RCA

Reference CCS Architecture

An initiative facilitated by the ERTMS Users Group and the EULYNX consortium

RCA System Architecture

This is a snapshot version. Please use it with caution.
There is ongoing work. The content of this document may be unfinished, will likely contain errors and can be changed without prior notice.

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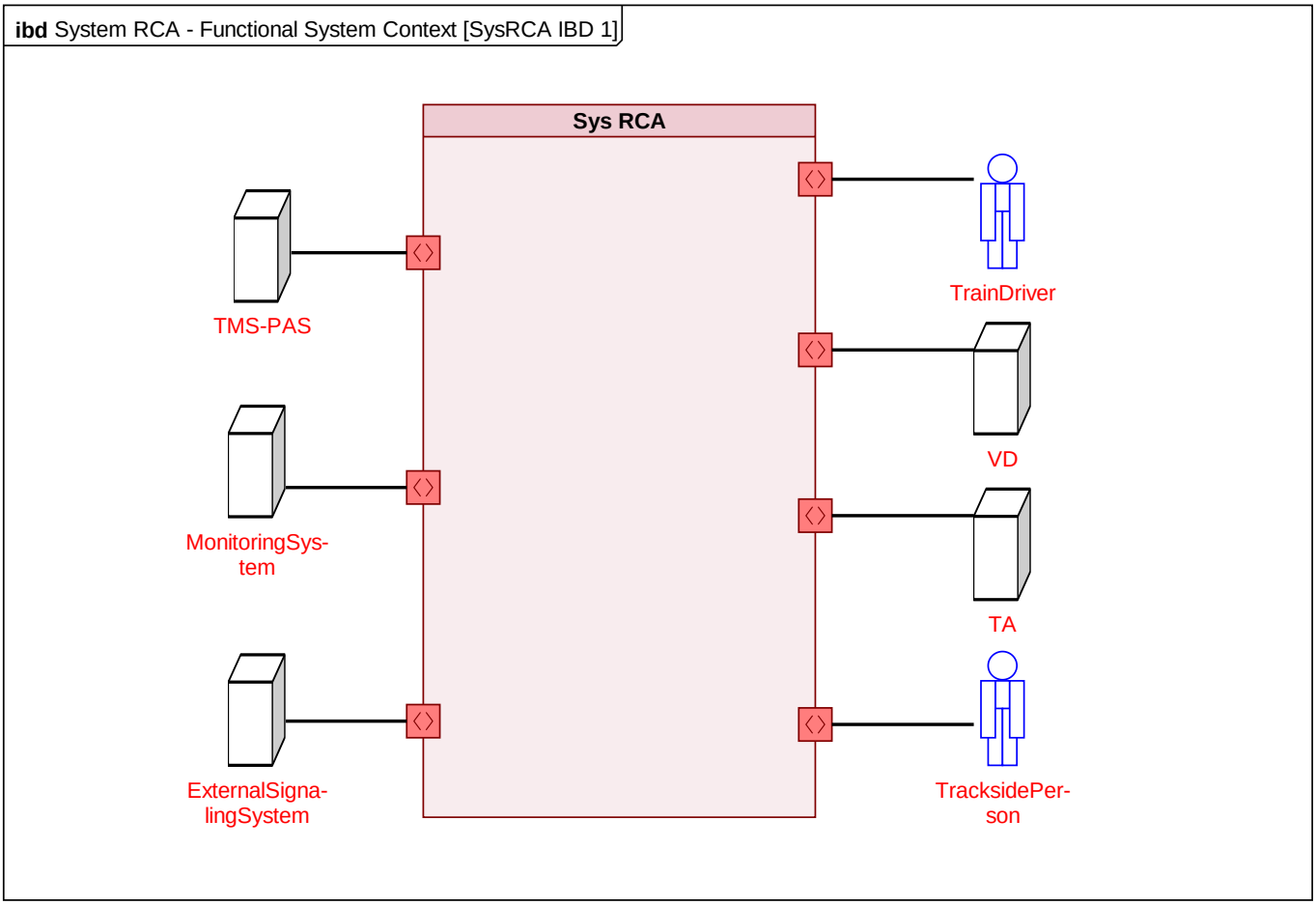
1. CONCEPT (PHASE 1)

Cenelec Phase 1 is not covered in this document

2. SYSTEM DEFINITION (PHASE 2)

2.1. System Context

Description: Sys RCA is a System that consists of subsystems. Sys RCA contains all functions to safely and efficently control movements and restrictions on the tracks.



Description: System RCA - Functional System Context [SysRCA IBD 1] shows Sys RCA in its context. The diagram shows all actors interacting with Sys RCA.

2.2. Descriptions of Actors

This section contains all actors interacting with Sys RCA and the Subsystems of Sys RCA. The actors in this section are external to Sys RCA and therefore not part of the system.

2.2.1. ExternalSignalingSystem

Description: ExternalSignalingSystem can be an RCA complaint APS or and existing interlocking system.

2.2.2. MonitoringSystem

Description: ToDo

2.2.3. TA

Description: TA represents the Trackside Assets. Trackside Assets are installations such as rail points, level crossing barriers, signals, Train Detection System (axle counters, track circuits), etc.

2.2.4. TMS-PAS

Description: TMS-PAS is the planning system for the traffic managment. It represents the functionality preparing and optimising the long-term and short-term production plan.

Source RCA Beta.1 (description has been modified)

2.2.5. TracksidePerson

Description: TracksidePerson is a person which is located within the area of the railway tracks. A TracksidePerson could be for example a track worker.

2.2.6. TrainDriver

Description: A person capable and authorised to drive trains, including locomotives, shunting locomotives, work trains, maintenance railway vehicles or trains for the carriage of passengers or goods by rail in an autonomous, responsible and safe manner.

Source: Directive 2007/59/EC of the European Parliament and of the Counsil

2.2.7. VD

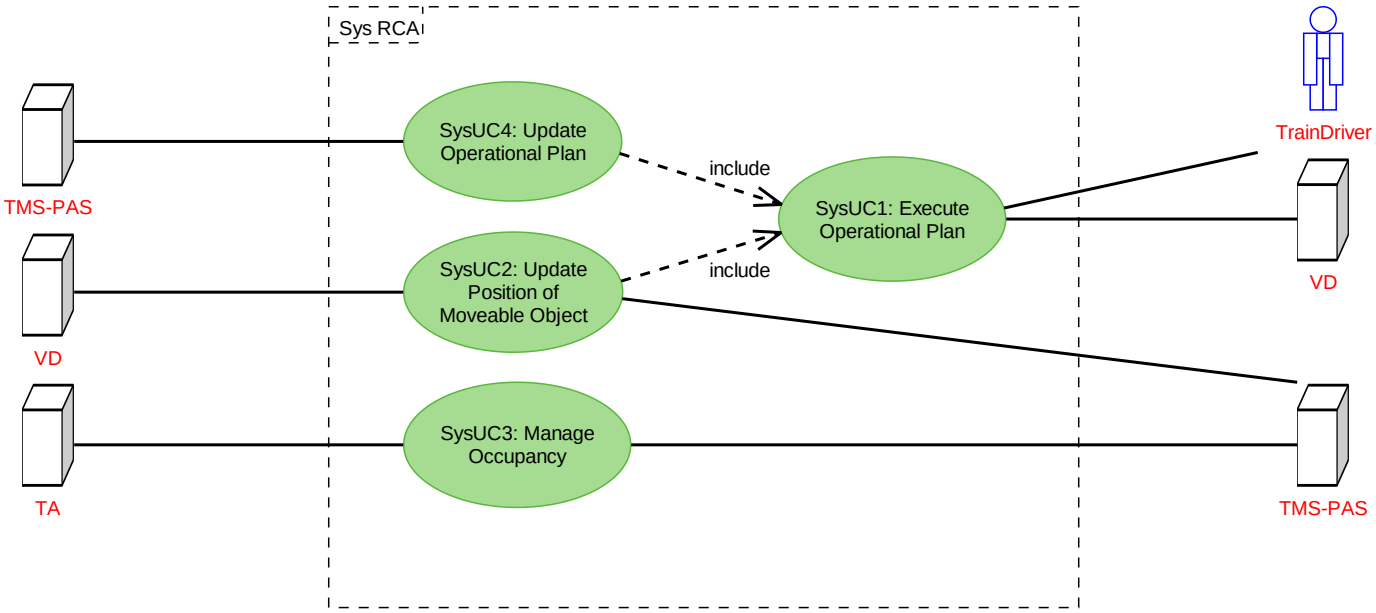
Description: VD represents the vehicle-based actors and sensors.

2.3. Interface Definition

Description: ToDo

2.4. UseCases

This section contains all end-to-end use cases for the overall Sys RCA showing the interaction between Sys RCA subsystems.



Description: System RCA - UseCase Definition - [Sys RCA UCD 1] shows the UseCases supported by Sys RCA and the involved actors. ToDo: This diagram is not yet complete.

2.4.1. SysUC1: Execute Operational Plan

Description: SysUC1: Execute Operational Plan defines what happens, if an Operational Plan has been recalculated by TMS-PAS. SysUC1: Execute Operational Plan describes a GoA scenario.

2.4.1.1. Alternative Scenario: Extend Movement Permission [Sys RCA SD 1.1.2]

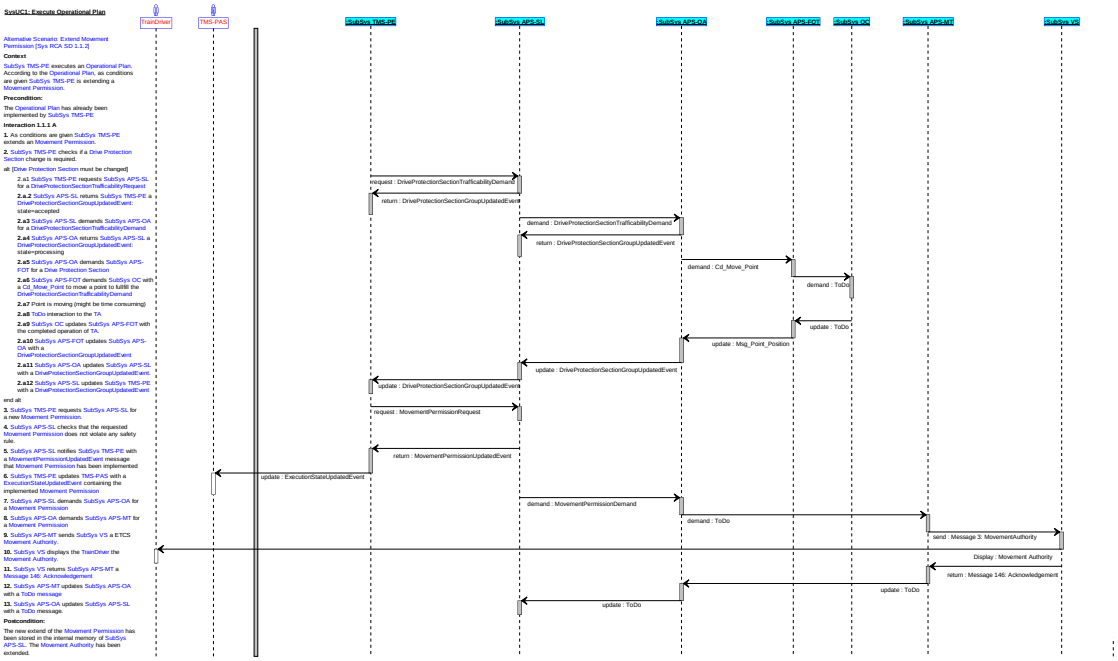


Figure 1 Alternative Scenario: Extend Movement Permission [Sys RCA SD 1.1.2]

2.4.1.2. Alternative Scenario: Shorten Movement Permission is accepted [Sys RCA SD 1.1.1]

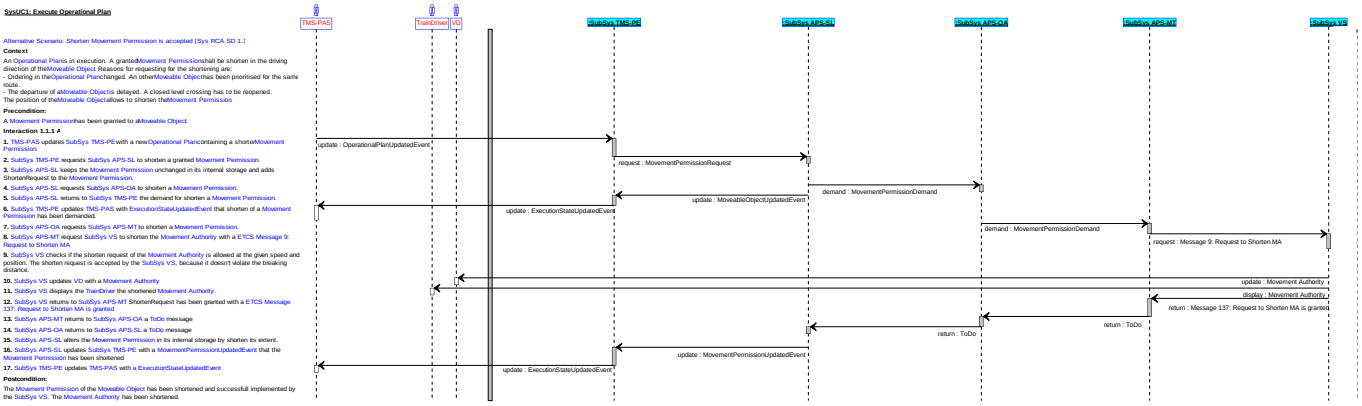


Figure 2 Alternative Scenario: Shorten Movement Permission is accepted [Sys RCA SD 1.1.1]

2.4.1.3. Alternative Scenario: Shorten Movement Permission is rejected [Sys RCA SD 1.1.3]

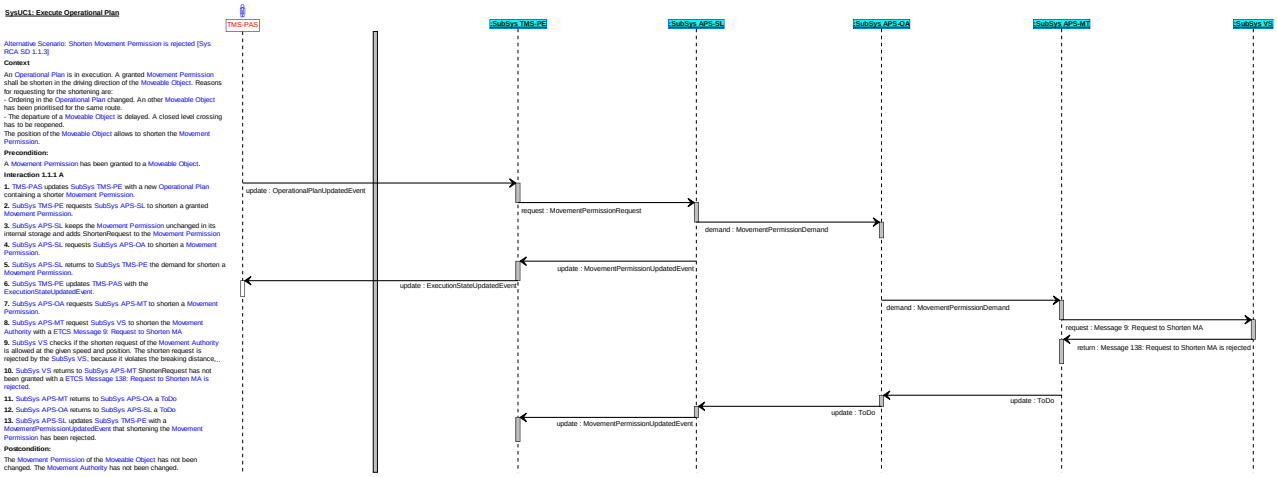


Figure 3 Alternative Scenario: Shorten Movement Permission is rejected [Sys RCA SD 1.1.3]

2.4.2. SysUC2: Update Position of Moveable Object

Description: SysUC2: Update Position of Moveable Object decribes the procedure for a position update of a Moveable Object.

