RCA

Reference CCS Architecture

An initiative of the ERTMS users group and the EULYNX consortium

A.P.M Objectives

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Version history

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1 Introduction

1.1 Release information

Basic document information:

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

1.3 Disclaimer

This issue is a preliminary version of this document. The content of this document reflects the current ongoing specification work of RCA. Formal requirements management and change management will be introduced in future iterations. The content may be unfinished, will likely contain errors and can be changed without prior notice.

1.4 Purpose of this document

In the document “A.P.M. business strategy and targets” a list of main targets is defined. For every of these targets “A.P.M. @objectives” are derived in this document. @Objectives are “high level solution requirements” (for the application, processes and systems) that give a more precise view how the targets “shall” or “could” be fulfilled.

The target group for this document are asset managers, product managers, system architects, designer of operational processes and system engineers.

1.5 Sources

This document uses, amends and aggregates results from several projects like OCORA, RCA, EULYNX, Linx4Rail, smartrail4.0.

1.6 Status of work

“Plan Execution” (PE), “Advanced Protection System” (APS) and “Map” are core projects inside RCA that is generating an architecture description (business/operational requirements and interface specifications) to be used as a **standard reference tender specifications** for enabling of further specification steps and specific implementations. All three together as a concept are called “**A.P.M**” in this document are: “**A**dvanced Protection System, plan execution and map data management”.

This document is part of a set of documents that form the overall “A.P.M concept”.

Currently, the “A.P.M concept” as well as this document are work in progress.

1.7 Use of this document

The A.P.M concept documentation shall be used as a general description that helps to understand the basic intentions behind the A.P.M. It will be used for communication and on-boarding events, for discussions about product development strategies or to describe the business expectations for feasibility studies or for the design of prototype projects and pilot lines.

2 “A.P.M” – in a nutshell

A.P.M sits in the middle of the CCS trackside architecture, which has the typical form of an “industrial automation pyramid”.

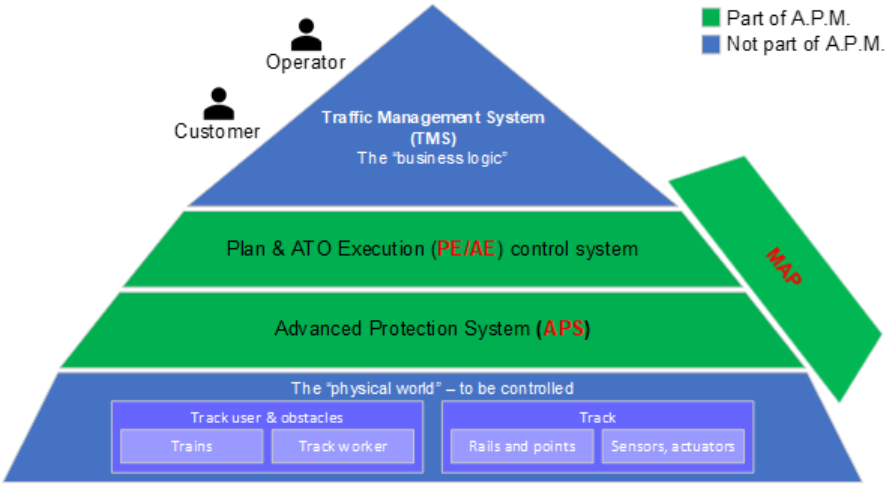

Figure 1: APS in the middle of the railway production

The Traffic Management System (TMS) plans and decides “when and what to do”. TMS is typically a large IT system landscape, which delivers a production plan. The production plan is analysed and executed by “plan execution” control systems that send commands to train (trackside automatic train operation systems, AE) and trackside (PE). The APS assures as a gatekeeper, that the plans and commands of the TMS and AE/PE create a safe traffic flow and then executes them. APS assures safe track usage and uses the sensors and actuators in trains, mobile track user devices (maintenance teams) or trackside assets to control and supervises the railway production. MAP provides reliable, validated topology and topography data (Map Data) for all operational RCA subsystems, including safety-critical components. Another important goal is to control the distribution of the Map Data from a single source to the relevant subsystems. A.P.M must fulfil very high availability, safety and security standards.

A.P.M is a generic term for functions of the future railway system architecture that are today located for example in centralized trackside control systems (CTC), interlocking (IXL), radio block centre (RBC) and trackside functions needed for controlling automated train operations. Or in other terms: A.P.M. is the trackside part of CCS without including TMS or the trackside assets. Analogy: Seeing the CCS trackside “as a computer” then TMS is the application software (“Microsoft Word” or “Outlook”), A.P.M is the operating system (“Microsoft Windows”) and trains/tracks are the hardware (“the PC”).

3 #Business targets and their allocation to @objectives

A.P.M. is part of the proposed 'Reference CCS Architecture' (RCA) and shall cover a majority of the essential #business targets identified in the document 'RCA.Doc.50, A.P.M Business Targets and Strategy'. In the following table only short versions of the business targets will be displayed. Please also consider the referenced documents for deeper understanding of the targets. Each #business target will be addressed with one or multiple business objectives, later referred to as @objective. The formulation of an @objective may already indicate a solution idea or working principle. (Any proposal for more adequate solutions or working principles are very welcome in the current design phase). The symbols (# and @) used to differentiate targets and objectives have no deeper meaning but should help to easily spot the level of requirement.

The prioritisation shall be done always in relation to LCC because a comparison for example of a "capacity effect" makes no sense. A required capacity can be achieved with nearly every technology. Traditional ETCS L2 installations will always have higher "capacity costs" than ETCS L3 installations that partly have no trackside train detection or no shunting signals.

In this chapter the objectives are allocated to overall concepts (A.P.M, APS, PE or MAP) to facilitate the readers path through the A.P.M documentation. The detailed description of the objectives and the solution approaches can be found in the concept papers

- RCA.Doc.47: Concept Plan Execution
- RCA.Doc.51: APS concept
- RCA.Doc.54: MAP concept

The allocation is shown in the table below. Whenever A.P.M is chosen, the respective objectives are relevant for all three concepts and will be addressed in each one. In order to fully understand how the objectives correspond to the business target, it is recommended to read the derived documentation.

Note: The part of Automated Train Operation (ATO) is not yet handled.

Table 1: #Business targets and their allocation to @objectives

Business target	Concept	Objective
#"Locally scalable" investment for mixed traffic densities	A.P.M.	A.P.M.@Provide scalable system architecture to be used in a modular way depending on local needs A.P.M.@Integrate upwards compatibility by design A.P.M.@Consider open interfaces to integrate as many formats as possible A.P.M.@Deployment of the system must be possible in various configurations but all of them need to fulfil basic requirements
	PE	O-PE@Reduce the RAMS requirements of the Planning System O-PE@Support the segmentation of the Area of Control of the Planning System O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Support clearly designed and robust interfaces for fully automated data exchange
	APS	APS@The building blocks and their interfaces should have as little version dependency as possible
#"modular safety" strategy	A.P.M.	A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys.

