information compared to the objects named in /RCA.Doc.69/. The reason is, that APS concepts only define objects to be used by current defined functions or conceptional ideas. In addition, within the APS Domain Objects only attributes are named with the same relation to functions or concepts. Thus, the MAP Object Catalogue (/RCA.Doc.69/) can cover more information compared to this document based on the overall background of summary of potential needed data in /RCA.Doc. 69/. For the APS Operating State any information "not defined yet" means, that from APS point of view there is no requirement given. Any first assumption can be already made in /RCA.Doc. 69/.

5.4.2 Categories of APS Domain Objects

The APS Domain Objects are classified into three categories: Infrastructure Objects, Movable Objects and Control Objects. Each specific APS Domain Object is assigned to one category (see table below).

Category	APS Domain Objects	Characteristics
Infrastructure Object	• Drive Protection Section (DPS) • Drive Protection Section Group (DPS Group) • Allocation Section (AS)	Infrastructure Objects are characterised by a static location and extent but having also dynamic attributes. That is why they are under shared responsibility of MAP and APS. MAP provides the static data and APS the dynamic data.
Movable Objects	• Movable Object (MOB) • Trackbound Movable Object (tMOB) • Non-Trackbound Movable Object (nMOB) • Resolved Trackbound Movable Object (rMOB) • Unresolved Trackbound Movable Object (uMOB)	Movable Objects are dynamic in their location and extent, except for uMOBs. Further details can be found in /RCA.Doc.67/. They are provided by APS.
Control Objects	• Movement Permission (MP) • Usage Restriction Area (URA) • Warning Area (WA)	Control Objects are dynamic in their location and extent. They might be provided by APS as well as by other subsystems or external actors.

In the following sections each APS Domain Object will be described. Please note: The object tables only list the attributes which are used by the APS Operating State. There might be further attributes which are not listed in this concept but in /RCA.Doc.69/.

5.4.3 Infrastructure Objects

5.4.3.1 Drive Protection Section

Definition

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, derailers, movable bridges, gates.

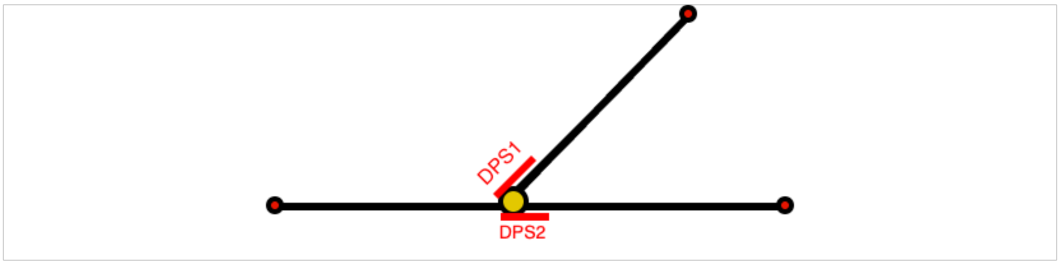
Drive Protection Sections of the same physical element have interdependencies - e.g. the two Drive Protection Sections of a simple point can not both be drivable at the same time. To indicate an interdependency, several DPS are grouped in one DPS Group (compare 'Drive Protection Section Group').

Physical Example

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

Representation

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.



Properties

DriveProtectionSection

Attributes	Description	Type	Range
id	Unique identifier within a DPS group.	not defined yet	not defined yet
appliesToTrackEdgeSection	Reference to Track Edge Section, for which the drive protection is valid.	TrackEdgeSection	-
flankProtectionDirection	Static configuration of the direction (in relation to the TrackEdgeSection) in which the DPS is able provide flank protection (only relevant for points and derailers). This attribute does not imply any explicit usage directions for the DPS.	ENUM	• None • Start to End • End to Start • Both
drivability	Drivability state as received from the Object Controller and translated by APS (dynamic state).	ENUM	• None • Limited • Feasibility_checked • Full

5.4.3.2 Drive Protection Section Group

Definition

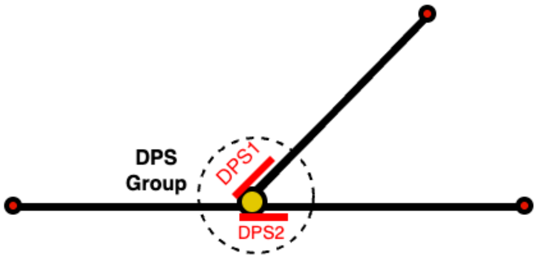
A Drive Protection Section Group (DPS Group) groups 1..n Drive Protection Sections which belong to the same switchable field element. DPS in one DPS Group might be dependent from each other. Furthermore, the DPS Group indicates the state of the switchable field element. Please note: a switchable field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