2.4.2.1. Alternative Scenario: Update MOB Position with Eurobalise [Sys RCA SD 2.1.1]

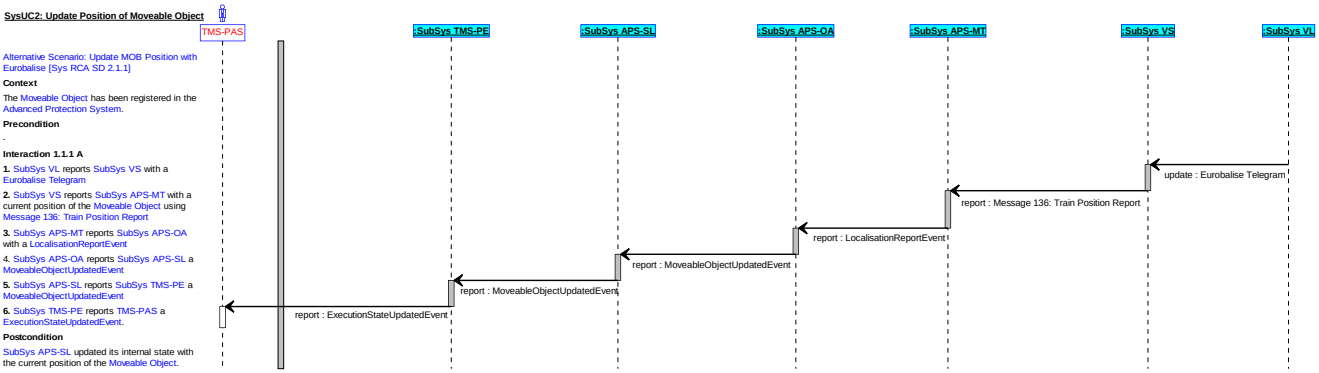


Figure 4 Alternative Scenario: Update MOB Position with Eurobalise [Sys RCA SD 2.1.1]

2.4.2.2. *Alternative Scenario: Update MOB Position with TDS [Sys RCA SD 2.1.2]*

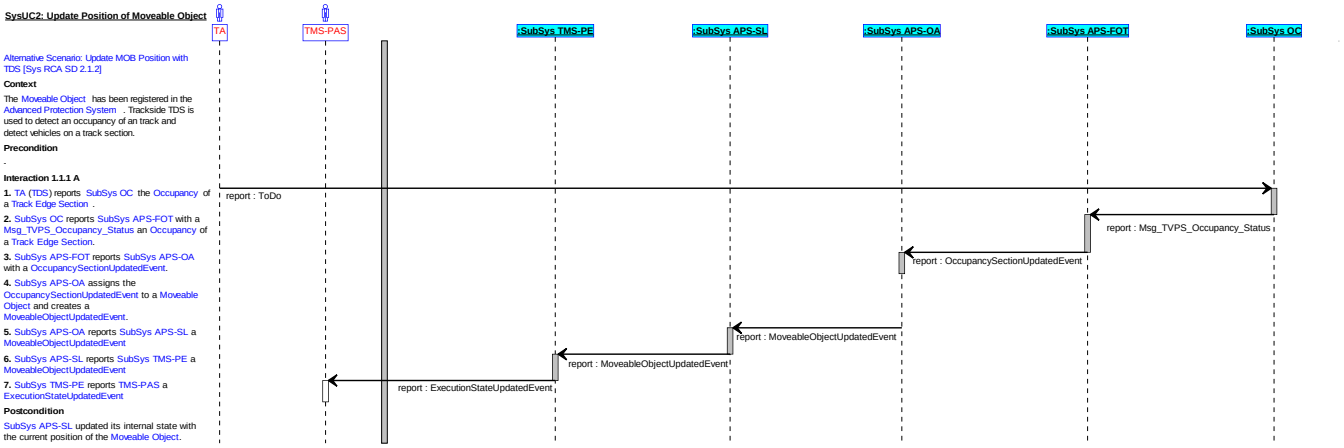


Figure 5 Alternative Scenario: Update MOB Position with TDS [Sys RCA SD 2.1.2]

2.4.2.3. *Alternative Scenario: Update MOB Position with Vehicle Locator [Sys RCA SD 2.1.3]*

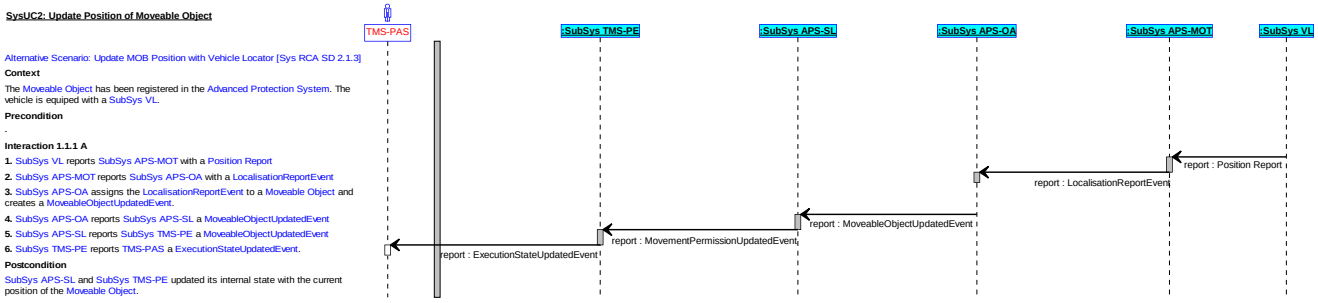


Figure 6 Alternative Scenario: Update MOB Position with Vehicle Locator [Sys RCA SD 2.1.3]

2.4.3. SysUC3: Manage Occupancy

Description: SysUC3: Manage Occupancy describes how Occupancys are created and removed.

2.4.3.1. Alternative Scenario: Create an Occupancy of a Track Section using TDS [Sys RCA SD 3.1.1]

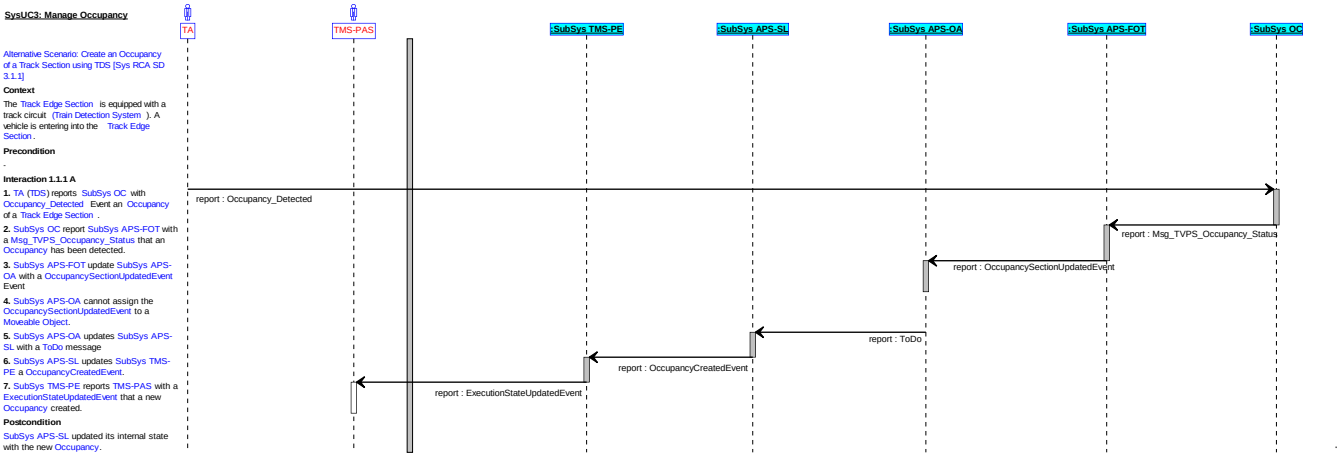


Figure 7 Alternative Scenario: Create an Occupancy of a Track Section using TDS [Sys RCA SD 3.1.1]

2.4.3.2. Alternative Scenario: Remove an Occupancy of a Track Section using TDS [Sys RCA SD 3.1.2]

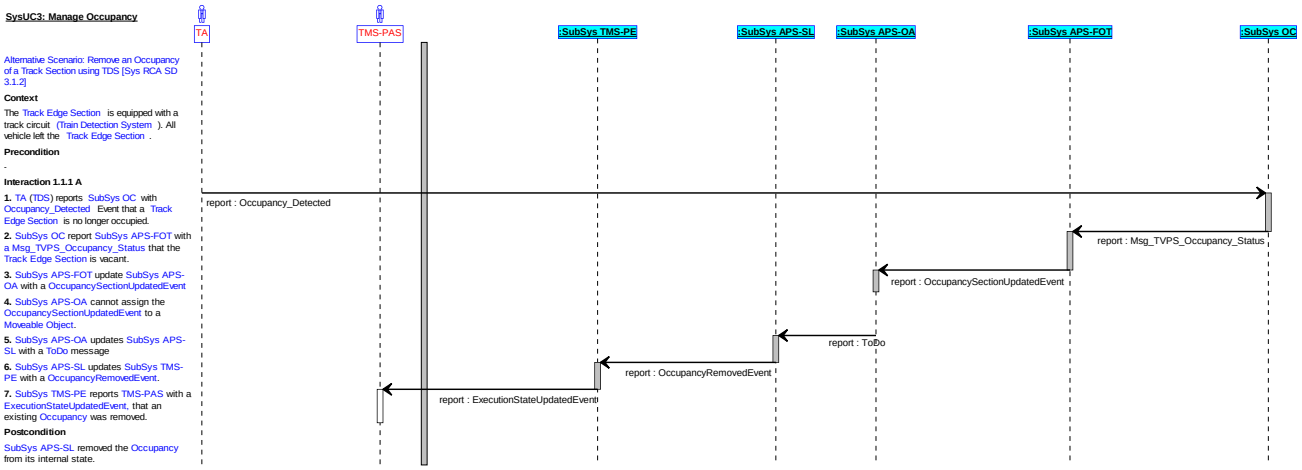


Figure 8 Alternative Scenario: Remove an Occupancy of a Track Section using TDS [Sys RCA SD 3.1.2]

2.4.4. SysUC4: Update Operational Plan

Description: SysUC4: Update Operational Plan describes the procedures if TMS-PAS is updating the Operational Plan.

2.4.4.1. Alternative Scenario: Update Operational Plan [Sys RCA SD 4.1.1]

SysUC4: Update Operational Plan

Alternative Scenario: Update Operational Plan [Sys RCA SD 4.1.1]

Context

As conditions for an update are given TMS-PAS recalculated an new Operational Plan.

Precondition:

The Operational Plan has already been implemented by SubSys TMS-PE

Interaction 1.1.1 A

1. TMS-PAS updates SubSys TMS-PE with a changed Operational Plan

2. SubSys TMS-PE checks impact of the Operational Plan changes.

alt [existing Movement Permission must be changed]

2.a1 SubSys TMS-PE inaugurates its systems <<include>> SysUC1: Execute Operational Plan

end alt

Postcondition:

The new Operational Plan has been implemented

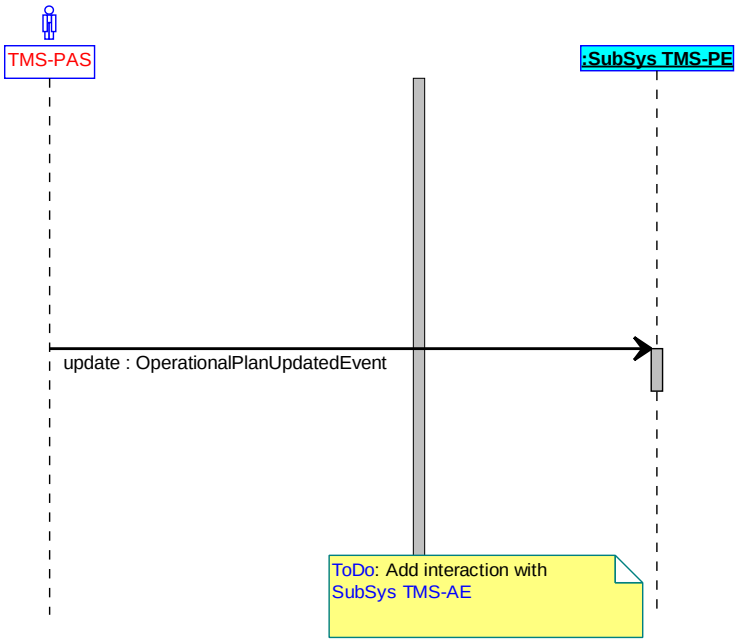


Figure 9 Alternative Scenario: Update Operational Plan [Sys RCA SD 4.1.1]

2.4.4.2. Alternative Scenario: Updated Operational Plan causes a rerouting [Sys RCA SD 4.1.2]

SysUC4: Update Operational Plan

Alternative Scenario: Updated Operational Plan causes a rerouting [Sys RCA SD 4.1.2]

Context

Due to a delay of an other train TMS-PAS recalculated an new Operational Plan. The new Operational Plan contains a new track route.

Precondition:

The Operational Plan has already been implemented by SubSys TMS-PE

Interaction 1.1.1 A

par

1.a1 TMS-PAS updates SubSys TMS-PE with a changed Operational Plan

1.a2 SubSys TMS-PE checks impact of the Operational Plan changes.

alt [existing Movement Permission must be changed]

2.a1 SubSys TMS-PE inaugurates its systems <<include>> SysUC1: Execute Operational Plan

end alt

also par

1.b1 TMS-PAS updates SubSys TMS-AE with a changed Operational Plan

1.b2 SubSys TMS-AE checks impact of the Operational Plan changes.

alt [existing Journey Profile must be changed]

2.b1 SubSys TMS-AE updates SubSys ATO-AT with an updated Journey Profile

2.b2 SubSys ATO-AT updates SubSys ATO-AV with an updated Journey Profile

2.b3 SubSys ATO-AV requests SubSys ATO-AT for a Segment Profile

2.b4 SubSys ATO-AT returns SubSys ATO-AV the Segment Profile

end alt

end par

Postcondition:

The new Operational Plan has been implemented

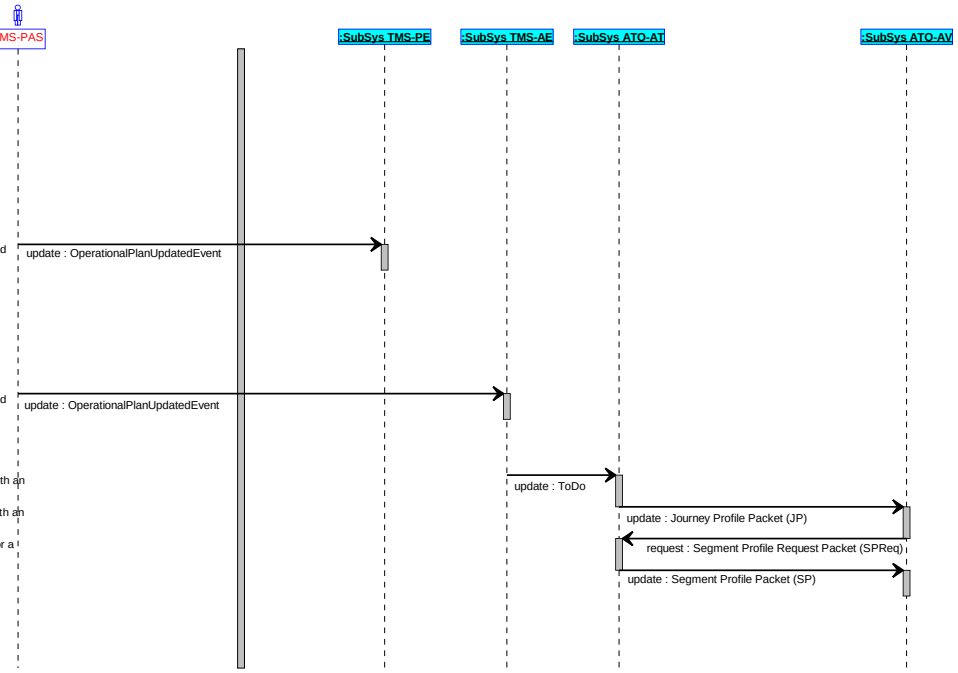


Figure 10 Alternative Scenario: Updated Operational Plan causes a rerouting [Sys RCA SD 4.1.2]

3. RISK ANALYSIS AND EVALUATION (PHASE 3)

Cenelec Phase 3 is not covered in this document

4. SYSTEM REQUIREMENTS (PHASE 4)

4.1. Logical Functions related to MovementPermission request

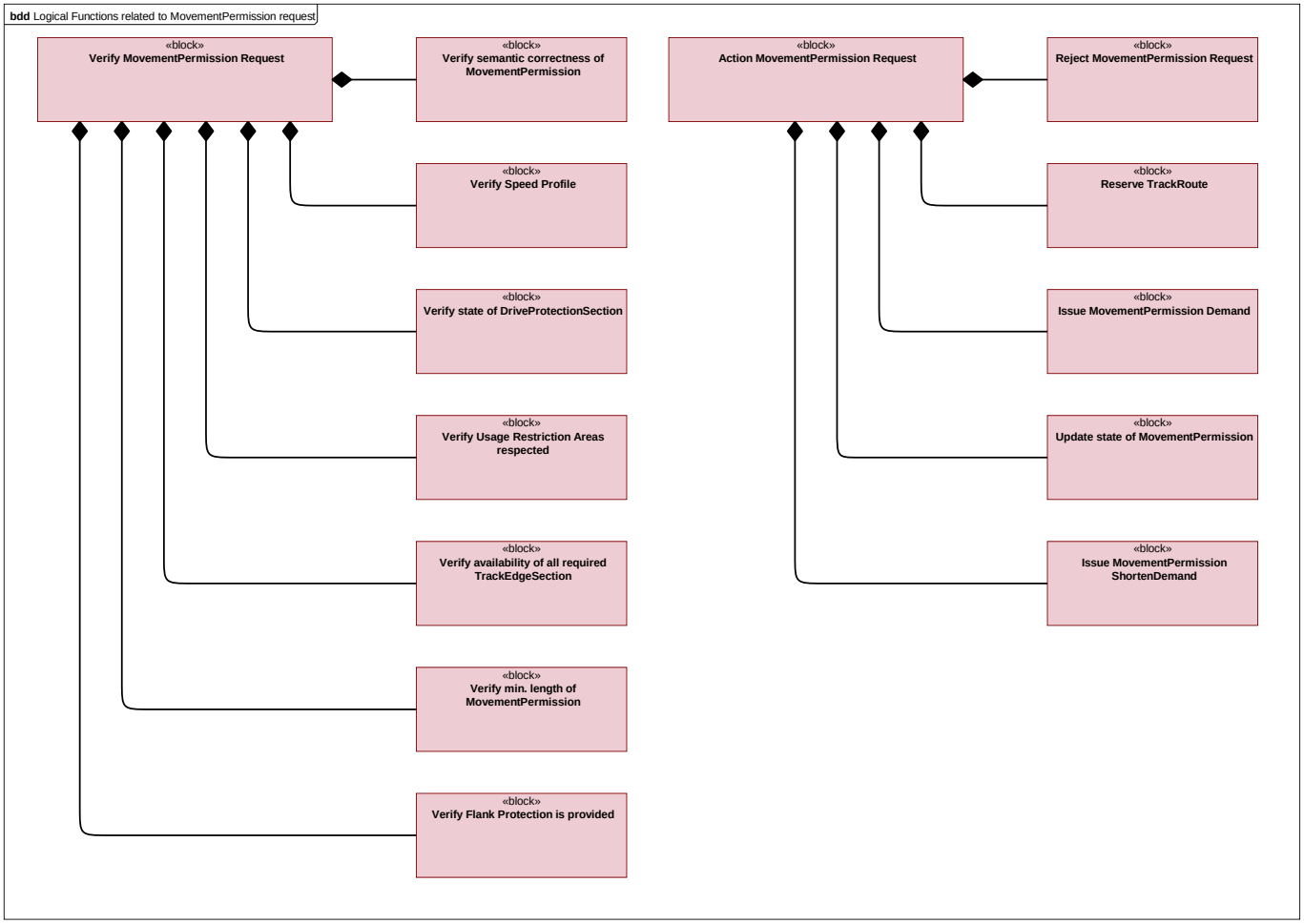


Figure 11 Logical Functions related to MovementPermission request

Description: This diagram show logical functions related to Movement Permission

4.2. Logical Functions related to Drive Protection Section request

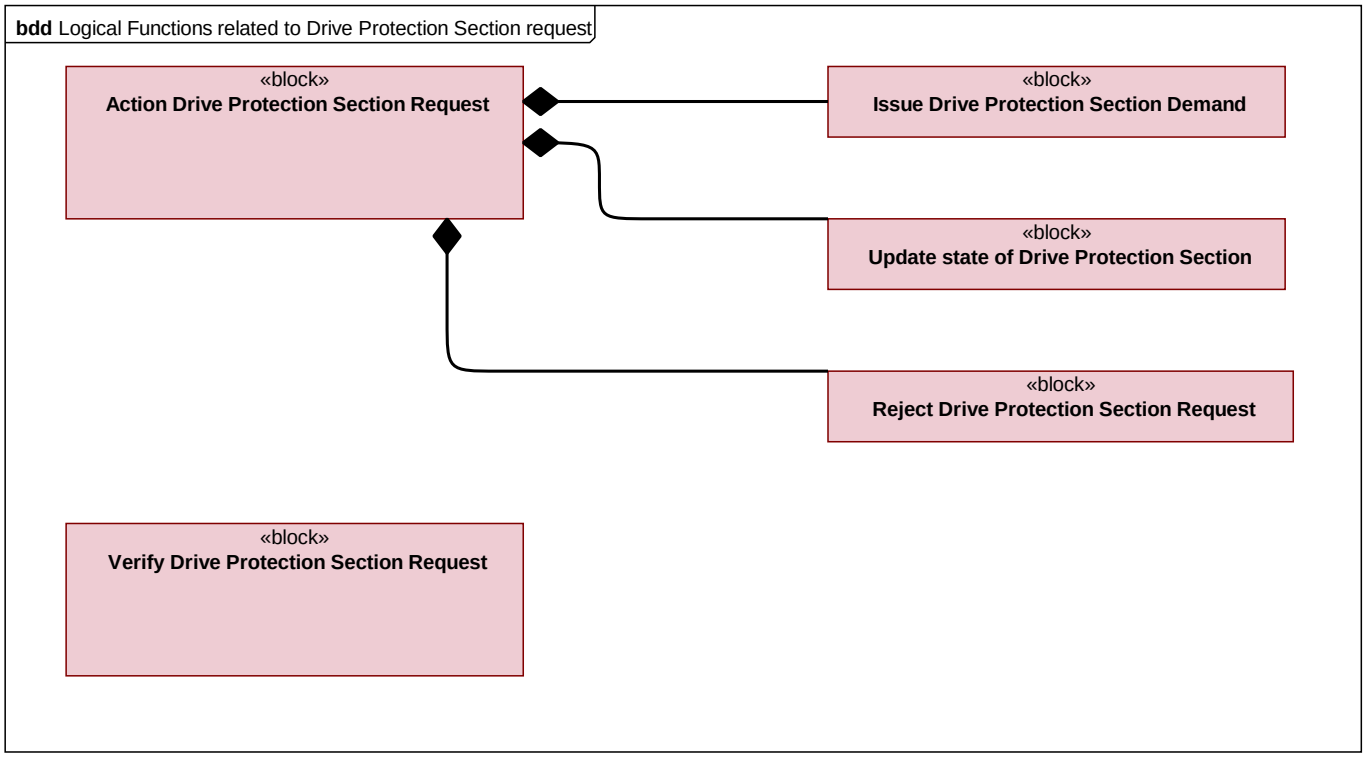


Figure 12 Logical Functions related to Drive Protection Section request

Description: This diagram shows the logical function related to Drive Protection Section