Business target	Con-cept	Objective
		A.P.M.@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance
	APS	APS@Enable changes, adaptations and extensions throughout the life cycle of the building blocks APS@Enable a safe system and its safety assurance based on building blocks in order to minimise effort for safety assurance APS@Demonstrate safety within the building blocks including its interface without knowledge or need of assumptions on the function of further building blocks behind the interface APS@The integration of building blocks with their own safety assurance shall result in a secure system that does not require further safety assurances. APS@The building blocks and their interfaces should have as little version dependency as possible
	PE	O-PE@Reduce the RAMS requirements of the Planning System O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance O-PE@Implement specific unscheduled manual operations which require up to SIL 2 within GUI-Application of SubSys WB (stationary or mobile) separated via SWI-PE from SubSys PE
	MAP	MO08@Provide reliable Map Data reflecting the actual topology MO10@Ensure modularity and modifiability for MAP systems and interfaces
#“on the fly” replacements	MAP	MO01@Provide Map Data versions for testing without impact on operation MO04@Efficient distribution of Map Data to Trackside Systems
	PE	O-PE@Support efficient and safe update of Map Data Version during runtime O-PE@Support independent updateability of HW and SW and Engineering Data
	APS	APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation APS@Support interfacing to additional field elements during runtime APS@The building blocks and their interfaces should have as little version dependency as possible APS@Update of safety demonstration documentation after replacement automatically APS@Support exchange of hardware and software components with the same functionality with less need of system approval
#“rich degraded modes	A.P.M.	A.P.M.@Malfunctioning of system components shall not lead to a shutdown of the system A.P.M.@several modes for degraded operation ensuring a high-level of safety and a high-level of operational system must be implemented by design
	APS	APS@Minimize the transfer of one or many safety responsibilities to a human operator even in degraded situations APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components APS@Less or no manual interaction between driver and signaller (to be substituted)

Business target	Concept	Objective
	PE	O-PE@Handle failures and degraded modes of the railway network efficiently O-PE@Handle failures and degraded modes of Physical Train Units efficiently O-PE@Handle failures and degraded modes of the Planning System efficiently O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Handle internal failures and degraded modes efficiently O-PE@Minimize the transfer of safety responsibilities to a human operator even in degraded situations
#15-30 %capacity improvement	APS	APS@Enable usage of train length and integrity information for optimised track occupancy without the restriction of fixed signalling blocks and/or train detection sections APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension
#35% LCC reduction	MAP	MO01@Provide Map Data versions for testing without impact on operation MO02@Efficient PREP processes and tools with highest economical grade of automation MO03@Efficient distribution of Map Data to On-board Systems MO04@Efficient distribution of Map Data to Trackside Systems MO05@Minimize engineering efforts MO10@Ensure modularity and modifiability for MAP systems and interfaces
	APS	APS@Use standard interface towards Field Elements to separate the lifecycles of hardware and software components APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic) APS@Separate data aggregation from data provisioning APS@Usage of different train localisation technologies for reduction of costs for trackside train detection system APS@Reduction of CCS trackside equipment on a needed level for operation by gaining capacity not only with standard CCS trackside enhancements (e.g. trackside train detection sections, shorter pre-set routes)
	A.P.M.	A.P.M.@Overlapping technology lifecycle profiles must be respected by the system design A.P.M.@Exchangeability between building blocks must be present wherever non-overlapping technology lifecycle profiles are present A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys.
	PE	O-PE@Support the adaptability of business logic to national specific operating rules O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance O-PE@Support independent updateability of HW and SW and Engineering Data

Business target	Concept	Objective
#50% faster rollout	MAP	MO02@Efficient PREP processes and tools with highest economical grade of automation MO04@Efficient distribution of Map Data to Trackside Systems MO05@Minimize engineering efforts
	APS	APS@Support EULYNX standards for interfacing with field elements via Object Controller APS@Use of existing infrastructure without the need of changes/alignment due to the use of APS APS@Allow the replacement of multiple legacy interlocking with one single APS APS@Reduction of CCS trackside equipment on a needed level for operation by gaining capacity not only with standard CCS trackside enhancements (e.g. trackside train detection sections, shorter routes)
	A.P.M.	A.P.M.@Allow large area of control segment sizes to reduce the amount of transitions to neighboring legacy systems in order to reduce integration efforts A.P.M.@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance
	PE	O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance O-PE@Support operation of an entire geographical rollout segment
#50% RAM improvement	APS	APS@Reduction of CCS trackside equipment on a needed level for operation by gaining capacity not only with standard CCS trackside enhancements (e.g. trackside train detection sections, shorter routes) APS@Provide data capturing to enable predictive maintenance in order to increase SubSys availability
	A.P.M.	A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys. A.P.M.@Reduce maintenance efforts by maximally reducing dependencies between building blocks A.P.M.@Reduce the number of individual systems, components, field elements sharing non-standardised interfaces A.P.M.@Provide data about system behaviour about RAMS and capacity usage to other systems
	MAP	MO05@Minimize engineering efforts MO08@Provide reliable Map Data reflecting the actual topology
	PE	O-PE@Support clearly designed and robust interfaces for fully automated data exchange O-PE@Provide data capturing to enable predictive maintenance
#A.P.M. implements the ERTMS operating rules (TSI CCS Appendix A) with some	APS	APS@Implement full supervision of all movements, also shunting APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation) APS@Support only of ETCS Level 2, 3 and mixed Level operation (i.e. hybrid train detection) on the same line

Business target	Con-cept	Objective
important enhance-ments and exclusions		APS@Support the TSI CCS enhancements (e.g. “always connected” UNISIG-CR 1350, “cab anywhere” UNISIG-CR 1367) APS@Support different ATO levels (GoA1 – GoA4) APS@Support automated coupling APS@Support connectionless communication also via FRMCS
	PE	O-PE@Support automated coupling and decoupling of Physical Train Units O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and a mixed level approach
#A.P.M. shall introduce the asset management excellence of digital systems	A.P.M.	A.P.M.@Asset management must support the demand for high-cadence asset modification A.P.M.@Demonstrably successful best practices in software development for highly available systems should be applied
	PE	O-PE@Enable changes, adaptations and extensions throughout the life cycle of the building blocks
		O-PE@The building blocks and their interfaces should have as little version de-pendency as possible
	APS	APS@Enable changes, adaptations and extensions throughout the life cycle of the building blocks APS@The building blocks and their interfaces should have as little version depend-ency as possible
	MAP	MO13@Frequently provide Map Data to ensure safety and high-cadence asset modification MO16@Allow partial Map Data update
#A.P.M. shall offer detailed production data to various automation systems	PE	O-PE@Provide information required for the operation of the RCA system
	APS	APS@Provide real-time Operating State
#achieve reliability for the Map Data for safe applications	MAP	MO08@Provide reliable Map Data reflecting the actual topology
#adaptable intelligent interface strategies	PE	O-PE@Support clearly designed and robust interfaces for fully automated data ex-change
	A.P.M.	A.P.M.@The overall system should be as robust as possible against version changes and missing information A.P.M.@Use interfaces with automatic adaptions and internal intelligence for inter-facing different versions of building blocks without the need of upgrade existing building blocks based on change in interface
	PE	O-PE@Process (partly automated) alarms regarding hazardous situations