Physical Example

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

Representation

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



Properties

DriveProtectionSectionGroup

Attributes	Description	Type	Range
id	Unique generated ID	UUID	-
consistsOfDriveProtectionSection	List of all interdependent Drive Protection Sections.	DriveProtection Section	-
dpsGroupState	DPS Group state as translated by APS using messages from the Object Controller (dynamic state).	ENUM	• Ready • Processing • Disturbed

Note: The 'dpsGroupState' indicates the availability of a DPS Group while the 'drivability' of a DPS shows the restriction of the operational usage. A state change to 'dpsGroupState' = 'Disturbed' will impact the drivability. The definition of the functions to be applied is not part of this document here.

5.4.3.3 Allocation Section

Definition

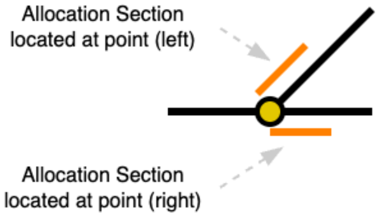
An Allocation Section (AS) is defined through an extent on the track. AS are located in Track Areas where one or more clearance gauge conflicts between different tracks arise. Thus, AS are associated to the representation of switchable field elements and further track connections like diamond crossings. An AS is typically represented as a directed Linear Contiguous Track Area of 1...n Track Edge Sections. The AS are used in terms of granting a Movement Permission request as condition for clearance in a certain area.

Several AS representing the different structure gauges can be present at the same location, enabling an efficient usage of different trains fitting to different clearance gauges.

Further details can be found in /RCA.Doc.14/.

Representation

The representation of Allocation Sections on a single point is shown in the following figure:



The two AS forming a specific topologic extent depending on structure gauge belonging too.

Properties

The specific detailing concerning the data needed, is not yet given. Each AS extent depends on the defined structure gauge.

5.4.4 Movable Objects

5.4.4.1 Movable Object (MOB) - Overall description

Definition

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.

Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.67/.

5.4.4.2 Non-Trackbound Movable Object (nMOB)

Definition

Identified and localised objects such as Construction Equipment and 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.

Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.67/.

5.4.4.3 Trackbound Movable Object (tMOB) - Overall description

Definition

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.

Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.67/.

5.4.4.4 Unresolved Trackbound Movable Object (uMOB)

Definition

Represents Trackbound Movable Objects which are 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 occupancy 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.

Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.67/.

5.4.4.5 Resolved Trackbound Movable Object (rMOB)

Definition

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.

Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.67/.

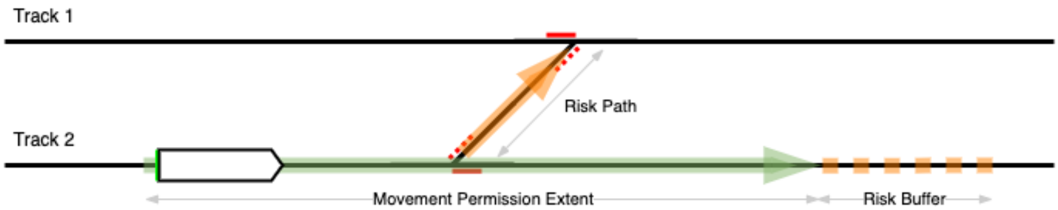
5.4.5 Control Objects

5.4.5.1 Movement Permission (MP)

Definition

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 Trackbound Movable Object.

Example of a Movement Permission:



Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.63/.

5.4.5.2 Usage Restriction Area (URA)

Definition

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 each other, for example when multiple construction sites overlap or specific limitations apply to the same location.

Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.63/.

5.4.5.3 Warning Area (WA)

Definition

A Warning Area is described by a TrackArea in which Authorised Trackside Persons 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.

Properties

Further details (e.g. attributes and further considerations) can be found in /RCA.Doc.63/.

6 Closure

The Operating State with its usage of the Domain Objects described above, enables the System RCA to operate more efficiently than current CCS systems by following the principles of Abstraction, Geometric representation and Aggregation.

In comparison to current CCS (as described in chapter 'Problem description'), the Operating State of RCA supports the representation of many more entities of the physical railway system, such as persons and construction sites.

From APS point of view, the APS Operating State becomes the enabler for performing checks of certain safety conditions before granting requests. The APS Operating State provides the required 'knowledge‘ for that. In addition, this 'knowledge' can be shared to other consumer (sub)systems - as described in certain interface concepts - for other purposes.