4.3. Logical Functions related to Emergency Situation

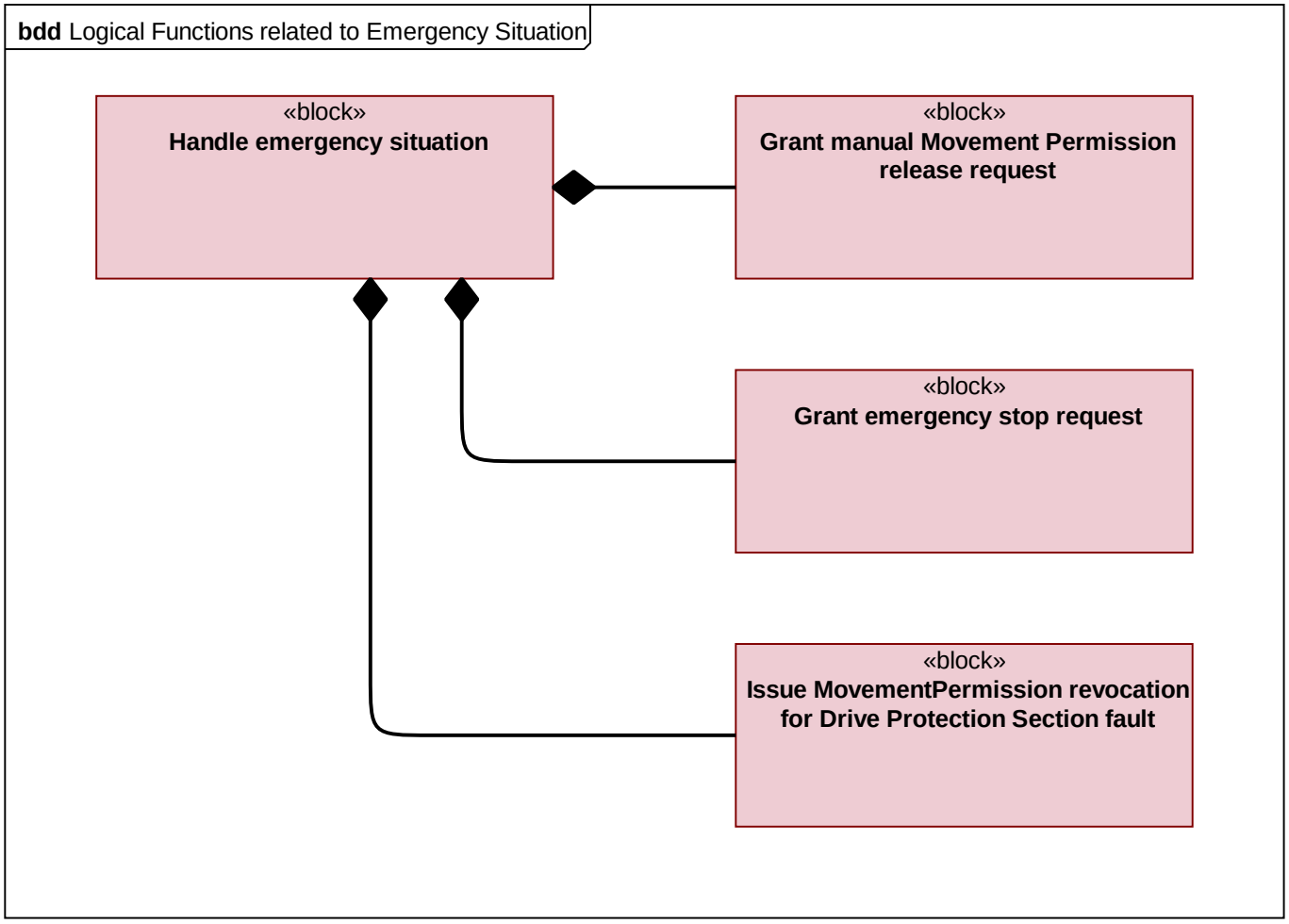


Figure 13 Logical Functions related to Emergency Situation

Description: This diagram shows logical functions related to safety situations.

4.4. Logical Functions related to Usage Restriction Area request

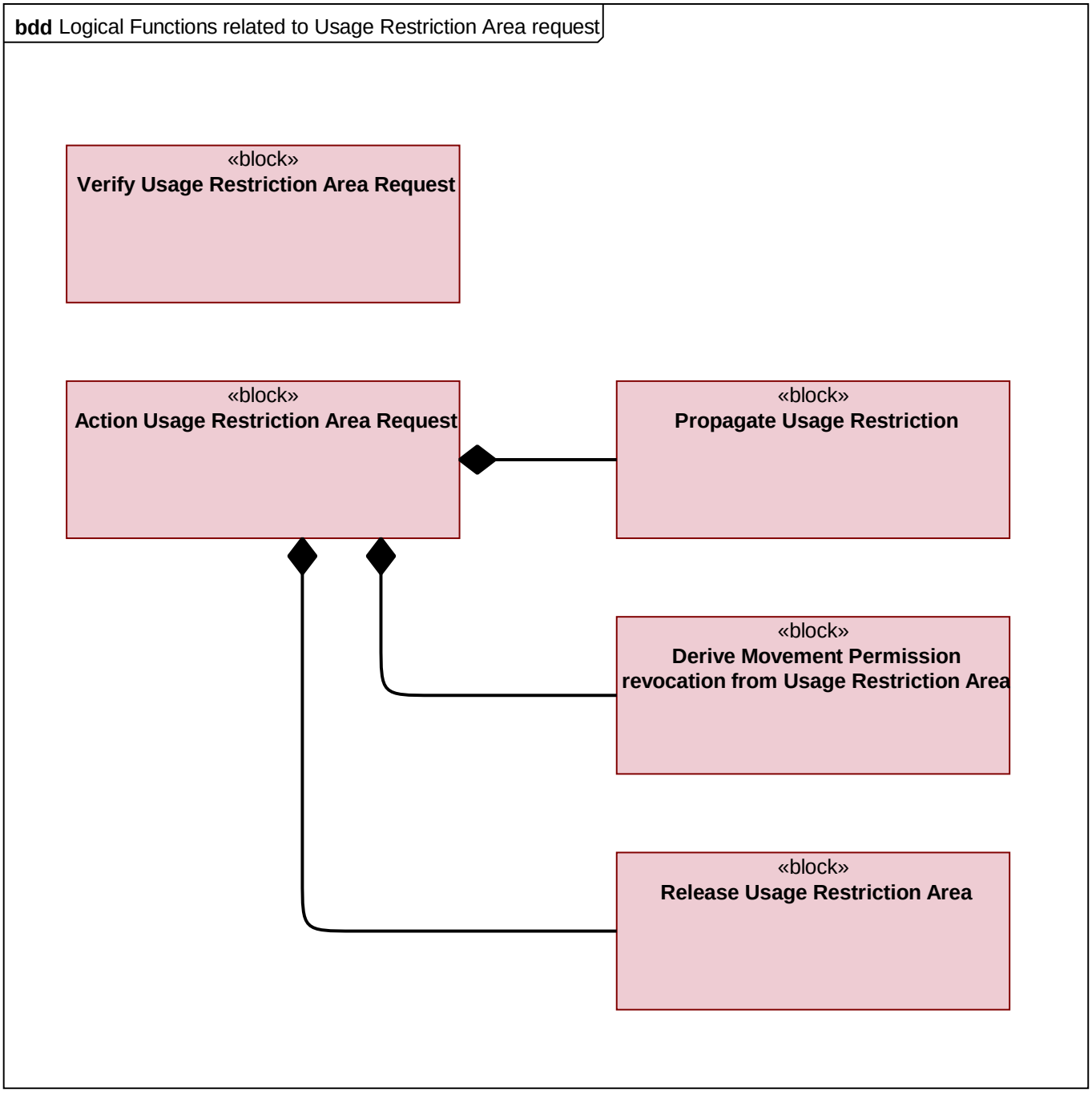


Figure 14 Logical Functions related to Usage Restriction Area request

Description: This diagram shows logical functions related to Usage Restriction Area

4.5. Logical Function Description

4.5.1. Action Drive Protection Section Request

Description: Implements a Drive Protection Section according to a request received.

4.5.2. Action MovementPermission Request

Description: Implements a Movement Permission according to a request received.

4.5.3. Action Usage Restriction Area Request

Description: Implements a Usage Restriction Area according to a request received.

4.5.4. Derive Movement Permission revocation from Usage Restriction Area

Description: Derives all Movement Permission that are affected by the Usage Restriction Area and issue the revocation of these Movement Permission.

4.5.5. Grant emergency stop request

Description: Handles an emergency stop.

4.5.6. Grant manual Movement Permission release request

Description: Allows releasing an implemented Movement Permission manually

4.5.7. Handle emergency situation

Description: Provides functions to handle emergency situations.

4.5.8. Handover Moveable Object to adjacent External Signaling System

Description: Function to hand over Moveable Object at the system border to adjacent ExternalSignalingSystem.

4.5.9. Issue Drive Protection Section Demand

Description: Sends a Drive Protection Section Demand to OA and observes its implementation

4.5.10. Issue MovementPermission Demand

Description: Sends a Movement Permission Demand to SubSys APS-OA and observes its implementation

4.5.11. Issue MovementPermission revocation for Drive Protection Section fault

Description: Issues a revocation of a Movement Permission because of a fault of a Drive Protection Section.

4.5.12. Issue MovementPermission ShortenDemand

Description: Sends a Movement Permission Shorten Demand to SubSys APS-OA and observes its implementation or handle its rejection. A rejection could happen, if the SubSys VS cannot guarantee, that the Moveable Object will stay within the shortened Movement Permission.

4.5.13. Propagate Usage Restriction

Description: Propagates the Usage Restriction Area that has been set and store the state of the Drive Protection Section according the request.

4.5.14. Reject Drive Protection Section Request

Description: Rejects the Drive Protection Section request because the verification of the safety rules for that request failed

4.5.15. Reject MovementPermission Request

Description: Rejects the Movement Permission request because the verification of the safety rules for that request failed

4.5.16. Release Usage Restriction Area

Description: Releases a Usage Restriction Area.

4.5.17. Reserve TrackRoute

Description: Reserve all Track Edge Sections and Drive Protection Sections along the path of the Movement Permission

4.5.18. Update state of Drive Protection Section

Description: Updates the altered state of the Drive Protection Section according the request

4.5.19. Update state of MovementPermission

Description: Updates the altered state of the Movement Permission according the request.

4.5.20. Verify availability of all required TrackEdgeSection

Description: Verify that all required Track Edge Sections of the Movement Permission are available.

4.5.21. Verify Drive Protection Section Request

Description: Does all verifications of safety rules before a Movement Permission can be implemented.

4.5.22. Verify Flank Protection is provided

Description: Verify that the Risk Path provided in the Movement Permission request ensures flank protection.

4.5.23. Verify length of MovementPermission

Description: Verify the length of the Movement Permission. The Moveable Object at the current position an its braking curve must be fully contained in the Movement Permission.

4.5.24. Verify min. length of MovementPermission

Description: Verify that the Movement Permission surrounds the Moveable Object, the stopping distance and the needed Risk Buffer (LoA or EoA&SvL) to operate safely.

4.5.25. Verify MovementPermission Request

Description: Does all verifications of safety rules before a Drive Protection Section can be implemented

4.5.26. Verify semantic correctness of MovementPermission

Description: Verifiy that the requested Movement Permission is semantically correct.

4.5.27. Verify Speed Profile

Description: Verify speed limits along path of the Movement Permission are correct

4.5.28. Verify state of DriveProtectionSection

Description: Verify that all Drive Protection Section needed within the Movement Permission are in the correct state.

4.5.29. Verify that Movement Authority is issued

Description: Checks the successful propagation of the Movement Authority to the vehicle.

4.5.30. Verify Usage Restriction Area Request

Description: Does all verifications of safety rules before a Usage Restriction Area can be implemented

4.5.31. Verify Usage Restriction Areas respected

Description: Verify affected Usage Restriction Area are respected (e.g. reduced speed limits)

5. SUBSYSTEM ARCHITECTURE (PHASE 5)

The logical architecture is a white box view. It defines the structure of Sys RCA. Note that the current version of this interface specification covers ATO GoA 2, but it is not yet complete with respect to ATO GoA 3/4.

Design Rationales: The functions for executing Operational Plans is devided in two separate components: SubSys TMS-PE and SubSys TMS-AE. The reason for this designis modularity and scalability to different needs (see RCA Architecture Overview, section 5.1).

Caption:

- Block red: SubSystem in scope of RCA. Subsystem and its interfaces will be fully specified by RCA

- Block gray: SubSystem in scope of RCA. Subsystem and its interfaces has been specified by another authority and as-defined used in RCA.

5.1. System RCA SR - Logical Architecture DCM Interfaces [SysRCA SR IBD 3]

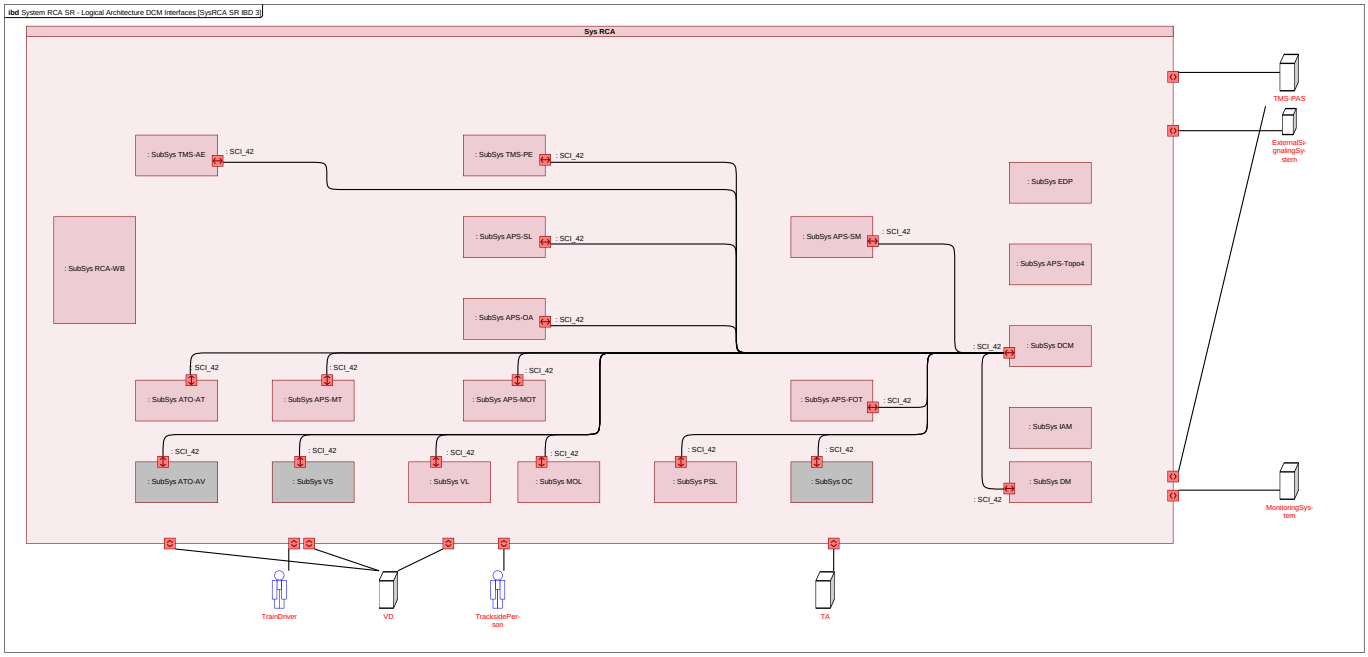


Figure 15 System RCA SR - Logical Architecture DCM Interfaces [SysRCA SR IBD 3]

Description: System RCA SR - Logical Architecture DCM Interfaces [SysRCA SR IBD 3] shows device and configuration management interfaces in the logical architecture of Sys RCA.