Business target	Concept	Objective
#Advanced situation specific safety-pattern recognition	APS	APS@Identify safety rule violations during runtime and initiate safety measures in order to mitigate safety hazards APS@Event patterns for the identification of safety rule violations shall be configurable including the required safety measure
#all railway operations for mainline, regional or urban railways.	APS	APS@Provide Ability for safe train movement on arbitrary railway network topologies with at least one clear-track signalling or localisation technology installed APS@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network APS@Support the configuration of national specific operating rules
	PE	O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and mixed level operation
	MAP	MO06@Flexible distribution of Map Data to On-board systems for different railway operations (mainline, highspeed, region, urban railways)
#Allow an instant network wide continuous improvement of the trackside CCS subsystem	PE	O-PE@Support the adaptability of business logic to national specific operating rules O-PE@Ensure network wide adaptability towards changes of the trackside CCS SubSys O-PE@Introduce generic capability-based interfaces (architectural design pattern that is building on interface segregation and version capability mapping)
	APS	APS@Ensure network wide adaptability towards changes of the trackside CCS SubSys APS@Introduce generic capabilitiy-based interfaces (architectural design pattern that is building on interface segregation and version capability mapping)
	MAP	MO04@Efficient distribution of Map Data to Trackside Systems
#allowing PE the detailed but supervised control over all actuator capabilities	APS	APS@Ensure safeguarding of all movements on railway tracks within a geographical region APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Request the driveability and flank protection state of field elements of the railway network to execute Operational Movements O-PE@Request Movement Permissions for Physical Train Units to execute Operational Movements
#any movements shall be performed on the highest level of supervision and only risk mitigation measures shall be taken into	APS	APS@Grant movements considering the operational needed safety level and the possible risk mitigation measures
	PE	O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures

Business target	Concept	Objective
account for securing the movement itself		
#The software-to-hardware-dependency for central A.P.M. systems shall be reduced to a level to decouple this relation (life cycle) where it is economically reasonable	A.P.M.	A.P.M.@Allow different system layouts from decentralized to highly centralized safe computing with virtualization and container technologies, n-modular redundancy, fast disaster recovery, multi-tenant and multi-company cloud structures A.P.M.@Handle internal failures and degraded modes efficiently
	PE	O-PE@Handle failures and degraded modes of the Planning System efficiently O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Support independent updateability of HW and SW and Engineering Data
	APS	APS@Ensure the generation of a fail-safe operating state after a reboot APS@Support independent updateability of Hardware, Software and Engineering Data APS@Handle failures and degraded modes of other RCA SubSys efficiently
#A.P.M.shall compensate missing capabilities automatically by for example reducing speeds or avoiding too small distances between trains	PE	O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures O-PE@Handle failures and degraded modes of the railway network efficiently O-PE@Handle failures and degraded modes of Physical Train Units efficiently O-PE@Handle failures and degraded modes of the Planning System efficiently O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Handle internal failures and degraded modes efficiently O-PE@Introduce generic capability-based interfaces
	APS	APS@Minimize the transfer of one or many safety responsibilities to a human operator even in degraded situations APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components
#APS allows to combine different sensors to get the full occupation and speed information	APS	APS@Support different localisation systems and localisation technologies for trackbound and non-trackbound objects in order to represent safely non-occupied track segments APS@Ensure integration of new localisation technologies that will only emerge in next future years APS@Support EULYNX standards for interfacing with field elements via Object Controller
	PE	O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units.
#APS does not support a traditional logic for lineside signalling	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Ensure interface compatibility to legacy interlocking systems still equipped with lineside signalling APS@Support lineside signals at Area of Control transitions to and from legacy interlocking/RBC systems APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation)
	MAP	MO07@Define standard interface for engineering data according RCA specifics

Business target	Concept	Objective
	PE	O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension.
#APS only as a “gatekeeper check function for safety”	APS	APS@Build a system that doesn’t consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic) APS@Publish safety rules and config data towards operational level
	PE	O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS
#APS shall allow the installation of new network or train elements in small steps “nearly on the fly”.	APS	APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation APS@Consider train specific characteristics when granting movements APS@Support interfacing to additional field elements during runtime
	MAP	MO01@Provide Map Data versions for testing without impact on operation MO02@Efficient PREP processes and tools with highest economical grade of automation MO03@Efficient distribution of Map Data to On-board Systems MO04@Efficient distribution of Map Data to Trackside Systems
	PE	O-PE@Support efficient and safe update of Map Data Version during runtime O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units.
#APS shall be safely assured with the ability to assure dynamically the same high safety level for every type of topology or function layout of the track	APS	APS@Ensure safeguarding of movements for any railway network topology that is compliant to the safety-related application conditions APS@Use the same high parameterisable safety level for any railway network topology (includes safe control at any time of existing and interfaced trackside assets) APS@Ensure process and system independence (control safe usage of track section regardless of how the rail network topology is physically realised)
	MAP	MO08@Provide reliable Map Data reflecting the actual topology
	PE	O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units.
#PE & APS shall support warning functions	APS	APS@Prevent granting a movement over predefined geometrical areas without prior warnings to track workers APS@Provide functionality to define geometrical extents for warning areas within the Area of Control APS@Support interfacing with existing warning systems for track workers
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated)
#A.P.M. shall provide reliable information	APS	APS@Support interfacing with existing warning systems for track workers

Business target	Con-cept	Objective
about the production status around persons on the track for their local safety systems		APS@Enable automatic warnings areas and movement limitations without the need for manual interactions APS@Provide operating state towards mobile devices
#A.P.M. shall support the replacement of a large set of trackside assets for large areas (e.g. keeping track of the asset test status over months or supporting forward-and-backward switching of lines)	APS	APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation
	MAP	MO01@Provide Map Data versions for testing without impact on operation MO02@Efficient PREP processes and tools with highest economical grade of automation MO04@Efficient distribution of Map Data to Trackside Systems
	PE	O-PE@Support efficient and safe update of Map Data Version during runtime
#A.P.M. shall support to integrate track worker safety as an efficient automated process seamless into the production CCS process	APS	APS@Prevent granting a movement over predefined geometrical areas without prior warnings to track workers APS@Provide functionality to define geometrical extents for warning areas within the Area of Control APS@Provide operating state towards mobile devices
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated)
#A.P.M. shall use modern dynamically scalable computing resources for central functions	APS	APS@Allow flexible adaption to data volumes and frequencies without the need to change the code basis APS@Allow flexible adaption to data volumes and frequencies without violating the RAMSS specifications
	PE	O-PE@Allow flexible adaption to data volumes and frequencies without the need to change the code basis O-PE@Allow flexible adaption to data volumes and frequencies without violating the RAMSS specifications
	MAP	MO18@Support scalable and robust architecture
#APS shall only have one future oriented interface to Plan Execution	APS	APS@Develop and commission standard interfaces APS@Support the segmentation of Map data in order to define Areas of Control of an APS APS@Support the AoC segment size of the interfaced Plan Exection
#simplify the RAMSS controlling for the development process und the RAMSS	A.P.M.	A.P.M.@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys

Business target	Concept	Objective
change impact analysis	APS	APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
	MAP	MO05@Minimize engineering efforts
	PE	O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance O-PE@Implement specific unscheduled manual operations which require up to SIL 2 within GUI-Application of SubSys WB (stationary or mobile) separated via SWI-PE from SubSys PE
#Automated integration	APS	APS@Disclose incompatibilities between building blocks and SubSys and their interfaces (i.e. incompatible software versions, incompatible protocol versions) APS@Incompatibility between an interconnected field element must not violate the SubSys' RAMSS requirements
	PE	O-PE@The building blocks and their interfaces should have as little version dependency as possible
#avoid physical trackside assets	MAP	MO07@Define standard interface for engineering data according RCA specifics MO12@Provide Map Data for enhanced localization with reduced number of physical balises
	PE	O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension. O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units.
	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Allow the replacement of different trackside devices implementations that comply to the standardised (transactor) interfaces with other implementations without effort APS@Usage of different train localisation technologies for reduction of costs for trackside train detection system APS@Support continuous and uninterrupted localisation of train units ("always on") APS@Reduction of CCS trackside equipment on a needed level for operation by gaining capacity not only with standard CCS trackside enhancements (e.g. trackside train detection sections, shorter pre-set routes)
#Better traffic flow near to construction sites by seamless integration of mobile / temporary CCS assets	MAP	MO02@Efficient PREP processes and tools with highest economical grade of automation MO04@Efficient distribution of Map Data to Trackside Systems MO13@Frequently provide Map Data to ensure safety and high-cadence asset modification

Business target	Concept	Objective
	APS	APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation APS@Support interfacing to additional field elements during runtime APS@Provide real-time Operating State
	PE	O-PE@Provide information required for the operation of the RCA system O-PE@Support efficient and safe update of Map Data Version during runtime
#assuring security and avoiding damage from cyberattacks	A.P.M.	A.P.M.@Use secure standard protocols A.P.M.@Avoid unnecessary authorisation by building trusted clusters A.P.M.@Support the integration with state of the art identity and access management service A.P.M.@Ensure security by design for all SubSys and data flows according to RCA
#build on common communication technologies	APS	APS@Presuppose the existence of a radio-based Train Control System (ETCS) assuming a continuous communication connection to each train on-board unit APS@Support FRMCS for communication between track side and on-board
#By applying a full standard , the pure check between correct deployed on-board and trackside systems must be possible	A.P.M.	A.P.M.@ Accompanying standardisation to reduce system compatibility testing between on-board and trackside
#capability-matching	PE	O-PE@The building blocks and their interfaces should have as little version dependency as possible
	APS	APS@Disclose incompatibilities between building blocks and SubSys and their interfaces (i.e. incompatible software versions, incompatible protocol versions) APS@Incompatibility between an interconnected field element must not violate the SubSys' RAMSS requirements
	MAP	MO18@Support scalable and robust architecture
#Capacity shall in terms of CCS only be dominated by the abilities of the trains and the physical track layout	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Only current occupancy claims and usage restrictions that forbid any movements shall hinder a movement APS@Consider train specific characteristics when granting movements
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension.
	MAP	MO03@Efficient distribution of Map Data to On-board Systems

Business target	Concept	Objective
#capitalize continuous precise on-board localisation		MO06@Flexible distribution of Map Data to On-board systems for different railway operations (mainline, highspeed, region, urban railways) MO15@Support localization by On-board Map in any operational mode
	APS	APS@Consider continuous precise on-board localisation information (speed/extent) APS@Enable cab-signalling for all movements APS@Implement full supervision of all movements, also shunting APS@Allow safe movements also when train characteristic are unknown APS@Support continuous and uninterrupted localisation of train units (“always on”) APS@Usage of different train localisation technologies for reduction of costs for trackside train detection system
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Provide information required for the operation of the RCA system O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension. O-PE@Receive and process initial and update requests for Operational Plans
#capitalize directly the capacity advantage of new trains that already know their integrity and safe length	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension. O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units. O-PE@Receive and process initial and update requests for Operational Plans
	APS	APS@Provide a set of safety functions with a basic configuration that enables safe railway operation APS@Provide a uniform user operating concept, independent of the site-specific rail network APS@Enable implementation of APS on existing track layout without changing it APS@Clear secured route path immediately when clearance has been identified (i.e. using safe train length, localisation tag) in order to maximise track capacity APS@Support future train integrity and safe length information from the very beginning
#changes can be done for smaller parts of installations	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfacesMO16@Allow partial Map Data update MO18@Support scalable and robust architecture

Business target	Con-cept	Objective
	APS	APS@Support published changes in Map Data (new, change, delete) during runtime without impact on operation APS@Separate trackside assets from interlocking software APS@Enable changes, adaptations and extensions throughout the life cycle of the building blocks APS@The building blocks and their interfaces should have as little version dependency as possible
	A.P.M.	A.P.M.@Build a modular system architecture that supports different lifecycles A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys.
	PE	O-PE@Support efficient and safe update of Map Data Version during runtime O-PE@Enable changes, adaptations and extensions throughout the life cycle of the building blocks O-PE@The building blocks and their interfaces should have as little version dependency as possible
#changes in safety cases shall not be mandatory or necessary when a change of component versions happens	APS	APS@Allow the replacement of components without changing the system safety case APS@Support interfacing to additional field elements during runtime APS@The building blocks and their interfaces should have as little version dependency as possible APS@There shall be no need to restart SubSys APS when interfaced component versions change
	PE	O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance
#cheap upgradeability	APS	APS@The building blocks and their interfaces should have as little version dependency as possible APS@Develop and commission standard interfaces APS@Support the change of a SubSys' software version during runtime without affecting the RAMS specification
	PE	O-PE@Support independent updateability of HW and SW and Engineering Data O-PE@Enable changes, adaptations and extensions throughout the life cycle of the building blocks O-PE@The building blocks and their interfaces should have as little version dependency as possible
	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces MO18@Support scalable and robust architecture
#Closing the existing gaps in the full supervision by functions and not by operational specific measures	APS	APS@Allow safe movements also when train characteristic are unknown APS@Support continuous and uninterrupted localisation of train units ("always on") APS@Support the aggregation of multiple localisation information in order to represent the entire occupancy claim of train units APS@Enable cab-signalling for all movements APS@Usage of different train localisation technologies for reduction of costs for trackside train detection system