5.2. System RCA SR - Logical Architecture Diagnostic Monitoring Interfaces [SysRCA SR IBD 4]

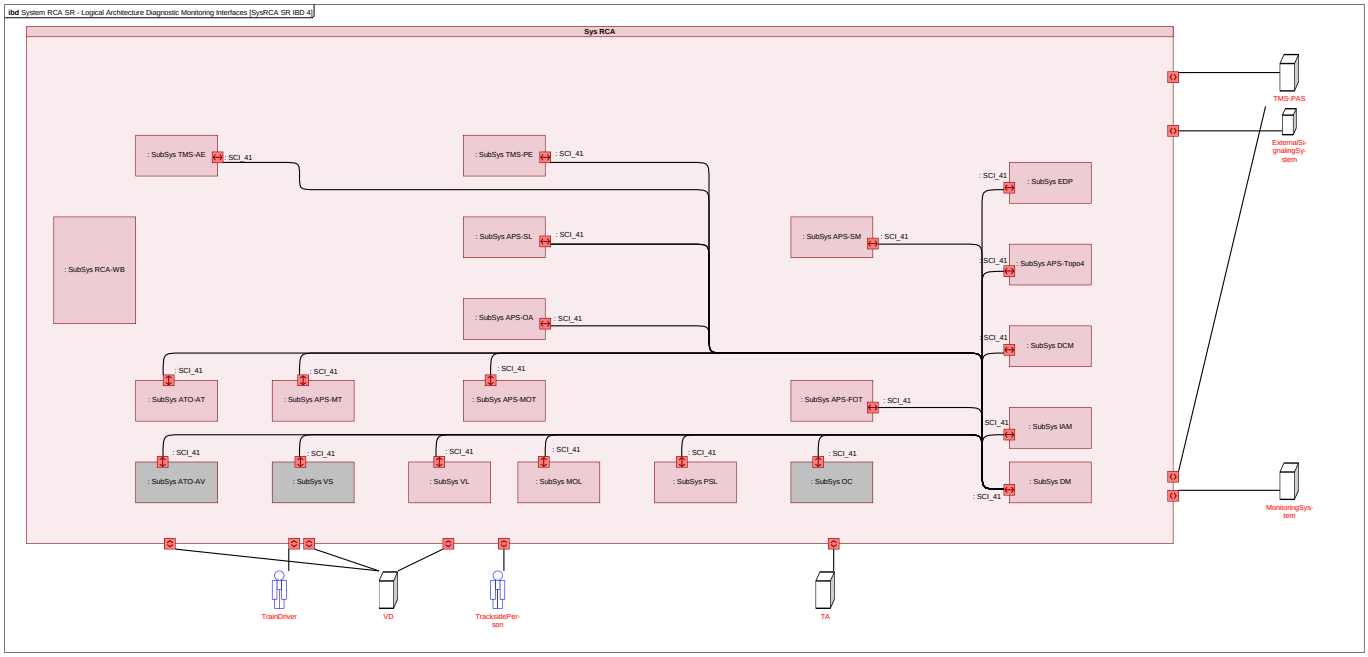


Figure 16 System RCA SR - Logical Architecture Diagnostic Monitoring Interfaces [SysRCA SR IBD 4]

Description: System RCA SR - Logical Architecture Diagnostic Monitoring Interfaces [SysRCA SR IBD 4] shows diagrnotic and monitoring interfaces in the logical architecture of Sys RCA.

5.3. System RCA SR - Logical Architecture Functional Interfaces [SysRCA SR IBD 1]

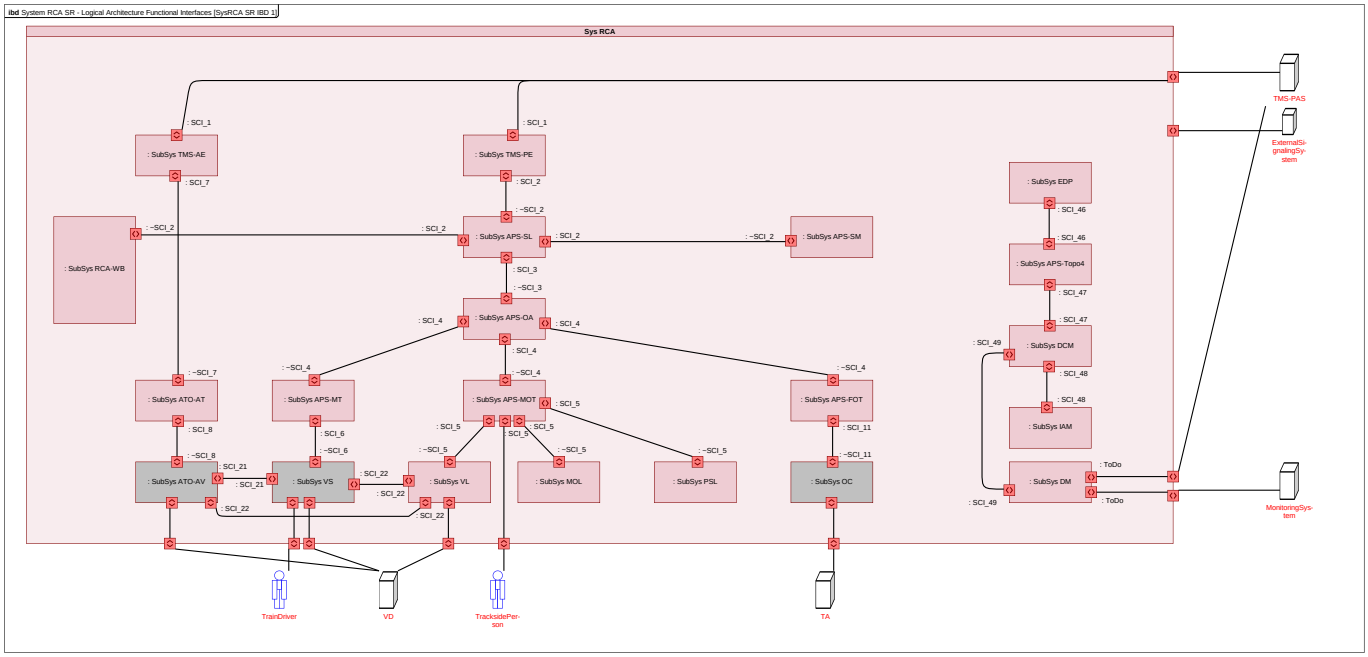


Figure 17 System RCA SR - Logical Architecture Functional Interfaces [SysRCA SR IBD 1]

Description: System RCA SR - Logical Architecture Functional Interfaces [SysRCA SR IBD 1] shows the functional interfaces in the logical architecture of Sys RCA.

5.4. System RCA SR - Logical Architecture Handover and Legacy Interfaces [SysRCA SR IBD 6]

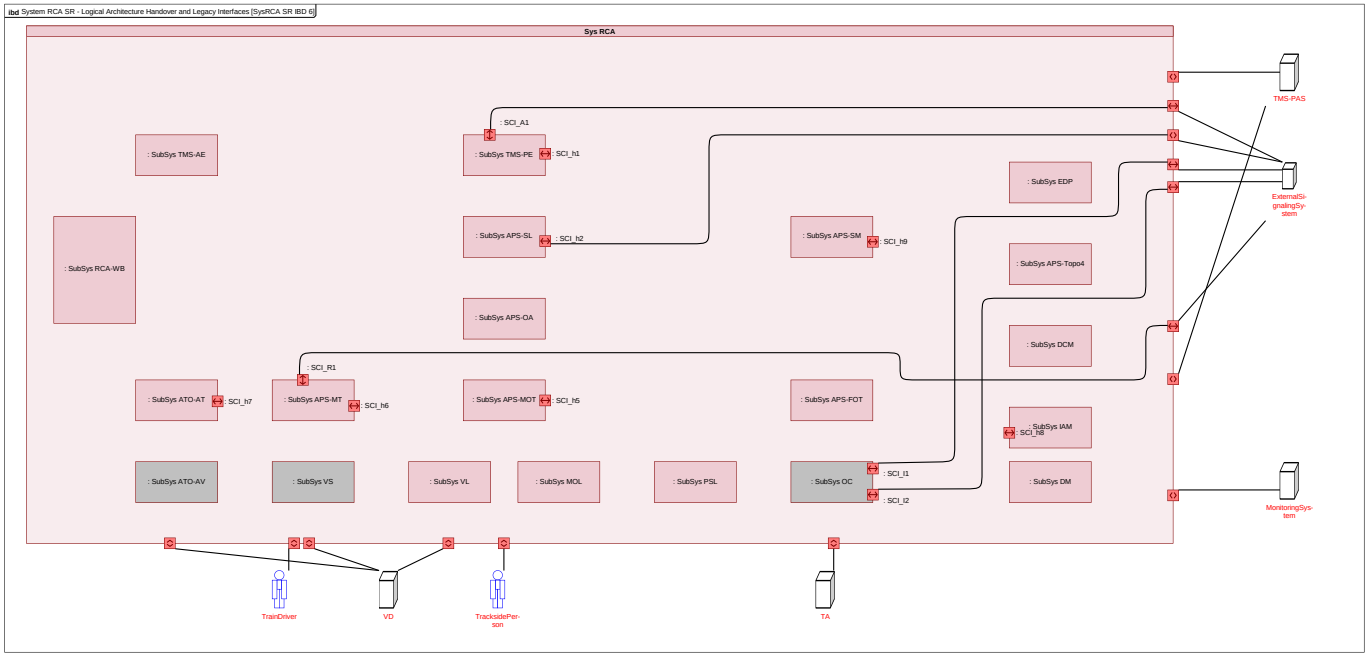


Figure 18 System RCA SR - Logical Architecture Handover and Legacy Interfaces [SysRCA SR IBD 6]

Description: System RCA SR - Logical Architecture Handover and Legacy Interfaces [SysRCA SR IBD 6] shows handover and legacy interfaces in the logical architecture of Sys RCA.

5.5. System RCA SR - Logical Architecture IAM Interfaces [SysRCA SR IBD 5]

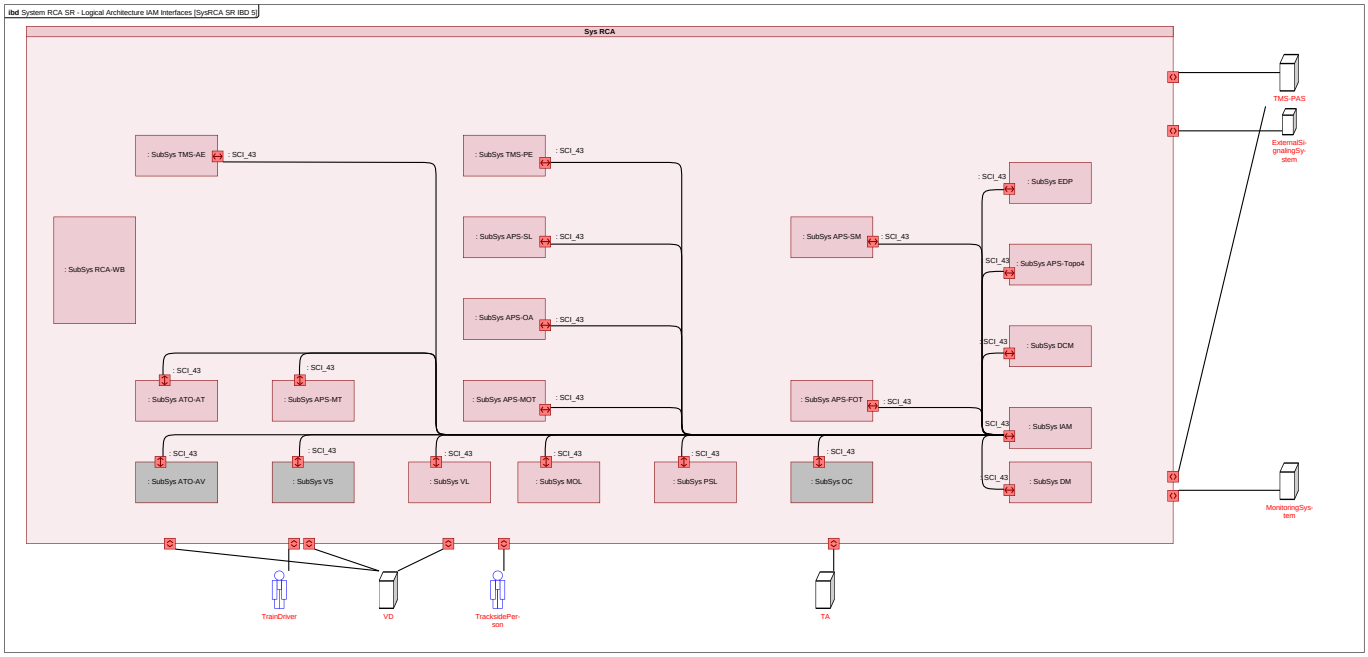


Figure 19 System RCA SR - Logical Architecture IAM Interfaces [SysRCA SR IBD 5]

Description: System RCA SR - Logical Architecture IAM Interfaces [SysRCA SR IBD 5] shows teh identity and access management interfaces in the logical architecture of Sys RCA.

5.6. System RCA SR - Logical Architecture Workbench Interfaces [SysRCA SR IBD 2]

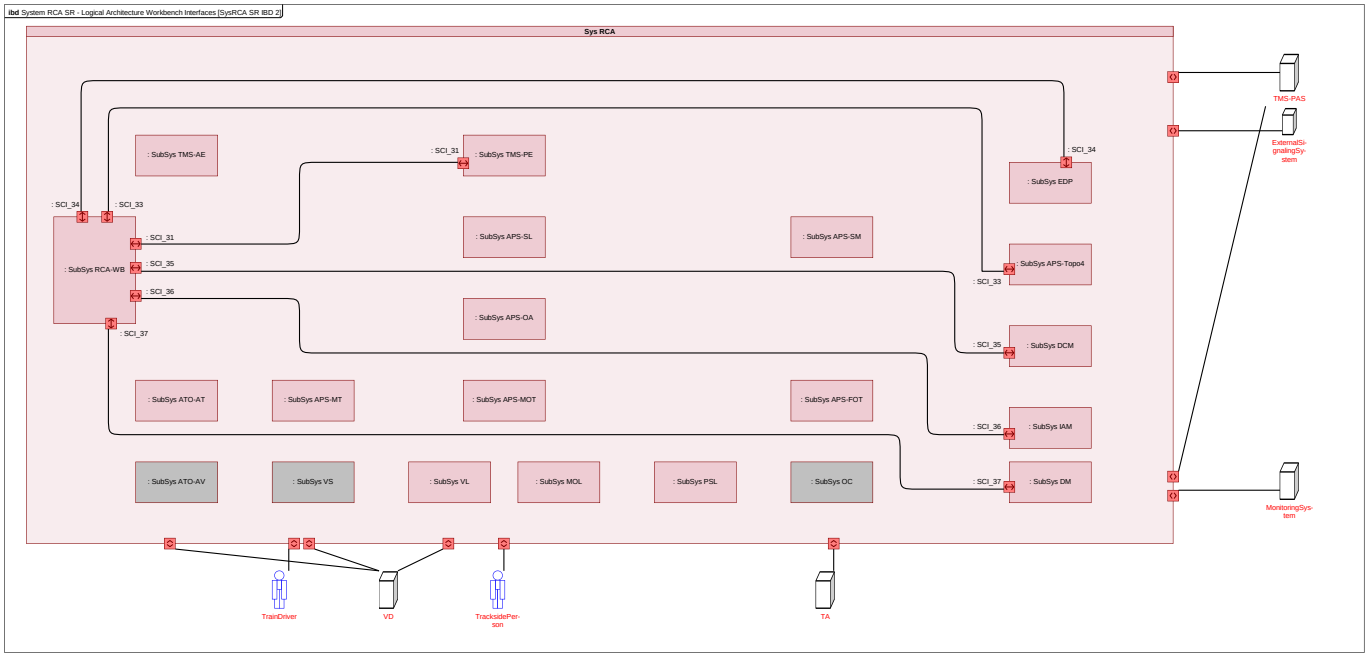


Figure 20 System RCA SR - Logical Architecture Workbench Interfaces [SysRCA SR IBD 2]

Description: System RCA SR - Logical Architecture Workbench Interfaces [SysRCA SR IBD 2] shows the workbench interface in the logical architecture of Sys RCA.

5.7. Subsystems

Description: Sys RCA represents the system specified in this document. Sys RCA is composed of several subsystems.

5.7.1. SubSys APS-MT

Description: SubSys APS-MT communicates with SubSys VS using the ETCS communication protocol (SUBSET 026). Among others it translates the movement permissions to ETCS Movement Authoritys and send them to the SubSys VS. In the other direction it will receive the train position reports, train data, etc. from the SubSys VS and forward them to SubSys APS-OA. Only radio-based ETCS is supported.

Source: RCA Alpha.1 (description has been modified)

5.7.2. SubSys APS-OA

Description: The SubSys APS-OA combines the information received from one or multiple Devices to one consolidated Object representation and provides that to SubSys APS-SL. That consolidated Object representation contains the state of the Moveable Object like position and extent (length) as well as the state of the TA. In the other communication direction, it dispatches information from the SubSys APS-SL to one or several transactors (SubSys APS-MT, SubSys APS-MOT or SubSys APS-FOT). This information includes the Movement Permission, the state request for the TA and warning messages for TracksidePersons and TrainDriver. Aggregation rules are configurable and have an isolated homologation. The SubSys APS-OA function therefore is a rule-interpreter together with a set of rules. The SubSys APS-OA "collects" Device information for an Object, that does not need to arrive at the same time. The rules shall describe the correct reaction on timing hazards.

Source: RCA Alpha.1 (Description has been modified)

5.7.3. SubSys APS-SL

Description: SubSys APS-SL decides, if a SubSys TMS-PE request is granted or rejected depending on the evaluated risk (rule-based). The request can ask for a state change of a TA, the creation / modification / removal of a Movement Permission or set / unset a Usage Restriction Area. For the decision, SubSys APS-SL is maintaining of a complete and up-to-date representation of the TA, the Movement Permissions, the position of Moveable Objects, the current Usage Restriction Areas and the Topology data.

Source: RCA Alpha.1 (Description has been modified)

5.7.4. SubSys APS-SM

Description: SubSys APS-SM continuously monitors the state of the system maintained in SubSys APS-SL, such that it can recognize patterns that are identifying hazardous situations. It

will trigger one or several reactions (e.g. emergency stop of a Moveable Object, reduction of the speed, extend Movement Permission) to prevent or minimize the danger. In addition, it also recognizes situations that require the warning of a Moveable Object (e.g. TracksidePerson). Danger pattern recognition, danger patterns as well as emergency reactions are configurable.

Source: RCA Alpha.1

5.7.5. SubSys VS

Description: SubSys VS is based on existing ETCS on-board with some change requests (CR). Necessary changes will rely on established CR processes. The SubSys VS displays to the TrainDriver (if existing) the current Movement Authority by using cab signaling. It also supervises the speed and ensures, that the train does not violate its Movement Authority. Further it will send the current position as a Train Position Report to the SubSys APS-MT. This supervision has the following functional aspects (which can be combined or used partially):

- ETCS: Functions of ETCS cab signaling as defined today with necessary adaptions e.g. for FRMCS / multi carrier communication, ATO interfaces, full moving block and mixed localization configurations
- "Full supervised shunting": Supervision with efficient management of low speed movements with less train information (just track occupation), multiple moves in different directions, and some local safety responsibilities
- "Supervision in degraded modes": Fallback functionality that allows to stay operable on a high level in degraded modes
- "AMS: Autonomous movement supervision": Diversely implemented fallback functionality that provides a basic safety with the minimal use of other functions (e.g. only train2train coordination and direct access to OC or TA). AMS could also be a completely isolated function.

For simplicity, the 4 functions have been described together. According to the decomposition principles of RCA, the 3 functions could be 3 independent subsystems.

Source: RCA Alpha.1 (Description has been modified)

5.7.6. SubSys TMS-PE

Description: The SubSys TMS-PE generates the requests to the SubSys APS-SL at the right point in time to execute the Operational Plan. According to the progress, it reports the execution status of the Operational Plan back to SubSys TMS-PE. The execution status describes the parts of the plan that are already executed and the parts of the plan that are allocated (e.g. when Movement Permission is already set). Near-time optimization is done in the TMS-PAS. Includes all traditional (non-safe) functions of interlockings and control systems, that are shifted out of APS (like Flank Protection) to SubSys TMS-PE. APS still ensures, that safety rules are applied (e.g. that Flank Protections are implemented).

Source: RCA Alpha.1 (Description has been modified)

5.7.7. SubSys TMS-AE

Description: SubSys TMS-AE controls and observes the execution of Operational Plans on the ATO side. SubSys TMS-AE translates Operational Plans into a into commands that are executable by SubSys ATO-AV and adds necessary Topology informations, so that SubSys ATO-AV is able to drive autonomously according the Operational Plan. SubSys TMS-AE processes a given Operational Plan early enough in time, so that SubSys ATO-AV has sufficient

time to prepare the train according the command received. SubSys TMS-AE receives reports from SubSys ATO-AV about the status of the execution of the commands and the status of train. With these informations SubSys TMS-AE provides the status of the execution of the Operational Plan.

5.7.8. SubSys APS-MOT

Description: SubSys APS-MOT manages the different kinds of Devices, namely SubSys VL, SubSys MOL and SubSys PSL, that are locatable and optionally can be warned. It provides information to those Devices, which they need to localize themselves.The SubSys APS-MOT processes the received localization information such that it can be forwarded to the SubSys APS-OA. It also forwards warning information to SubSys MOL and SubSys PSL.

Source: RCA Alpha.1 (Description has been modified)

5.7.9. SubSys APS-FOT

Description: SubSys APS-FOT communicates with all the relevant SubSys OC. It translates the abstract commands of the SubSys APS-OA to asset specific commands when fitting to its own capabilities. In the other direction, it translates the asset specific status of the SubSys OC to an abstract status for the Subsystem APS-OA along the trackside asset's capabilities.

Source: RCA Alpha.1

5.7.10. SubSys OC

Description: SubSys OC monitors and controls one or multiple TA. The SubSys OC can be either in the interlocking room or in the field directly at the TA. For each type of TA there is a type of SubSys OC. The SubSys OC specifications are made by EULYNX.

Source: RCA Alpha.1 (Description has been modified)

5.7.11. SubSys MOL

Description: SubSys MOL sends its current location to the SubSys APS-MOT. If attached to a physical object, it can be used to locate any type of object on or near of the track. Can be used for multiple use cases like tagging an obstacle, a crane, a train end, a wagon or coach, a door that swings on the track, a person, etc

Source: RCA Alpha.1 (Description has been modified)

5.7.12. SubSys PSL

Description: SubSys PSL can either be set up to block tracks or to warn or authorize the person or a group of persons (different forms of implementation / hardware solutions) in accordance with configurable parameters if another Moveable Object / vehicle approaches. SubSys PSL can be a tag, a TracksidePerson safety system or an app on a tablet that interacts with the person. A SubSys PSL integrates typically a SubSys MOL function.

Source: RCA Alpha.1 (Description has been modified)

5.7.13. SubSys VL

Description: SubSys VL uses mobile localization technology to safely and reliably provide position and speed information of the train. It may emulate a location balise to the ETCS functions. In addition, it provides the actual position to the VD and over a direct interface to the SubSys APS-MOT. The SubSys VL sends the full virtual track occupation of the train or only a part of it (only the front or rear position). This implies a new equipment requirement for vehicles. For safe length different options are possible (train integrity or second localization unit at the other end).

Source: RCA Alpha. (Description has been modified)

5.7.14. SubSys ATO-AT

Description: SubSys ATO-AT manages the communication with all registered ATO vehicles. It maintains existing connections or establishes new connections to SubSys ATO-AV. If necessary SubSys ATO-AT wakes up an SubSys ATO-AV. SubSys ATO-AT receives executable commands from SubSys TMS-AE, generates a Journey Profile and Segment Profiles and sends them to the related SubSys ATO-AV. SubSys ATO-AT provides status reports coming from SubSys ATO-AV with SubSys TMS-AE.

Design Rationales: Due to memory limitations of SubSys ATO-AV and to save bandwidth, SubSys ATO-AT sends only a part of the Journey Profile and Segment Profile that will be needed by the SubSys ATO-AV soon in time. As consequence SubSys ATO-AT caches Journey Profiles and Segment Profiles received from SubSys TMS-AE. SubSys ATO-AV may request further parts of Journey Profile and Segment Profiles.

5.7.15. SubSys ATO-AV

Description: The SubSys ATO-AV operates the vehicle automatically and optimizes the speed such that it reaches given points at a given time as received from the SubSys ATO-AT. SubSys ATO-AV has no safety function. To ensure safety it is supervised by SubSys VS.

Source: RCA Alpha.1 (Description has been modified)

Design Rationales: In order to minimize bandwidth usage for transmitting data between SubSys ATO-AT and SubSys ATO-AV, SubSys ATO-AV may cache Segment Profiles (Topology data). It will request only Segment Profiles that are not known by SubSys ATO-AV.

5.7.16. SubSys RCA-WB

Description: SubSys RCA-WB isolates the functional logic and user processes. Its function is to present a process specific frontend to different types of user roles that can even change in certain events. User interface elements are registered to WB statically and dynamically depending on the actual registered functions and devices. The user process management of the SubSys RCA-WB invokes different sets of user interface elements depending on the process situation. User interface elements and SubSys RCA-WB are functions that optimize the input and output efficiency as much as possible and that offer collaborative frontend functions as well

as synchronized input and output on multiple device. SubSys RCA-WB can handle safe and unsafe user interface elements.

Source: RCA Alpha.1

5.7.17. SubSys EDP

Description: SubSys EDP provides the configuration data for the ToDo: APS and SubSys APS-MOT. It highly automates the process of capturing and validating the data.

Source: RCA Beta.1

5.7.18. SubSys APS-Topo4

Description: SubSys APS-Topo4 provides correct Topology and Topology data for SIL4 systems by combining information from different sources, which also includes the acquisition of data by mobile measurement devices in the field. Note: additional (non-safe) Topology data may be needed in the TMS-PAS, SubSys TMS-AE and SubSys TMS-PE. The architecture allows an export of the safe data to be used in other systems, but the non-safe Topology systems are out-of-scope for RCA.

Source: RCA Beta.1

5.7.19. SubSys DCM

Description: SubSys DCM is used to register, setup,and manipulate Devices. This includes updating the configuration data and the software version. Safety criticality: SubSys DCM is safety critical in so far, that part of the configuration is safety critical. Not the whole SubSys DCM needs to be on highest Safety Integrity Levels.

Source: RCA Beta.1

5.7.20. SubSys DM

Description: SubSys DM collects monitoring and diagnostics informations from all systems such as central systems, trackside assets or the vehicles. The information is on one side used to derive capacity limitation and an estimated duration of the capacity limitation that is used in TMS-PAS to reschedule Operational Plans. On the other side the information is forwarded to a monitoring system of the IM, which triggers the corrective maintenance actions.

Source: RCA Beta.1

5.7.21. SubSys IAM

Description: The Identity & Access Management authenticates and authorizes users and technical systems and grants or denies access to the system. Therefore, it will need to store the credentials to authenticate the entities. Supports the implementation of an ISO27001/IEC 62443 compatible architecture.

Source: RCA Beta.1

5.8. RCA Interfaces

5.8.1. SCI_6

Description: SCI_6 is the existing ERTMS interface (ETCS trackside-ETCS OBU) with additional functions that are necessary for the RCA. Needed change requests will be handled using established CR processes. An example for such a CR would be inclusion of more train data from the vehicle “upwards” e.g. the current brake capabilities (for lambda and gamma trains).

Candidate interface definition: ERTMS SUBSET-026 System Requirements Specification, ongoing work at S2R, EUG, UIC.

Source: RCA Beta.1

5.8.2. SCI_5

Description: SCI_5 is used to communicate with the (safe) mobile devices. It includes the following information:

- Management of the Device

- Provides information to the Device, which it needs to localize itself.

- Position of the Device

- Requests to warn the Moveable Object

Source: RCA Beta.1

5.8.3. SCI_3

Description: Interface between an SubSys APS-SL and the outsideworld that it controls. It includes the following information:

Downstream:

- Requests the required allocation state of the elements in a route (e.g. TA)

- Grant Movement Permission to the Moveable Object.

- Warn Moveable Object (e.g. TracksidePerson)

Upstream:

- Provides the current allocation state (updates) of the elements in a route (e.g. TA).

- Provides the position and the extent (length) of all the Moveable Object.

Source: RCA Beta.1

5.8.4. SCI_2

Description: SCI_2 allows that the non-safety critical block requests state changes from the SubSys APS-SL and monitors the SubSys APS-SL. It includes the following main information:

Downstream:

- Request required allocation state of the elements in a route (e.g. TA)

- Request Movement Permission for a Moveable Object

. Request Usage Restriction Area

- Request Warning

Upstream:

- Provides the current allocation state (updates) of the elements (e.g. TA)

- Provides the state of the Moveable Object, position,and extent

- Provides Usage Restriction Area

- Updates about actions taken by SubSys APS-SM

Candidate interface definition: Adaption of EULYNX SCI-CC.

Source: RCA Beta.1

5.8.5. SCI_1

Description: SCI_1 provides the operation plan from the planning part to the control part and gives the current execution statusback to the planning level. It includes the following information:

Downstream:

- The current version of the operation plan for each planned capacity object includes:

  - In the case of a capacity reservation (Train Run, Shunting Movement, Stabling):

  - The track-precise path defined for the capacity reservation

  - The order in which the different capacity reservations are allowed to use each track

  - Time constraints for departure, arrival or passthrough at cer-tain points in the track network.

  - Relations between capacity reservation for interconnections, usage of vehicles and personnel.

  - The optimized speed profile

- In the case of a planned Capacity Limitation (e.g. planned maintenance work)

  - The affected area on the topology

  - The start and end time of the limitation.

  - Details about the limitation like allowed speed.

  - The order relative to the track usage of the Capacity Reservation, such that a capacity limitation is not activated before the preceding Capacity Reservation have used the track.

Upstream:

- The execution status for each capacity object. The status is not only provided for the Capacity Object planned in the Operation Plan but also for unplanned Capacity Object (e.g. unavailable track due to a failure).

- This includes updates about actions taken by SubSys APS-SM.

Source: RCA Beta.1

5.8.6. SCI_4

Description: Thisinterface is a single device-oriented interface, which can provide or consume only part of the control or monitor information. It includes the following information:

Downstream:

- Requests the required allocation state of the elements in aroute (e.g. TA)

- Grant Movement Permissions directly to the Moveable Object or indirectly via a trackside signal.

- Warn a Moveable Object (e.g. TracksidePerson)

Upstream:

- Provides the current allocation state (updates) ofthe elements in a route (e.g. TA).

- Provides information about the position and extent (length) of a Moveable Object. The information can already be assigned to a Moveable Object or be just location based without an assignment to a Moveable Object (e.g. Occupancy).

Source: RCA Beta.1

5.8.7. SCI_11

Description: SCI_11 connects the Advanced Protection System to the different types of TA by using an SubSys OC according to EULYNX specifications.

Source: RCA Beta.1

5.8.8. SCI_External

Description: ToDo: Temporary solution

5.8.9. SCI_h2

Description: The SubSys APS-SL handover interface is used to pass a Moveable Object from one SubSys APS-SL to the next(adjacent SubSys APS-SL). Therefore, it must be possible to request a Movement Permission that start in one instance of SubSys APS-SL and ends in another SubSys APS-SL. The two instances can be from two different IMs or the same.

Candidate interface definition: Basis EULYNX SCI-ILS.

Source: RCA Beta.1

5.8.10. SCI_8

Description: This interface connects the SubSys ATO-AT to the SubSys ATO-AV function, that controls the vehicle Device.

Candidate interface definition: ATO over ETCS SUBSET-126 ATO-OB / ATO-TS Interface Specification.

Source: RCA Beta.1

5.8.11. SCI_46

Description: SCI_46 is used to provide the needed acquisition of data to SubSys APS-Topo4 and to return the validated data back to SubSys APS-Topo4.

Source: RCA Beta.1

5.8.12. SCI_47

Description: SCI_47 is used to synchronize the device references.

Source: RCA Beta.1

5.8.13. SCI_48

Description: SCI_48 is used to synchronize Device capability rights.

Source: RCA Beta.1

5.8.14. SCI_22

Description: The Vehicle Localization Interface is an interface to forward the localization information computed by SubSys VL to SubSys VS and SubSys ATO-AV. It transports: position, speed and acceleration with confidence intervals.

Source: RCA Beta.1

5.8.15. SCI_21

Description: The SCI_21 is used between the two Device controllers SubSys ATO-AV and SubSys VS to coordinate their parallel vehicle control. It includes the following information transfers: ATO Status ("AD Mode request", "ATO Engaged"), ETCS Train Data, Dynamic ETCS Data (e.g. "EB is requested", "Positioning Information", "MA Information", "Speed Information"), ETCS supervision information.

Candidate interface definition: ERTMS SUBSET-130.

Source: RCA Beta.1

5.8.16. SCI_49

Description: SCI_49 is used to synchronize the Device status.

Source: RCA Beta.1

5.8.17. SCI_h1

Description: The SubSys TMS-PE handover interface is used between two SubSys TMS-PE to exchange information about each other's areas and to pass a Moveable Object from one region to the next.

Source: RCA Beta.1

5.8.18. SCI_h5

Description: The SubSys APS-MOT handover interface is used to pass a Mobile Object from one SubSys APS-MOT to the next.

Source: RCA Beta.1

5.8.19. SCI_h6

Description: The SubSys APS-MT handover interface is mainly the ERTMS interface to hand over a vehicle from one SubSys APS-MT to the next SubSys APS-MT.

Candidate interface definition: ERTMS SUBSET-039 FIS for the RBC/RBC Handover; ERTMS SUBSET-98/129/26 RBC-RBC Safe Communication Interface.

Source: RCA Beta.1

5.8.20. SCI_h8

Description: The SubSys IAM-SubSys IAM interface allows to find out the communication parameters for RCA components (like SubSys APS-Topo4 or SubSys DCM) in other networks.

Source: RCA Beta.1

5.8.21. SCI_A1

Description: The SubSys TMS-PE legacy interface allows to coordinate the SubSys TMS-PE with a legacy SubSys TMS-PE, that controls a neighbouring region. Related to SCI_h1.

Source: RCA Beta.1

5.8.22. SCI_R1

Description: Connect an SubSys APS-MT to an ETCS RBC using the ETCS RBC-RBC protocol.

Candidate interface definition: ERTMS SUBSET-039 FIS for the RBC/RBC Hando-ver; ERTMS SUBSET-98/129/26 RBC-RBC Safe Communication Interface

Source: RCA Beta.1

5.8.23. SCI_I1

Description: This interface is used for switching one SubSys OC to be controlled by two different IXL (for large segment commissioning). Also called the“Y-switch”.

Source: RCA Beta.1

5.8.24. SCI_I2

Description: The block interface is used at the system border (adjacent interlocking) to enter and leave Moveable Objects. This electrical interface would be addressed over a new SubSys OC of type “Block”. A design alternative is currently evaluated, which would remove this interface and move it to the SCI_h2 interface.

Source: RCA Beta.1

5.8.25. SCI_31

Description: The Operational Plan, the operation status and all object control requests are part of this interface/API. This will also be a mobile UI that provides the user interaction for the Personnel at Trackside including but not limited to entering requests (e.g. request a shunting movement) or display current information about next capacity usages.

Source: RCA Beta.1

5.8.26. SCI_33

Description: This API/interface provides safe input/output functions for the SubSys APS-Topo4.

Source: RCA Beta.1

5.8.27. SCI_34

Description: This API/interface provides rich input/output functions for the Engineering / Data Preparation SubSys EDP.

Source: RCA Beta.1

5.8.28. SCI_35

Description: This API/interface provides input/output functions forthe Device & Configuration Management SubSys DCM.

Source: RCA Beta.1

5.8.29. SCI_36

Description: This API/interface provides safe input/output functions to edit the identity and access register.

Source: RCA Beta.1

5.8.30. SCI_37

Description: This API/interface provides rich input/output functions to monitor and analyse diagnostic data.

Source: RCA Beta.1

5.8.31. SCI_41

Description: The diagnostics interface is used between SubSys DM (diagnostics & monitoring) and the monitored components.

Candidate interface definition: EULYNX SDI

Source: RCA Beta.1

5.8.32. SCI_42

Description: The device and configuration management nterface is used between SubSys DCM (device & configuration management) and the managed components.