Business target	Concept	Objective
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension.
#communication for track worker access to the track or trackside assets shall be automated	APS	APS@Support safe entry and exit from a construction site or maintenance location for track worker and machinery APS@Interface with mobile devices in order to confirm the removal of a usage restriction area APS@Interface with mobile devices in order to represent safely the existence of a usage restriction area
	PE	O-PE@Implement specific unscheduled manual operations which require up to SIL 2 within GUI-Application of SubSys WB (stationary or mobile) separated via SWI-PE from SubSys PE
#compensate (temporarily) missing capabilities of a system by a reduced form of interaction	APS	APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components
	PE	O-PE@Handle failures and degraded modes of the railway network efficiently O-PE@Handle failures and degraded modes of Physical Train Units efficiently O-PE@Handle failures and degraded modes of the Planning System efficiently O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Handle internal failures and degraded modes efficiently
#Components should expose the minimal and necessary information	APS	APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components APS@Disclose incompatibilities between building blocks and SubSys and their interfaces (i.e. incompatible software versions, incompatible protocol versions)
	PE	O-PE@Handle internal failures and degraded modes efficiently
#Components should retrieve on runtime what service is possible by other components and be flexible to make use of different service offers or to combine them.	APS	APS@Demonstrate safety within the building blocks including its interface without knowledge or need of assumptions on the function of further building blocks behind the interface APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components
	PE	O-PE@Handle failures and degraded modes of other RCA SubSys efficiently
#frame conditions (radio-based ETCS, different types of railway	APS	APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation) APS@Support only of ETCS Level 2, 3 and mixed level operation (i.e. hybrid train detection) on the same line

Business target	Concept	Objective
lines, modular migration, ATO up to GoA4)		APS@Provide Ability for safe train movement on arbitrary railway network topologies with at least one clear-track signalling or localisation technology installed APS@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network APS@Minimize the transfer of one or many safety responsibilities to a human operator even in degraded situations APS@Enable usage of mix of different ETCS OBU system versions (migration facilitation) APS@Support different ATO levels (GoA1 – GoA4)
	PE	O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and a mixed level operation
	MAP	MO05@Minimize engineering efforts
#create the potential for a broader market offer by more specialized companies	A.P.M.	A.P.M.@Standardize all main CCS processes, functionalities and interfaces A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys. A.P.M.@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance A.P.M.@Build a modular system architecture that supports different lifecycles
#cross-border operation in European corridors	APS	APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation) APS@Support only of ETCS Level 2, 3 and mixed level operation (i.e. hybrid train detection) on the same line APS@Support safe handovers of movements from and to adjacent legacy safety systems
	MAP	MO17@Ensure interoperability for provisioning of On-board Map Data
	PE	O-PE@Support handovers of Operational Movements from and to adjacent SubSys Plan Execution O-PE@Support handovers of Operational Movements from and to adjacent legacy CTC systems
#data preparation synergy	A.P.M.	A.P.M.@All building blocks shall utilise an identical MAP data reference, provided by each MAP data version in order to prevent interpretation efforts
	MAP	MO02@Efficient PREP processes and tools with highest economical grade of automation MO08@Provide reliable Map Data reflecting the actual topology MO11@Define standard interfaces for provisioning of Map Data to RCA trackside and on-board systems
#Decouple different types of life cycles	A.P.M.	A.P.M.@Enable changes, adaptations and extensions throughout the life cycle of the building blocks A.P.M.@Overlapping technology lifecycle profiles must be respected by the system design

Business target	Concept	Objective
		A.P.M.@Exchangeability between building blocks must be present wherever non-overlapping technology lifecycle profiles are present
#dependency reduction between components in general from a functional and safety level point of view	A.P.M.	A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys. A.P.M.@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance
	APS	APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components APS@Allow the replacement of components without changing the system safety case APS@Support interfacing to additional field elements during runtime APS@The building blocks and their interfaces should have as little version dependency as possible APS@There shall be no need to restart SubSys APS when interfaced component versions change
	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces
	PE	O-PE@Reduce the RAMS requirements of the Planning System O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Support standalone usage of ATO without A.P.M. O-PE@Implement specific unscheduled manual operations which require up to SIL 2 within GUI-Application of SubSys WB (stationary or mobile) separated via SWI-PE from SubSys PE
#detailed production status to PE/TMS	APS	APS@Provide real-time Operating State
#device function abstraction	APS	APS@Support EULYNX standards for interfacing with field elements via Object Controller
	PE	O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units.
	MAP	MO05@Minimize engineering efforts
#dynamically scalable architecture	APS	APS@The building blocks and their interfaces should have as little version dependency as possible
	PE	O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units. O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems O-PE@Provide functionality to operate APS fully automated, half automated or manually

Business target	Con-cept	Objective
		O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and mixed level operation O-PE@Support standalone usage of ATO without A.P.M. O-PE@Support handovers of Operational Movements from and to adjacent legacy CTC systems. O-PE@Support operation of an entire geographical rollout segment O-PE@Support independent updateability of HW and SW and Engineering Data O-PE@Support clearly designed and robust interfaces for fully automated data exchange O-PE@Ensure network wide adaptability towards changes of the trackside CCS SubSys
	MAP	MO18@Support scalable and robust architecture
#enable smart TMS optimizers to tune the traffic flow dynamically by using algorithms based and detailed production data recording	APS	APS@Provide real-time Operating State
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Provide information required for the operation of the RCA system O-PE@Receive and process initial and update requests for Operational Plans
#enable the TMS to precisely steer	APS	APS@Provide real-time Operating State
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Provide information required for the operation of the RCA system
	MAP	MO08@Provide reliable Map Data reflecting the actual topology
#Enable TMS to control the precise optimal speed (curve)	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Receive and process initial and update requests for Operational Plans
	MAP	MO08@Provide reliable Map Data reflecting the actual topology
#every change of track or CCS functions is proven as handled safe by APS in general.	APS	APS@Separate railway network topology data from functional code APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation APS@Regard Map data as fail safe APS@Enable changes, adaptations and extensions throughout the life cycle of the building blocks APS@Enable a safe system and its safety assurance based on building blocks APS@The integration of building blocks with their own safety assurance shall result in a secure system that does not require further safety assurances.