Candidate interface definition: evolution of EULYNX SMI

Source: RCA Beta.1

5.8.33. SCI_43

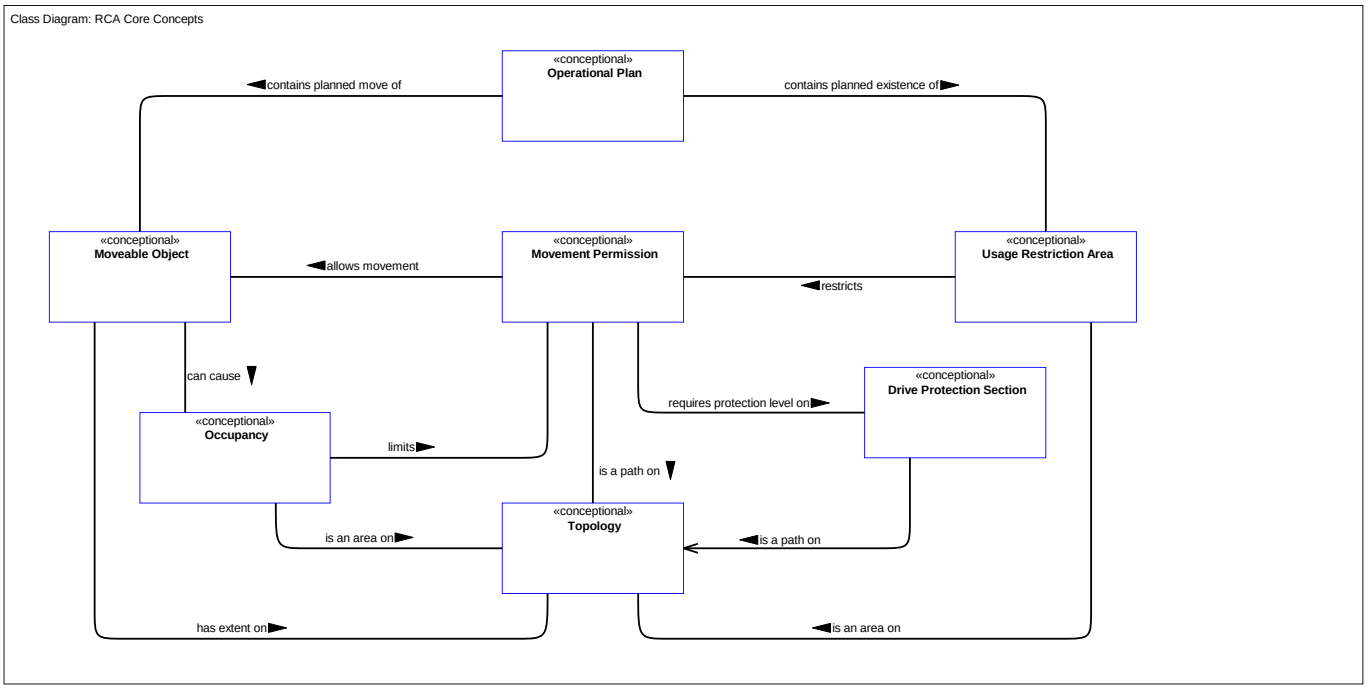
Description: The Identity & Access Management Interface provides services for authenticate and authorize human user and technical systems.

Source: RCA Beta.1

6. CROSSCUTTING (PHASE 1-5)

6.1. Domain Knowledge

6.1.1. Domain Core



Description: Core Concepts shows the core concepts of RCA and their relationships.

Name	Description
Moveable Object	A Moveable Object is a representation of a real world movable object in the Operating State. Such Moveable Objects can be track guided (as trains) or non-track guided (as workers). Any real moveable object which is detected as such by a person or system with safety responsibility will be represented as a Moveable Object in the Operating State. ToDo: Lifecycle of a MOB Design Rationales**:** A Moveable Object shall have assigned a Movement Permission all the time. As a Moveable Object is registering in the Advanced Protection System a Movement Permission for that Moveable Object is created at the same time. The Movement Permission can be altered afterward (see Alternative Scenario: Updated Operational Plan causes a rerouting [Sys RCA SD 4.1.2] and Alternative Scenario: Shorten Movement Permission is accepted [Sys RCA SD 1.1.1]). The extent of the Movement Permission shall be at least as big as the extent of the Moveable Object all the time. Reason: Advanced Protection System is responsible for granting conflict free Movement Permissions and safe movements of vehicles. The vehicles (OBU) are responsible for staying inside the Movement Permission all the time. Therefore a Moveable Object must have a Movement Permission all the time. Exception: If a vehicle is not registered, trackside assets (Train Detection System) detects the vehicles and creates Occupancy for the occupied track section.

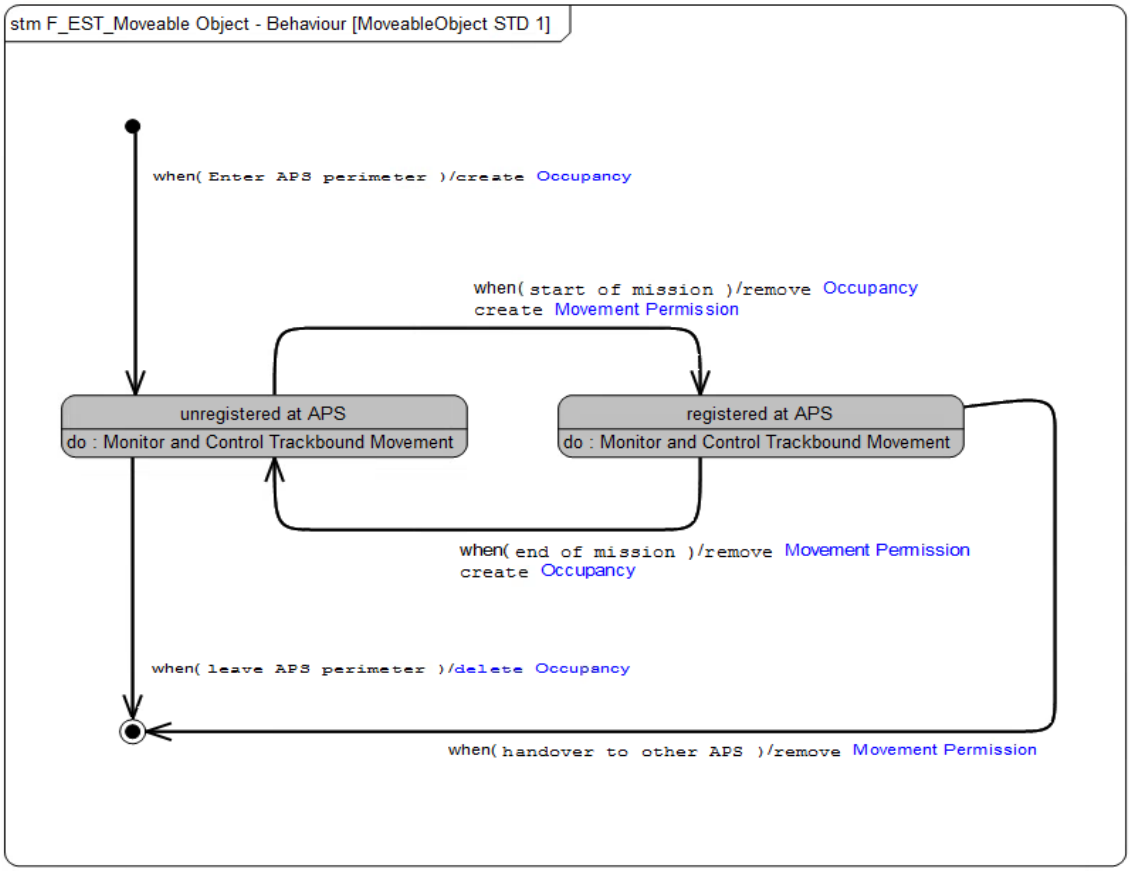
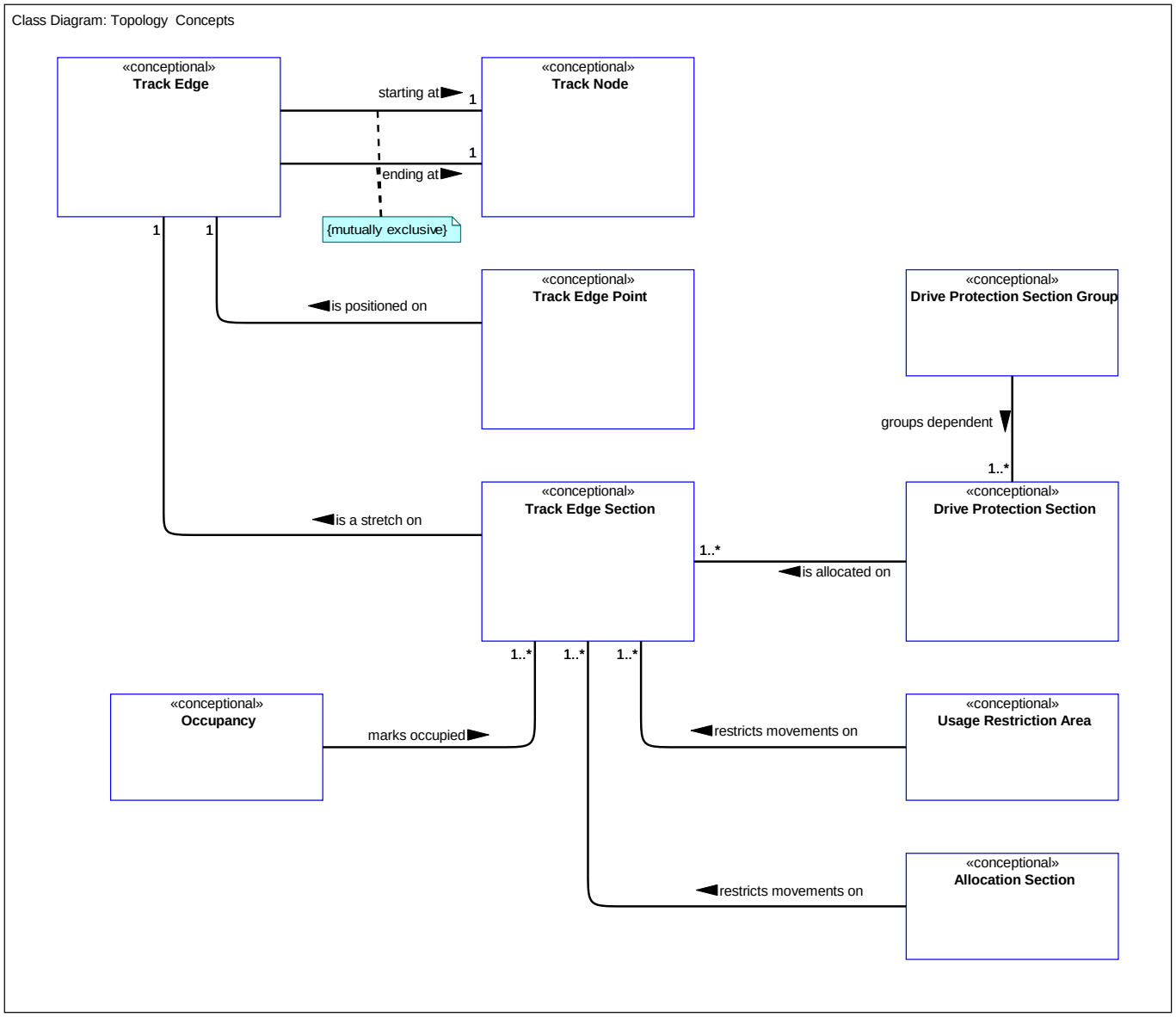
Name	Description
	

Table 1 Core

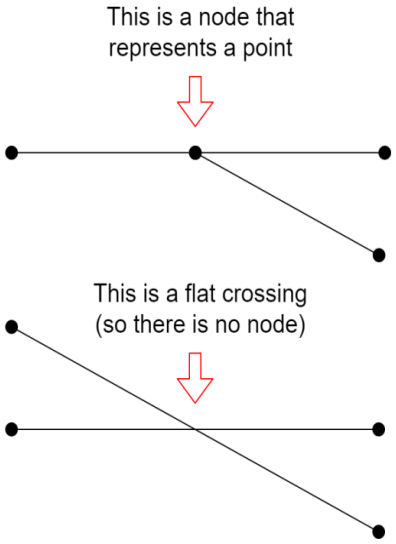
6.1.2. Domain Topology

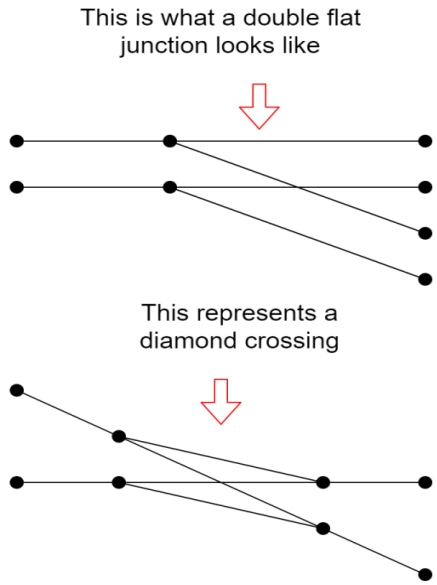
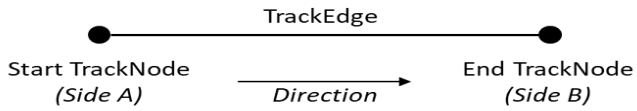


Description: This class diagram shows the relationships between the main topology concepts.

Design Rationales: Occupancy and Usage Restriction Area are designed as distinct concepts. From a topology perspective the two concepts might look quite similar. From a functional view Occupancy and Usage Restriction Area are completely different. Occupancy depends on messages generated from TA. Usage Restriction Area are managed by the TMS-PAS. The processes related to the concepts are different too. ToDo: Reference related use cases.

Name	Description
Topology	The Topology is a representation of the infrastructure facilities (points, tracks, stations, etc.) at different levels of abstraction (typically the track & line network).
Track	A Track Node is a position on the topological model of the track network where a Track Edge

Name	Description
Node	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 - Note that even if you would typically say that at a point only one Track Edge begins while another passes through the point, the Track Node that represents the point splits the passing track into two Track Edge • Buffer stops • System borders, e.g. the border between two infrastructure operators - Even if the physical track continues logically one track ends and another begins Examples showing Track Nodes and Track Edges for describing certain topologies 

Name	Description
	
Track Edge	An Track Edge is a linear object that connects exactly two Track Nodes. One of its Track Node is defined as Start Track Node called side A, the other is defined to be the End Track Node called Side B. Track Edges are directed. Each route path between two Track Nodes are represented by an Track Edge. 
Track Edge Point	A Track Edge Point is a generic construct used to describe a directed position on an Track Edge. While Track Nodes are exclusively located at the begin or end of a Track Edge, Track Edge Point can be located at any position on a Track Edge.
Track Edge Section	An Track Edge Section is a contiguous stretch of track within one single Track Edge used to describe a specific property or state of the track on that stretch. Track Edge Sections are used to define properties of tracks (like permitted speed, axle load) as well as states (like "allocated in a move permission", "closed") or any other issues that can be projected to a stretch of track.
Drive Protection Section	A Drive Protection Section is defined through an extent on the track. It logically represents a part of an trackside asset that changes trafficability. Drive Protection Sections have a DriveProtectionLevel associated, that represents the trafficability of a Drive Protection Section. The DriveProtectionLevel can have the following values Blocked, Full Protection or Limited Protection. A Drive Protection Section comprises one or several Track Edge Sections where, for missions to pass safely, a controllable infrastructure element has to be set to and secured in a specific position. ToDo: The list of possible Drive Protection Levels may be enhanced in future versions of this speficiation: Further differentiation may be needed between both extremes BLOCKED (not trafficable at all) and FULL PROTECTION (trafficable without any restrictions), i.e. trafficable with

Name	Description

reduced speed or only with a special mode.

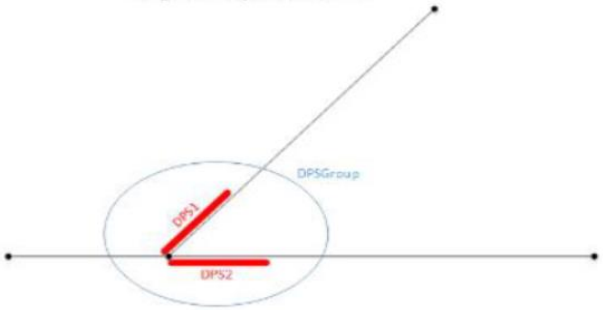
Note that the Drive Protection Section does not represent the controllable element itself but rather a single track that is passing through the element. Therefore one controllable element may affect several Drive Protection Section. A simple point has two Drive Protection Sections for the two branching tracks and a level crossing has as many Drive Protection Section as tracks are passing through the level crossing.

Common controllable infrastructure elements that require Drive Protection Sections are (non-complete list): points, level crossings, derailers, movable bridges, gates, turntables.

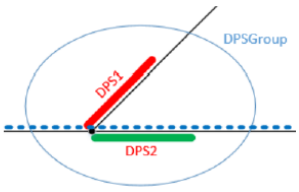
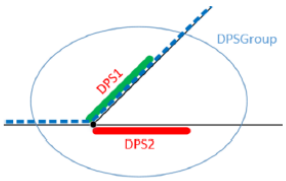
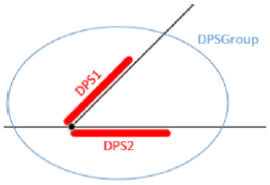
Example of using Drive Protection Section for a point:

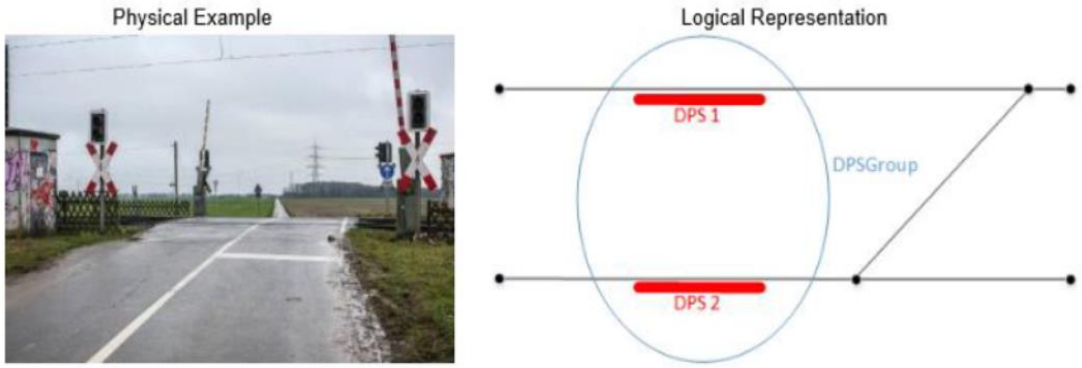
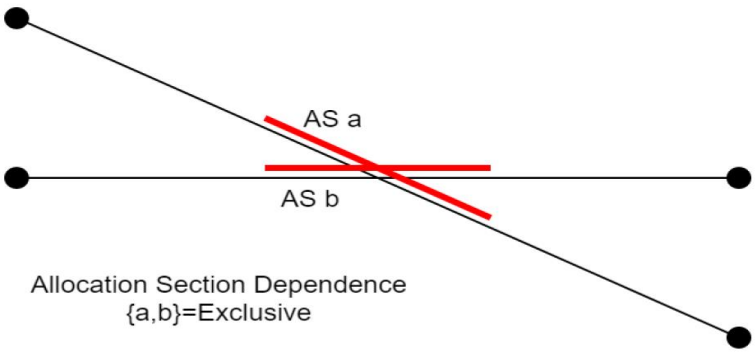
Physical Example

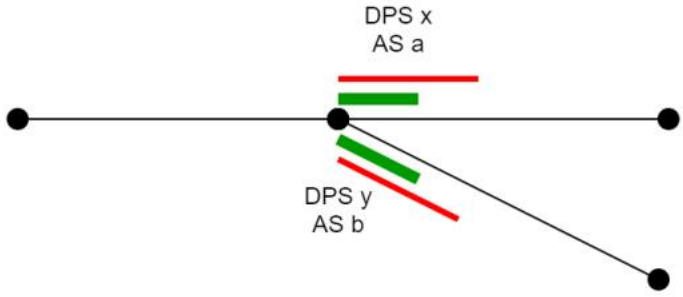
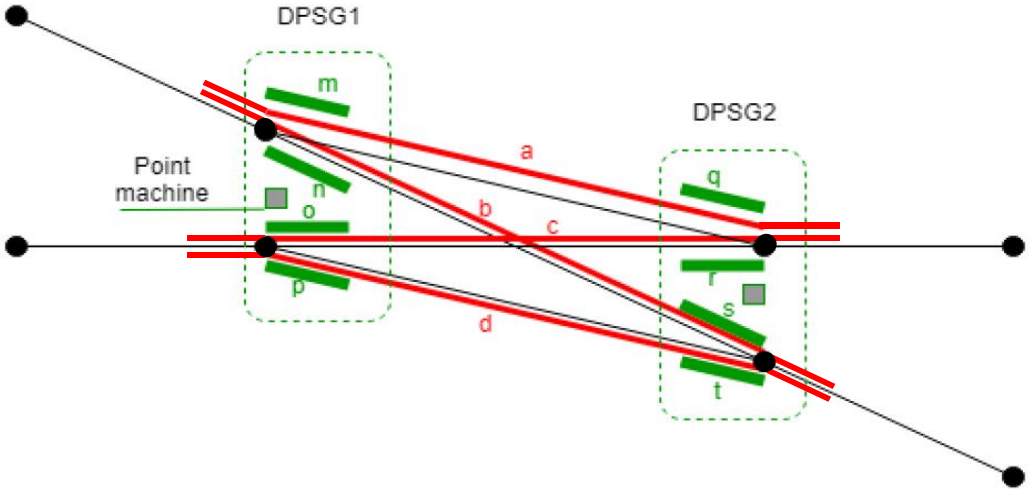
Logical Representation



Examples for using DriveProtectionLevel on a point:

DPL of DPS1	DPL of DPS2	Physical Point	
BLOCKED	FULL_PROTECTION	trafficable right	
FULL_PROTECTION	BLOCKED	trafficable left	
BLOCKED	BLOCKED	failure or changing the points	
...	...	...	...

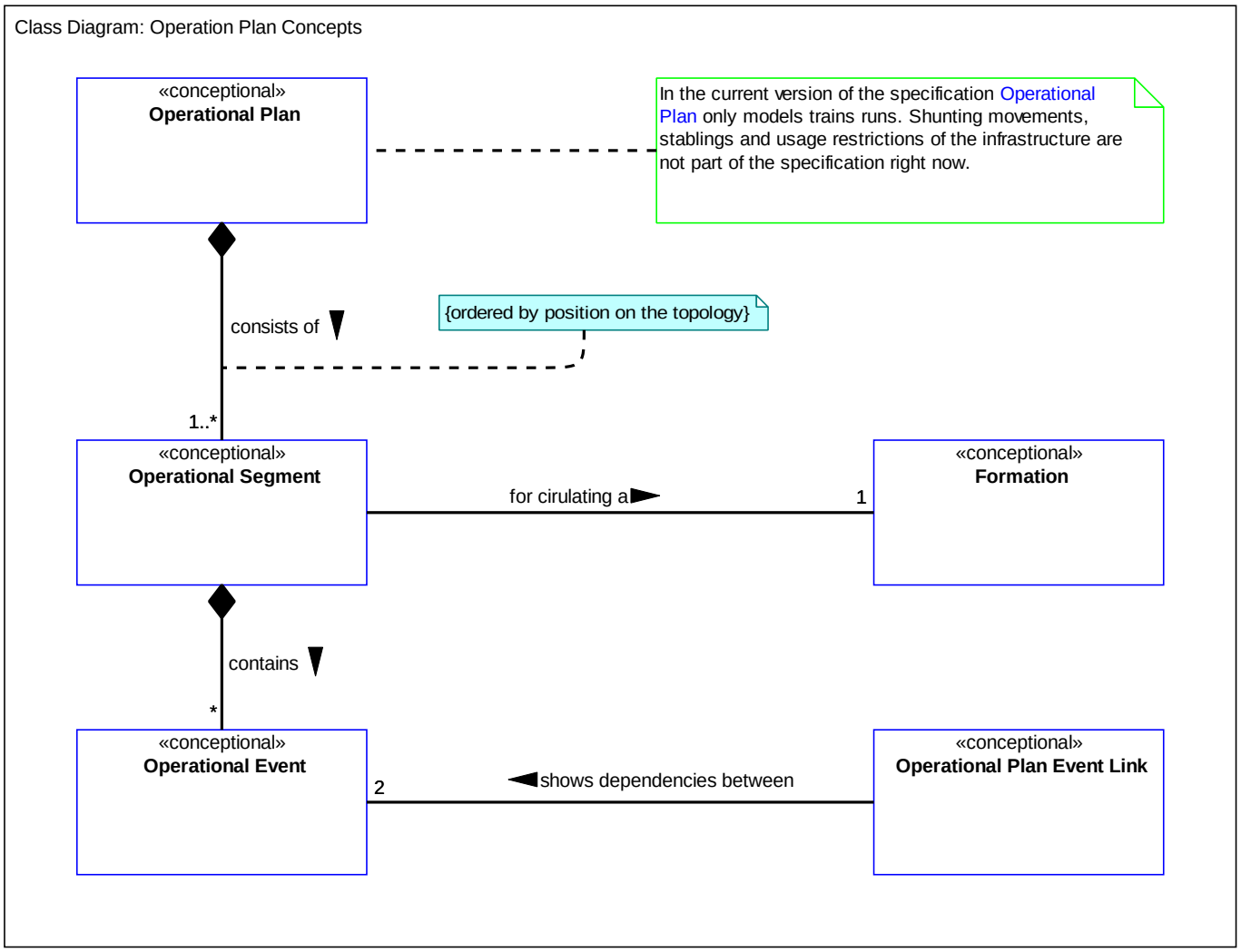
Name	Description
Drive Protection Section Group	A Drive Protection Section Group groups Drive Protection Sections that have interdependencies. Example of level crossing where a Drive Protection Section Group is used: 
Allocation Section	An Allocation Section contains 1...n Track Edge Sections where, for missions to pass safely, other Track Edge Sections must not be allocated to other missions (so protected against the presence of other standing or moving train units). Used where for geometric reasons two routes are mutually exclusive. A non-complete list of usages is: flat crossings, points and gauntlet tracks. The Allocation Section is foreseen for cases where the geometric exclusion is valid for all trains. Geometric exclusion by the features of a specific train unit, e.g. freight trains that exceed the regular loading gauge, is not solved with Allocation Sections. It is even possible to have multiple Allocation Sections for the same area bound to different classes of loading gauges, Example of a flat crossing:  Example of a point:

Name	Description
	 Drive Protection Section Interdependence {x,y}=EXCLUSIVE Allocation Section Interdependence {a,b}=EXCLUSIVE Example of a double slip crossing: The following diagram shows a double slip crossing, where both points on each side of the crossing are controlled by one point machine. This creates equal interdependencies. 
Usage Restriction Area	A Usage Restriction Area limits or hinders movements on an area described by an overlapping free but not necessarily connected set of Track Edge Sections. Under certain conditions, a Movement Permission may overlap a Usage Restriction Area (e.g. construction vehicle must enter in a construction site). Usage Restriction Area are used for construction site, speed restriction, exceptional situation (e.g. fire, landslide). Usage Restriction Area can overlap, as example when multiple construction sites overlap.
Occupancy	A not necessarily linear extend on Track Edges which can be reported as clear or occupied. Occupancy will be used, if a track is occupied e.g. by vehicles that are not registered as a Moveable Object. Occupancy are reported by clear track signaling installations (TDS). **Design Rationales:** The Occupancy concept was introduced because of several reasons. In a ideal situation where vehicle is always connected and registered in the Advanced Protection

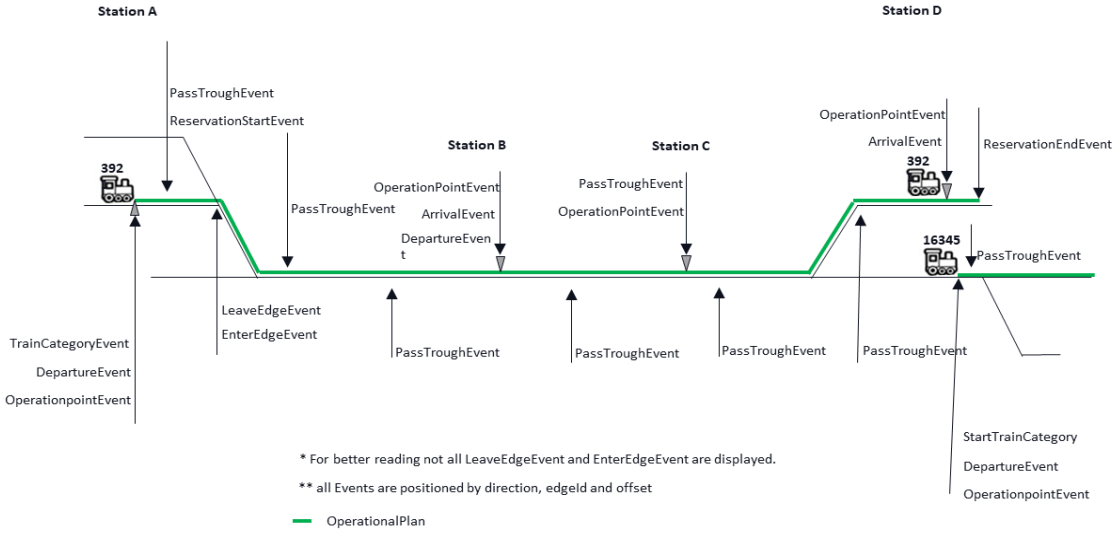
Name	Description
	System, Occupancy might be not necessary. In real situations and during the long migration phase Occupancy will be necessary in the following situations (non-exhaustive list): • parked vehicles, that are not equipped (e.g. freight waggons) with or have a defective an onboard unit • coupling/decoupling trains • shunting movements • trains with ETCS onboard unit and a localisation tag at the end and/or using trackside Train Detection System.

Table 2 Topology

6.1.3. Domain Operational Plan



Description: This class diagrams shows the Operational Plan and its elements.

Name	Description
Operational Plan	The Operational Plan is the detailed plan of all track usage, including train runs, shunting movements, stablings and usage restrictions of the infrastructure (e.g. for construction and maintenance). Each train run is represented by a separate Operational Plan. The Operational Plan is the output of the planning process of TMS-PAS. The Operational Plan is executed by SubSys TMS-PE. The following examples shows an Operational Plan with a single Operational Segment and its Operational Events.  Note that currently only train runs are covered in this specification. Stabling, shunting movements and usage restrictions are not specified yet.
Operational Segment	The Operational Segment is the detailed plan that describes all track usage for exactly one Formation. Every Formation change will lead to new Operational Segment. A turnback is also considered a change in Formation due to the change of the direction of travel.
Operational Event	An Operational Event is a part of an Operational Plan. An Operational Event describes an planned action, that should occur at a defined location on the tracks. EnterEdgeEvent and LeaveEdgeEvent are used to describe the route through track network. Other Operational Events describe additional planned actions along this route (e.g. for defining departure and arrival times).
Operational Plan Event Link	A Operational Plan Event Link is a relationship between two Operational Events which are part of Operational Plans. The linked Operational Events can be part of the same or different Operational Plans. Operational Plan Event Link are used for describing circulation of a rolling stock (split, join, change of OperationId) and turnbacks. Example of an Operational Plan Event Link usage:

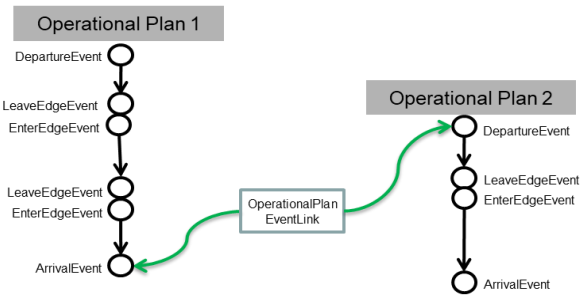
Name	Description
	
Formation	A Formation is an ordered sequence of vehicles in driving direction.

Table 3 Operational Plan

The aim of Concepts is to explain the underlying concepts used by RCA and to improve the comprehensibility of this specification document. However Concepts is not part of the formal interface specification. Concepts may have different implementations, depending on the specific need on a interface. A <<realise>> relationship indicates that a class is implementing a concept. Concepts are modelled as UML classes with the stereotype conceptional associated.

6.2. Terms

This section provides definitions for the terms used in this specification.

Name	Description
Advanced Protection System	A group of components in the RCA interface architecture, aggregates approximately the function of today's interlockings
Application Lifecycle Management	Application Lifecycle Management is the product lifecycle management (governance, development, and maintenance) of computer programs and continues after development until the application is no longer used.
Application Programming Interface	In computer programming, an Application Programming Interface is a set of subroutine definitions, communication protocols, and tools for building software.
APS Fixed Object Transactor	A device abstraction component in the RCA interface architecture. See SubSys APS-FOT.
APS Mobile Object Transactor	A device abstraction component in the RCA interface architecture. See SubSys APS-MOT
APS Movement	A device abstraction component in the RCA interface architecture. See SubSys APS-

Name	Description
Authority Transactor	MT
APS Object Aggregation	Object Abstraction component in the RCA interface architecture. See SubSys APS-OA
APS Safety Logic	Safety Control component in the RCA interface architecture. See SubSys APS-SL
APS Safety Manager	Safety control component in the RCA interface architecture. See SubSys APS-SM
ATO GoAx	ATO is an operational safety enhancement device used to help automate operations of trains. See Grade of Automation.
ATO Transactor	Device Abstraction component in the RCA interface architecture. See SubSys ATO-AT
ATO Vehicle	A device control component in the RCA interface architecture. See SubSys ATO-AV
Business Continuity Management	The process of creating systems of prevention and recovery to deal with potential threats to a company. In addition to prevention, the goal is to permit ongoing operation, before and during execution of Disaster recovery.
Change Control Board	A Change Control Board is a committee that consists of Subject Matter Experts and Technical Chiefs, who will make decisions regarding whether or not proposed changes to a software project should be implemented.
Change Request	A change request is a document containing a call for an adjustment of a system; it is of great importance in the change management process.
Cluster Management Committee	Organization group in EULYNX.
Comand, Control and Signaling	The systems, which are ensuring the safe operation of the railways as e.g. the train control system or the interlocking.
Community of European Railway and Infrastructure Companies	CER's role is to represent the interests of its members on the EU policy-making scene, in particular to support an improved business and regulatory environment for European railway operators and railway infrastructure companies. www.cer.be
Confidentiality, Integrity, and Availability	Confidentiality, integrity and availability, also known as the CIA triad, is a model designed to guide policies for information security within an organization. The elements of the triad are considered the three most crucial components of security.