Business target	Concept	Objective
	MAP	MO08@Provide reliable Map Data reflecting the actual topology
#exact train data getting available (speed, position, type)	APS	APS@Provide real-time Operating State
	PE	O-PE@Provide information required for the operation of the RCA system
#fast recovery	A.P.M.	A.P.M.@Support of self/remote diagnostics A.P.M.@Support fast module replacement A.P.M.@Handle internal failures and degraded modes efficiently
	APS	APS@Ensure the generation of a fail-safe operating state after a reboot APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components
	PE	O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Handle internal failures and degraded modes efficiently
#faster adaptation of infrastructure to operational needs	A.P.M.	A.P.M.@Support a broad applicability to different railways and in various types of traffic and operational processes
	APS	APS@Support published changes in Map Data (new, change, delete) during runtime without impact on operation APS@Use standard interface towards Field Elements to separate the lifecycles of hardware and software components APS@Implement a strict object aggregation for enabling of usage of different information sources and simplification of interfaces within the system and future adjacent systems (avoid the need to implement a logic knowing exact behaviour of interfacing parts)
	PE	O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension. O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units. O-PE@Receive and process initial and update requests for Operational Plans
	MAP	MO02@Efficient PREP processes and tools with highest economical grade of automation MO11@Define standard interfaces for provisioning of Map Data to RCA trackside and on-board systems
#flexible operational alternatives	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Provide information required for the operation of the RCA system O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension. O-PE@Handle failures and degraded modes of the railway network efficiently O-PE@Handle failures and degraded modes of Physical Train Units efficiently

Business target	Concept	Objective
		O-PE@Receive and process initial and update requests for Operational Plans
#Flexible safety pattern configuration	APS	APS@Provide a set of safety functions with a basic configuration that enables safe railway operation APS@Identify safety rule violations during runtime and initiate safety measures in order to mitigate safety hazards APS@Enable individual adaptation of the basic configuration without having to adapt the safety case and the functionality of a component for it
	PE	O-PE@Consider safety rules of SubSys SL
#full automation of infrastructure and vehicle operation	APS	APS@Provide a set of safety functions with a basic configuration that enables safe railway operation APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Minimize the transfer of one or many safety responsibilities to a human operator even in degraded situations APS@Support different ATO levels (GoA1 – GoA4)
	PE	O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and mixed level operation
#functionality shall be reduced to an absolute minimum of necessary safety functions	A.P.M.	A.P.M.@Design a modular system architecture with small as possible amount of safety relevant components
	APS	APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@Delegate non-safety relevant functions to planning system
	PE	O-PE@Execute Operational Plans considering the operationally needed safety level and the possible risk mitigation measures O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance
#generic hazard management for the generic application is ensured on European level	APS	APS@Consider hazards of current solutions and reduce impact through system design APS@Perform generic hazard management by an overall system authority APS@Reduce need of Infrastructure Manager related hazard evaluation
	PE	O-PE@Implement specific unscheduled manual operations which require up to SIL 2 within GUI-Application of SubSys WB (stationary or mobile) separated via SWI-PE from SubSys PE
#generic risk pattern recognition	APS	APS@Enable individual adaptation of the basic configuration without having to adapt the safety case and the functionality of a component APS@Identify safety rule violations during runtime and initiate safety measures in order to mitigate safety hazards

Business target	Con-cept	Objective
#generic standardised safety check function with a generic safety assurance	APS	APS@Enable a safe system and its safety assurance based on building blocks APS@Demonstrate safety within the building blocks including its interface without knowledge or need of assumptions on the function of further building blocks behind the interface APS@Minimise effort for safety assurance APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@The integration of building blocks with their own safety assurance shall result in a secure system that does not require further safety assurances.
#guarantee high reliability by redundant central systems	APS	APS@Ensure the generation of a fail-safe operating state after a reboot APS@Support independent updateability of Hardware, Software and Engineering Data APS@Handle internal failures and degraded modes efficiently
	PE	O-PE@Handle internal failures and degraded modes efficiently O-PE@Support independent updateability of HW and SW and Engineering Data O-PE@Guarantee high availability (99.95%)
#hardware abstraction	APS	APS@Support independent updateability of Hardware, Software and Engineering Data
#harmonized operational concept	APS	APS@Enable cab-signalling for all movements APS@Implement full supervision of all movements, also shunting APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Enable usage of train length and integrity information for optimised track occupancy without the restriction of fixed signalling blocks and/or train detection sections
	PE	O-PE@Provide information required for the operation of the RCA system
#high grade of operational automation	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Provide real-time Operating State APS@Minimize the transfer of one or many safety responsibilities to a human operator even in degraded situations APS@Support different ATO levels (GoA1 – GoA4)
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully auto-mated) O-PE@Provide functionality to operate APS fully automated, half automated or manually
#Highly efficient platform track usage or shunting without special installations	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Support different localisation systems and localisation technologies for trackbound and non-trackbound objects in order to represent safely non-occupied track segments APS@Enable cab-signalling for all movements APS@Implement full supervision of all movements, also shunting

Business target	Con-cept	Objective
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully auto-mated) O-PE@Receive and process initial and update requests for Operational Plans
#impact of changes is automated or strongly supported by auto-mated toolchains and recognisable by the safety supervision de-partments of the oper-ator and the authori-ties as well	APS	APS@Capturing of operational data covering RAMSS performance requirements and assumptions during operation APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance
#impact resolution au-tomation	A.P.M.	A.P.M.@Use interfaces with automatic adaptions and internal intelligence for inter-facing different versions of building blocks without the need of upgrade existing building blocks based on change in interface
#implement all prepa-ration and automation processes in the archi-tecture layers above APS	APS	APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
	PE	O-PE@Provide information required for the operation of the RCA system O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Ele-ments and Physical Train Units.
	MAP	MO02@Efficient PREP processes and tools with highest economical grade of auto-mation MO08@Provide reliable Map Data reflecting the actual topology
#Increase the traffic density by reducing the train ahead times	APS	APS@Enable usage of train integrity information for optimised track occupancy with-out the restriction of fixed signalling blocks APS@Provide real-time Operating State APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Clear secured route path immediately when clearance has been identified (i.e. using safe train length, localisation tag) in order to maximise track capacity APS@Usage of different train localisation technologies for reduction of costs for trackside train detection system APS@Support continuous and uninterrupted localisation of train units ("always on")
	PE	O-P: Ensure the precise implementation of Operational Plans for Operational Move-ments, Operational Restrictions and Operational Warning Measures (fully auto-mated) O-PE@Provide information required for the operation of the RCA system O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension O-PE@Receive and process initial and update requests for Operational Plans
#intelligent incident handling	APS	APS@Identify safety rule violations during runtime and initiate safety measures in order to mitigate safety hazards