Name	Description
Consortium Management Bureau	The Consortium Management Bureau forms the central core team of the consortium and consists of the Technical Lead, Liaising expert and the support staff.
Design Rationales	Explains the reason for a certain design decision
Device	A Device is a "technical thing" in the real world like a TA, a VD, etc.
Device & Configuration Management	Generic function component in the RCA interface architecture. See SubSys DCM
Diagnostics & Monitoring	Generic Function component in the RCA interface architecture. See SubSys DM
Digital Railway	DR is the name of the British programme for digitalization of CCS System (see DSD, SR40).
Digitale Schiene Deutschland	Digitale Schiene Deutschland is the German programme for digitization of CCS Systems (see also DR, SR40).
Driver Machine Interface	The interface to enable direct communication between the ERTMS/ETCS on-board equipment and the driver.
Engineering & Data Preparation	Generic Function component in the RCA interface architecture. See SubSys EDP
ERTMS Users Group	The mission of the ERTMS Users Group is to help the railway companies in applying ERTMS/ETCS in a harmonized and interoperable way, to enable the free flow of trains and a competitive railway. www.ertms.be
EULYNX	EULYNX is a European initiative in the area of railway signaling, with the aim of reducing the cost and installation time of signaling equipment. Currently, there are 12 members from North and Central Europe, with baseline 1 published in March 2017 and baseline 2 published in December 2017. The project documents lay down a system architecture for interlocking systems, including standard interfaces for the individual interlocking components, that can be used in any of the participating countries. The objective is to turn interlockings into modular systems, where different parts of one interlocking can be supplied by different manufacturers while maintaining the high safety and reliability levels required of a critical railway safety system. Link: https://www.eulynx.eu/ (Source: wikipedia)
European Committee for Electrotechnical	CENELEC is the European Committee for Electrotechnical Standardization and is responsible for standardization in the electrotechnical engineering field. www.cenelec.eu

Name	Description
Standardization	<http://www.cenelec.eu
European Rail Infrastructure Managers	The role of EIM is to provide a single voice to represent its members (infrastructure managers vis-à-vis to the relevant European institutions and sector stakeholders. EIM also assists members to develop their businesses through the sharing of experiences and contributing to the technical and safety activities of the Agency (ERA). www.eimrail.org
European Rail Traffic Management System	The European Rail Traffic Management System is a major industrial project developed by eight UNIFE members - Alstom Transport, Ansaldo STS, AZD Praha, Bombardier Transportation, CAF, Mermec, Siemens Mobility and Thales - in close cooperation with the Eu-ropean Union, railway stakeholders and the GSM-R industry.
European Train Control System (Level x)	The European Train Control System is the signaling and control component of the European Rail Traffic Management System (ERTMS). It is a replacement for legacy train protection systems and designed to replace the many incompatible safety systems currently used by European railways. ETCS is specified at four numbered levels (x = 0, 1, 2, 3).
European Union Agency for Railways	The European Union Agency for Railways is established to provide the EU Member States and the Commission with technical assistance in the development and implementation of the Single European Railway Area. www.era.europa.eu
European Union Public Licence	The European Union Public Licence is a free software licence that has been created and approved by the European Commission.
European Vital Computer	The European Vital Computer is the heart of local computing capabilities in the driving vehicle. It is connected with external data communication, internal controls to speed regulation of the loco, location sensors and all cab devices of the driver.
Flank Protection	A means of protecting movements of trains across junctions by the setting of Point (either manually or automatically) that prevent any other unauthorised movement coming into contact with it. (Source: https://safety.networkrail.co.uk)
Form Fit Function Interface Specification	Form, Fit, and Function is the identification and description of characteristics of a part or assembly. Each defines a specific aspect of the part to help engineers match parts to needs. The FFF framework increases design change flexibility by allowing changes to the part with minimal documentation and design cost as long as the fit, form and function of the product are maintained.
Future Railway Mobile Communication System	FRMCS has the objective to become the worldwide standard, conforming to European regulation as well as responding to the needs and obligations of rail organizations outside of Europe. As such, the UIC FRMCS project duly associates non-European members and is a first concrete application of UIC strategy to build a Global Rail Traffic Management System for the whole rail industry. www.uic.org/frmcs

Name	Description
Global Navigation Satellite System	Global Navigation Satellite System refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The receivers then use this data to determine location.
Global Positioning System	The Global Positioning System is a satellite-based radio navigation system owned by the United States government and operated by the United States Air Force. It is a global navigation satellite system that provides geolocation and time information to a GPS receiver anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites.
Global system for mobile communication Railway	GSM-R is an international wireless communications standard for railway communication and applications.
Grade of Automation	Grade of Automation refers to the degree of automation in remote train control (ATO). The list of automatable activities of the driver is divided into 5 categories: GoA 0: No automation, everything is in the hands of the driver. GoA 1: The driver is prevented from unsafe actions (e.g. driving over a signal). GoA 2: The train driver is present, but during the journey a system takes over the speed control or at the station the door control (autopilot). GoA 3: No person is present in the driver's cab, most processes are automated. In situations that are difficult to automate (e.g. driving on sight in the event of faults), manual remote control is provided by the train attendant or the operations centre, for example. GoA 4: All train control processes are automated. Intervention groups only intervene on site in the event of locomotive malfunctions or evacuations.
Hardware	Hardware includes the physical, tangible parts or com-ponents of a computer.
Horizon 2020	Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. https://ec.europa.eu/programmes/horizon2020/en
Identity and Access Management	IAM is, in computer security, the security and business discipline that "enables the right individuals to access the right resources at the right times and for the right reasons". Generic Function component in the RCA interface architecture. See SubSys IAM
Independent Verification & Validation	Independent Verification & Validation is targeted at safety-critical software systems and aims to increase the quality of software products, thereby reducing risks and costs through the operational life of the software. IVV provides assurance that software performs to the specified level of confidence and within its designed parameters and defined requirements.

Name	Description
Infrastructure Manager	A railway infrastructure manager is any body or undertaking that is responsible in particular for establishing and maintaining railway infrastructure. This also includes the management of infrastructure control and safety systems.
Institute of Electrical and Electronics Engineers	IEEE is the world's largest technical professional organ-ization dedicated to advancing technology for the bene-fit of humanity. IEEE and its members inspire a global community through its highly cited publications, confer-ences, technology standards, and professional and educational activities. www.ieee.org
Intellectual Property Rights	Intellectual property is a category of property that includes intangible creations of the human intellect. Intellectual property encompasses two types of rights; industrial property rights (trademarks, patents, designations of origin, industrial designs and models) and copyright.
Interlocking	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, lock and detected in safe combinations. See also APS
International Electrotechnical Commission	The IEC is the world's leading organization for the preparation and publication of International Standards for all electrical, electronic and related technologies. These are known collectively as "electrotechnology". www.iec.ch
International Organization for Standardization	ISO is an independent, non-governmental international organization with a membership of 164 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Stand-ards that support innovation and provide solutions to global challenges. www.iso.org
International Requirements Engineering Board	The International Requirements Engineering Board, a non-profit organization, is the provider of the CPRE (Certified Professional for Requirements Engineering) certification scheme. The board consists of leading RE representatives, who come from science, research, industry and consulting.
Level Crossing	A place where a railway and a road cross at the same level. (Source: https://safety.networkrail.co.uk)
Life Cycle Cost	Life Cycle Cost refers to the total cost of ownership over the life of an asset. Costs considered include the financial cost which is relatively simple to calculate and also the environmental and social costs which are more difficult to quantify and assign numerical values. Typical areas of expenditure which are included in calculating the whole-life cost include planning, design, construc-tion and acquisition, operations, maintenance, renewal and rehabilitation, depreciation and cost of finance and replacement or disposal.

Name	Description
Man Machine Interface	The Man Machine Interface (also called User Interface) is the space where interactions between humans and machines occur. The goal of this interaction is to allow effective operation and control of the machine from the human end, whilst the machine simultaneously feeds back information that aids the operators' decision-making process.
Mean Time to Recovery resp. Repair	Mean Time to Recovery is the average time that a device will take to recover from any failure.
Middleware	Middleware is computer software that provides services to software applications beyond those available from the operating system. It can be described as "software glue".
Mission	Any train movement started under the supervision of an ERTMS/ETCS on-board equipment in one the following modes: FS, LS, SR, OS, NL, UN, or SN. The ETCS mission is ended when any of the following modes is entered: SB, SH. A concept used in the ETCS Standard. Source: ETCS Specification SUBSET-023 v330
Mobile Object	Objects like persons, cars that are close to the track.
Mobile Object Locator	A device control component in the RCA interface architecture. See SubSys MOL
Model-Based Systems Engineering	Model-Based Systems Engineering is a systems engineering methodology that focuses on creating and ex-ploiting domain models as the primary means of information exchange between engineers, rather than on document-based information exchange.
Movement Authority	Movement Authority is the permission for a train to move to a specific location within the constraints of the infrastructure and with supervision of speed. End of Authority is the location to which the train is permitted to proceed and where target speed is equal to zero. See Movement Authority
National Safety Authority	Authority for authorization of CCS components and systems.
Non Functional Requirement	In systems engineering and requirements engineering, a Non Functional Requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors.
Object	An Object is an abstract, logical representation of one or several Devices.

Name	Description
Object Controller	A device control component in the RCA interface architecture.The different OC component types and their interfaces are defined in EULYNX. See SubSys OC
On Board Unit	The ETCS equipment located on the driving vehicle.
Open CCS Onboard Reference Architecture	European initiative to define the CCS vehicle architecture. Confirms with the COAT program of smartrail 4.0.
Operating State	The Operating State is the representation of all relevant objects known to the Advanced Protection System, including their state. It is the only true representation of all safety critical objects and their states.
Operating System	An Operating System is system software that manages computer hardware and software resources and provides common services for computer programs.
Operation Point	Infrastructure elements such as railway stations. In TAF/TAP Operation Points are called locations
Operational Train 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.
Overlap	Overlap is the space of the track beyond the end of Movement Authority, that is kept clear in case the trains overruns the end of Movement Authority.
Person Supervisor & Locator	A device control component in the RCA interface architecture. See SubSys PSL
Platform of Rail Infrastructure Managers in Europe	PRIME was established between DG MOVE and Infrastructure Managers at the end of 2013 with the objective to improve the cooperation of rail infrastructure managers across borders, support implementation of Europe-an rail policy and develop performance benchmarking for the exchange of best practices.
Point	A junction of two railway lines that can be set to guide a train onto one of two alternative routes, or allow two lines to merge into one. Points can either be in “Reverse” or “Normal”. Reverse being : The position of points where the reversed position indicates that the points are set for the less commonly used route. Normal being: The position of Point where the normal position indicates that the points are set for the more commonly-used route, usually straight running. (Source: https://safety.networkrail.co.uk)

Name	Description
Radio Block Centre	A Radio Block Centre is a specialized computing device with specification Safety Integrity Level (SIL4) for generating Movement Authoritys and transmitting it to trains. It gets information from signaling control and from the trains in its section. It hosts the specific geographic data of the railway section and receives cryptographic keys from trains passing in. According to conditions the Radio Block Centre will attend the trains with Movement Authority until leaving the section.
Railway Undertaking	Rail transport undertaking means a private or public undertaking which is authorized to carry persons or goods by rail and which ensures traction or which only ensures traction.
RCA Architecture Overview	RCA Architecture Overview Document, published on the ERTMS Website. Version: Alpha.1. Source: https://ertms.be/sites/default/files/2019-02/RCA_Alpha_Architecture_Overview_1.pdf
RCA Workbench	A component in the RCA interface architecture. See SubSys RCA-WB
Reference CCS architecture	Reference CCS architecture is an initiative by the members of EUG and EULYNX to define a harmonized architecture for the future railway CCS, with the main goal to substantially in-crease the performance/TCO ratio of CCS in comparison with today's implementations.
Reliability, Availability, Maintainability (and Safety)	RAMS constitutes the key element of the assessment in the rail industry today. For rail system operator, RAMS means a safe, reliable, high-quality service and lower operating and maintenance costs. For the rail system provider, RAMS is representing a high-quality system and product.
Research and Development	Research and Development refers to the work a business conducts for the innovation, introduction and improvement of its products and procedures. It is a series of investigative activities to improve existing products and procedures or to lead to the development of new products and procedures.
Safety Integrity Level	Safety Integrity Level is defined as a relative level of risk reduction provided by a safety function, or to specify a target level of risk reduction. In simple terms, Safety Integrity Level is a measurement of performance required for a safety instrumented function. The Safety Integrity Levels are defined in the European norm EN 50128.
Shift2Rail	Shift2Rail 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.
SIL4	Safety Integrity Level 4. Level 4 is the highest level.

Name	Description
smartrail 4.0	With the smartrail 4.0 program, the Swiss railway industry is harnessing digitalization and the potential of new technologies to further increase capacity and safety, make more efficient use of railway infrastructure, save costs and thus maintain the railway's competitiveness in the longer term. www.smartrail40.ch
Software	Software is a collection of data or computer instructions that tell the computer how to work. Software includes computer programs, libraries and related non-executable data, such as online documentation or digital media.
Systems Modeling Language	The Systems Modeling Language is a general purpose architecture modeling language for systems engineering applications. Systems Modeling Language supports the specification, analysis, design, verification and validation of a broad range of systems and systems-of-systems. These systems may include hardware, software, information, processes, personnel, and facilities. www.sysml.org
Technical Specification for Interoperability	The Technical Specification for Interoperability are specifications drafted by the European Railway Agency and adopted in a decision by the European Commission, to ensure the interoperability of the trans-European rail system. The interoperability issues apply to the lines within the Trans-European Rail network.
TIMS	Abbreviation for Train Integrity Monitoring System
TMS ATO Execution	A movement control component in the RCA interface architecture. See SubSys TMS-AE
TMS Plan Execution	A movement control component in the RCA interface architecture. See SubSys TMS-PE
Total Cost of Ownership	Total Cost of Ownership is a financial estimate intended to help buyers and owners determine the direct and indirect costs of a product or system. It is a management accounting concept that can be used in full cost accounting or even ecological economics where it includes social costs.
Trackside Asset	Trackside Assets are installations such as rail points, level crossing barriers, signals, Train Detection System (axle counters, track circuits), etc. Trackside Asset are external actors in the RCA interface architecture. See TA
Traffic Management System	Traffic Management System provide permanent control across the network, automatically sets routes for trains and logs train movements as well as detects and solves potential conflicts.
Train Detection	Train Detection System is a system which determines the occupancy status of track vacancy proving sections. Train detection system may be a track circuit or an axle

Name	Description
System	counting system. (Source: EULYNX Glossary)
Train Integrity Monitoring System	System to monitor and confirm train integrity when train detection is absent.
Train Position Report	ToDo
Union des Industries Ferroviaires Européennes	Union des Industries Ferroviaires Européennes is representing the European rail manufacturing industry. Union des Industries Ferroviaires Européennes' purpose is to represent its members' interests at international and EU level. The mission of the association is to proactively foster an environment where its members can provide competitive railway systems for the growing demand for rail transport. www.unife.org
Union Industry of Signaling	Union Industry of Signaling is a working group of UNIFE with the goal to create the ERTMS/ETCS specifications.
Union Internationale des Chemins de fer or International Union of Railways	The worldwide railway organization. www.uic.org
Unique Selling Proposition	A Unique Selling Proposition refers to the unique benefit exhibited by a company, service, product or brand that enables it to stand out from competitors. The Unique Selling Proposition must be a feature that highlights product benefits that are meaningful to consumers.
Vehicle Devices	An external actor in the RCA interface architecture, See VD
Vehicle Locator	a device control component in the RCA interface architecture. See SubSys VL
Vehicle Supervisor	A device control component in the RCA interface architecture. See SubSys VS
Verification and Validation	Verification and validation are independent procedures that are used together for checking that a product, service, or system meets requirements and specifications and that it fulfills its intended purpose.

Table 4 Terms

6.3. Abbreviations

Name	Description

Name	Description
ALM	Abbreviation for Application Lifecycle Management
API	Abbreviation for Application Programming Interface
APS	Abbreviation for Advanced Protection System
APS-FOT	Abbreviation for APS Fixed Object Transactor
APS-MOT	Abbreviation for APS Mobile Object Transactor
APS-MT	Abbreviation for APS Movement Authority Transactor
APS-OA	Abbreviation for APS Object Aggregation.
APS-SL	Abbreviation for APS Safety Logic
APS-SM	Abbreviation for APS Safety Manager
ATO	Abbreviation for Automatic Train Operation
ATO-AT	Abbreviation for ATO Transactor
ATO-AV	Abbreviation for ATO Vehicle
BCM	Abbreviation for Business Continuity Management
CCB	Abbreviation for Change Control Board
CCS	Abbreviation for Comand, Control and Signaling
CENELEC	Abbreviation for European Committee for Electrotechnical Standardization
CER	Abbreviation for Community of European Railway and Infrastructure Companies
CIA	Abbreviation for Confidentiality, Integrity, and Availability

Name	Description
Class1	
CMB	Abbreviation for Consortium Management Bureau
CMC	Abbreviation for Cluster Management Committee
CR	Abbreviation for Change Request
DCM	Abbreviation for Device & Configuration Management
DM	Abbreviation for Diagnostics & Monitoring
DMI	Abbreviation for Driver Machine Interface
DPL	Abbreviation for Drive Protection Level
DPS	Abbreviation for Drive Protection Section
DR	Abbreviation for Digital Railway
DSD	Abbreviation for Digitale Schiene Deutschland
EDP	Abbreviation for Engineering & Data Preparation
EIM	Abbreviation for European Rail Infrastructure Managers
ERA	Abbreviation for European Union Agency for Railways
ERTMS	Abbreviation for European Rail Traffic Management System
ETCS	Abbreviation for European Train Control System (Level x)
EUG	Abbreviation for ERTMS Users Group

Name	Description
EUPL	Abbreviation for European Union Public Licence
EVC	Abbreviation for European Vital Computer
FFFIS	Abbreviation for Form Fit Function Interface Specification
FRMCS	Abbreviation for Future Railway Mobile Communication System
GNSS	Abbreviation for Global Navigation Satellite System
GoA	Abbreviation for Grade of Automation
GPS	Abbreviation for Global Positioning System
GSM-R	Abbreviation for Global system for mobile communication Railway
HW	Abbreviation for Hardware
IAM	Abbreviation for Identity and Access Management
IEC	Abbreviation for International Electrotechnical Commission
IEEE	Abreviation for Institute of Electrical and Electronics Engineers
IM	Abbreviation for Infrastructure Manager
IPR	Abbreviation for Intellectual Property Rights
IREB	Abbrevation for International Requirements Engineering Board
ISO	Abbreviation for International Organization for Standardization
IVV	Abbreviation for Independent Verification & Validation
IXL	Abbreviation for Interlocking

Name	Description
LCC	Abbreviation for Life Cycle Cost
MA	Abreviation for Movement Authority.
MBSE	Abbreviation for Model-Based Systems Engineering
MMI	Abbreviation for Man Machine Interface
MO	Abbrevation for Mobile Object
MOB	Abbreviation for Moveable Object
MOL	Abbreviation for Mobile Object Locator
MP	Abbreviation for Movement Permission
MTTR	Abbreviation for Mean Time to Recovery resp. Repair
MW	Abbreviation for Middleware
NFR	Abbreviation for Non Functional Requirement
NSA	Abbreviation for National Safety Authority
OBU	Abbreviation for On Board Unit
OC	Abbreviation for Object Controller
OCORA	Abbreviation for Open CCS Onboard Reference Architecture
OS	Abbreviation for Operating System
OTN	Abbreviation for Operational Train Number

Name	Description
PRIME	Abbreviation for Platform of Rail Infrastructure Managers in Europe
PSL	Abbreviation for Person Supervisor & Locator
R&D	Abbreviation for Research and Development
RAM(S)	Abbreviation for Reliability, Availability, Maintainability (and Safety)
RBC	Abbreviation for Radio Block Centre
RCA	Abbreviation for Reference CCS architecture
RCA WB	Abbreviation for RCA Workbench
RU	Abbreviation for Railway Undertaking
S2R	Abbreviation for Shift2Rail
SIL	Abbreviation for Safety Integrity Level
SoM	Abbreviation for Start of Mission. A Term used in ETCS.
SR40	Abbreviation for smartrail 4.0
SW	Abbreviation for Software
SysML	Abbreviation for Systems Modeling Language
TA	Abbreviation for Trackside Asset
TCO	Abbreviation for Total Cost of Ownership
TDS	Abbreviation for Train Detection System.
TMS	Abbreviation for Traffic Management System

Name	Description
TMS-AE	Abbreviation for TMS ATO Execution
TMS-PAS	Abbreviation for TMS Planning System
TMS-PE	Abbreviation for TMS Plan Execution
TSI	Abbreviation for Technical Specification for Interoperability
UI	Abbreviation for user interface. See Man Machine Interface
UIC	Abbreviation for Union Internationale des Chemins de fer or International Union of Railways
UML	Abbreviation for Unified Modelling Language
UNIFE	Abbreviation for Union des Industries Ferroviaires Européennes
USP	Abbreviation for Unique Selling Proposition
V&V	Abbreviation for Verification and Validation
VD	Abbreviation for Vehicle Devices
VL	Abbreviation for Vehicle Locator
VS	Abbreviation for Vehicle Supervisor

Table 5 Abbreviations