Business target	Concept	Objective
		APS@Provide measures to reduce hazard when safety rule violation is identified APS@Provide real-time Operating State
	PE	O-PE@Handle failures and degraded modes of the railway network efficiently O-PE@Handle failures and degraded modes of Physical Train Units efficiently O-PE@Handle failures and degraded modes of the Planning System efficiently O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Handle internal failures and degraded modes efficiently
#interface segregation	MAP	MO07@Define standard interface for engineering data according RCA specifics MO10@Ensure modularity and modifiability for MAP systems and interfaces MO11@Define standard interfaces for provisioning of Map Data to RCA trackside and on-board systems
	APS	APS@Encapsulate minimal viable functionalities in building blocks to enable an individual configuration of the building blocks and simple interfaces APS@The building blocks and their interfaces should have as little version dependency as possible A.P.M.@Exchangeability between building blocks must be present wherever non-overlapping technology lifecycle profiles are present
	PE	O-PE@Support clearly designed and robust interfaces for fully automated data exchange
#Interface to traditional interlockings/RBC and to other APS	APS	APS@Consider open interfaces to integrate as much formats as possible APS@Ensure interface compatibility to legacy interlocking systems still equipped with lineside signalling APS@Support the transition of a train movement between a legacy interlocking/RBC and an APS Area of Control in both directions without limiting operation
	PE	O-PE@Support the segmentation of the Area of Control of the Planning System O-PE@Support handovers of Operational Movements from and to adjacent legacy CTC systems
#Large platforms shall be avoided	A.P.M.	A.P.M.@Provide scalable system architecture to be used in a modular way depending on local needs A.P.M.@Use interfaces with automatic adaptions and internal intelligence for interfacing different versions of building blocks without the need of upgrade existing building blocks based on change in interface A.P.M.@Allow different system layouts from decentralized to highly centralized safe computing with virtualization and container technologies, n-modular redundancy, fast disaster recovery, multi-tenant and multi-company cloud structures
#LCC-based RAMSS scalability	A.P.M.	A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys. A.P.M.@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance
#low rate of wrong decisions	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Provide real-time Operating State

Business target	Con-cept	Objective
		APS@Minimize the transfer of one or many safety responsibilities to a human operator even in degraded situations
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Consider safety rules of SubSys SL O-PE@Minimize the transfer of safety responsibilities to a human operator even in degraded situations O-PE@Provide functionality to operate APS fully automated, half automated or manually
#migration strategy reaching a unified technical base	APS	APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation) APS@Support only of ETCS Level 2 and 3 (also mixed on the same line APS@Enable implementation of APS on existing track layout without changing it APS@Support EULYNX standards for interfacing with field elements via Object Controller
	A.P.M.	A.P.M.@Avoid temporary investments (e.g. avoid temporary interfaces between old and new interlockings by supporting technically the efficient and stable replacement of full lines by just replacing safety logic but not the OC)
	PE	O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems O-PE@ Develop RCA SubSys according to EN 50128 and EN 50126-1 O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network
#Migration support for existing TMS	PE	O-PE@Support migration for different expansion stages of Planning Systems
#Migration support to connect to existing interlockings/RBC	APS	APS@Consider open interfaces to integrate as much formats as possible APS@Ensure interface compatibility to legacy interlocking systems still equipped with lineside signalling APS@Support the transition of a train movement between a legacy interlocking/RBC and an APS Area of Control in both directions without limiting operation
#mix of different ETCS baselines	APS	APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation) APS@Support only of ETCS Level 2, 3 and mixed level operation (i.e. hybrid train detection) on the same line
	PE	O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network
#modern and proven ICT architecture, maintenance, and deployment strategies	APS	APS@Allow flexible adaption to data volumes and frequencies without the need to change the code basis APS@Allow flexible adaption to data volumes and frequencies without violating the RAMSS specifications
	PE	O-PE@Support independent updateability of HW and SW and Engineering Data
#more assistance	A.P.M.	A.P.M.@Implement ATO GoA2 or GoA3-4

Business target	Concept	Objective
	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Minimize the transfer of one or many safety responsibilities to a human operator even in degraded situations APS@Support different ATO levels (GoA1 – GoA4) APS@Support automated coupling APS@Identify safety rule violations during runtime and initiate safety measures in order to mitigate safety hazards APS@Provide measures to reduce hazard when safety rule violation is identified
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Support automated coupling and decoupling of Physical Train Units O-PE@Handle failures and degraded modes of the railway network efficiently O-PE@Handle failures and degraded modes of Physical Train Units efficiently O-PE@Handle failures and degraded modes of the Planning System efficiently O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Handle internal failures and degraded modes efficiently O-PE@Minimize the transfer of safety responsibilities to a human operator even in degraded situations O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and mixed level operation O-PE@Support efficient and safe update of Map Data Version during runtime O-PE@Process (partly automated) alarms regarding hazardous situations
#Movement permissions are requested and granted in that moment when they are really needed	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated)
	APS	APS@Ensure safeguarding of movements for any railway network topology that is compliant to the safety relevant application conditions APS@Implement full supervision of all movements, also shunting
#Much less ETCS balises	APS	APS@Support different localisation systems and localisation technologies for trackbound and non-trackbound objects in order to represent safely non-occupied track segments APS@Ensure integration of new localisation technologies that will only emerge in next future years APS@Support continuous and uninterrupted localisation of train units (“always on”)
	MAP	MO12@Provide Map Data for enhanced localization with reduced number of physical balises

Business target	Con-cept	Objective
#Much less trackside train detection sys-tems	APS	APS@Support different localisation systems and localisation technologies for track-bound and non-trackbound objects in order to represent safely non-occupied track segments APS@Ensure integration of new localisation technologies that will only emerge in next future years APS@Support continuous and uninterrupted localisation of train units (“always on”) APS@Enable usage of train integrity information for optimised track occupancy with-out the restriction of fixed signalling blocks APS@Ensure localisation precision and safety with (only) on-board position reporting
	PE	O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units.
#New train types and their specific detailed constraints, proper-ties, weaknesses, or strengths concerning the safe production (e.g. braking capacity) can be introduced to the full network in one (central) step and can be validated or meas-ured on runtime	APS	APS@Enable individual adaptation of the basic configuration without having to adapt the safety case and the functionality of a component for it APS@Consider train specific characteristics when granting movements
	PE	O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Ele-ments and Physical Train Units.
#No lineside light sig-nals	APS	APS@Enable cab-signalling for all movements APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Ensure interface compatibility to legacy interlocking systems still equipped with lineside signalling APS@Support lineside signals at Area of Control transitions to and from legacy in-terlocking/RBC systems
	PE	O-PE@Execute Operational Plans by requesting Movement Permissions with any operationally appropriate geometric extension
	MAP	MO07@Define standard interface for engineering data according RCA specifics
#no movements cate-gories necessary like “shunting” with special modes	APS	APS@Enable cab-signalling for all movements APS@Implement full supervision of all movements, also shunting APS@Allow safe movements also when train characteristic are unknown APS@Support continuous and uninterrupted localisation of train units (“always on”)
	PE	O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures
#No shunting signals	APS	APS@Enable cab-signalling for all movements APS@Implement full supervision of all movements, also shunting APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals

Business target	Con-cept	Objective
	PE	O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures
	MAP	MO07@Define standard interface for engineering data according RCA specifics
#No unnecessary loss of capacity at points on the track where the speed limit changes	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Consider speed limitations only on the specific geometric extent
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully auto-mated) O-PE@Receive and process initial and update requests for Operational Plans
#No unnecessary use or worst-case safety constraints in the op-erational process	PE	O-PE@Handle failures and degraded modes of the railway network efficiently O-PE@Handle failures and degraded modes of Physical Train Units efficiently O-PE@Handle failures and degraded modes of the Planning System efficiently O-PE@Handle failures and degraded modes of other RCA SubSys efficiently O-PE@Handle internal failures and degraded modes efficiently
	APS	APS@Minimize the transfer of one or many safety responsibilities to a human oper-ator even in degraded situations APS@Ensure functionality even in case of incomplete information due to limited func-tionality of interfaced components APS@Minimize the transfer of one or many safety responsibilities to a human oper-ator even in degraded situations
	MAP	MO20@Handle internal failures and degraded modes efficiently
#not generate needs for voice communica-tion	A.P.M.	A.P.M.@several modes for degraded operation ensuring a high-level of safety and a high-level of operational system must be implemented by design A.P.M.@Handle internal failures and degraded modes efficiently A.P.M.@Malfunctioning of system components shall not lead to a shutdown of the system A.P.M.@several modes for degraded operation ensuring a high-level of safety and a high-level of operational system must be implemented by design
#Obsolescence shall lead most often to “simple exchange” from the standard in-terface perspective in-stead of “change of configuration”	APS	APS@The building blocks and their interfaces should have as little version depend-ency as possible APS@Support exchange of hardware and software with the same functionality treated as 1:1 maintenance with less need of system approval
	PE	O-PE@Support clearly designed and robust interfaces for fully automated data ex-change
#old compatible with new	MAP	MO07@Define standard interface for engineering data according RCA specifics MO19@Integrate legacy systems into On-board Map Data publishing MO22@Integrate legacy systems into Trackside Map Data publishing
	APS	APS@Ensure interface compatibility to legacy interlocking systems still equipped with lineside signalling APS@Consider open interfaces to integrate as much formats as possible

Business target	Concept	Objective
		APS@Use interfaces with automatic adaptions and internal intelligence for interfacing different versions of building blocks without the need of upgrade existing building blocks based on change in interface APS@Support EULYNX standards for interfacing with field elements via Object Controller APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation)
	PE	O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems
#only needs actual topology and train information	APS	APS@Ensure safeguarding of movements for any railway network topology that is compliant to the safety relevant application conditions APS@Use the same high parameterisable safety level for any railway network topology (includes safe control at any time of existing and interfaced trackside assets) APS@Ensure process and system independence (control safe usage of track section regardless of how the rail network topology is physically realised) APS@Provide Ability for safe train movement on arbitrary railway network topologies with at least one clear-track signalling or localisation technology installed APS@Consider train specific characteristics when granting movements
	PE	O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units. O-PE@Support efficient and safe update of Map Data Version during runtime
	MAP	MO02@Efficient PREP processes and tools with highest economical grade of automation MO04@Efficient distribution of Map Data to Trackside Systems MO08@Provide reliable Map Data reflecting the actual topology MO05@Minimize engineering efforts
#plan-based	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Receive and process initial and update requests for Operational Plans
#protocol translation	APS	APS@Deliver transactors to separate and translate formats and protocols and to adapt technologies between APS and assets/sensors
#reduce interface complexity and manual work for data conversion processes	APS	APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@Use standard interface towards Field Elements to separate the lifecycles of hardware and software components
	PE	O-PE@Support clearly designed and robust interfaces for fully automated data exchange
	MAP	MO02@Efficient PREP processes and tools with highest economical grade of automation

Business target	Con-cept	Objective
		MO05@Minimize engineering efforts MO10@Ensure modularity and modifiability for MAP systems and interfaces
#reduce planning, engineering, and authorisation effort by more than 50 %	APS	APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@Use of existing infrastructure without the need of changes/alignment due to the use of APS APS@Enable a safe system and its safety assurance based APS@Support EULYNX standards for interfacing with field elements via Object Controller APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation
	PE	O-PE@Support migration for different expansion stages of Planning Systems O-PE@Guarantee railway operation with a mixed ETCS level approach (L2/L3) of trains and rail network O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and mixed level operation O-PE@Support the adaptability of business logic to national specific operating rules O-PE@Support operation of an entire geographical rollout segment
	MAP	MO01@Provide Map Data versions for testing without impact on operation MO02@Efficient PREP processes and tools with highest economical grade of automation MO05@Minimize engineering efforts
#reduce the safety case effort	APS	APS@Enable changes, adaptations and extensions throughout the life cycle of the building blocks APS@Enable a safe system and its safety assurance based on building blocks APS@Demonstrate safety within the building blocks including its interface without knowledge or need of assumptions on the function of further building blocks behind the interface APS@Minimise effort for safety assurance APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@The integration of building blocks with their own safety assurance shall result in a secure system that does not require further safety assurances.
	PE	O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance
#reduce the size of the “SIL4 layers”	APS	APS@Build a system that doesn’t consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic) APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks
	A.P.M.	A.P.M.@Use standardized processes and systems

Business target	Concept	Objective
#reduce the technical skill demand for IM	APS	APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety approval APS@Encapsulate minimal viable functionalities in building blocks to enable an individual configuration of the building blocks and simple interfaces APS@Demonstrate safety within the building blocks including its interface without knowledge or need of assumptions on the function of further building blocks behind the interface APS@Enable automatic warnings areas and movement limitations without the need for manual interactions APS@Minimize the transfer of safety responsibilities to a human operator even in degraded situations
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Support automated coupling and decoupling of Physical Train Units O-PE@Minimize the transfer of safety responsibilities to a human operator even in degraded situations O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Support different ATO levels (GoA1 – GoA4), ETCS levels (L2/L3) and mixed level operation O-PE@Support efficient and safe update of Map Data Version during runtime O-PE@Process (partly automated) alarms regarding hazardous situations O-PE@Provide data capturing to enable predictive maintenance O-PE@Guarantee high availability (99.95%)
	MAP	MO02@Efficient PREP processes and tools with highest economical grade of automation MO07@Define standard interface for engineering data according RCA specifics MO05 - @Minimize engineering efforts
#reduction of integration effort	APS	APS@Consider open interfaces to integrate as much formats as possible APS@Separate railway network topology data from functional code APS@Use the same high parameterisable safety level for any railway network topology (includes safe control at any time of existing and interfaced trackside assets) APS@Ensure process and system independence (control safe usage of track section regardless of how the rail network topology is physically realised) APS@Use interfaces with automatic adaptions and internal intelligence for interfacing different versions of building blocks without the need of upgrade existing building blocks based on change in interface
	PE	O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems
	MAP	MO07@Define standard interface for engineering data according RCA specifics MO10@Ensure modularity and modifiability for MAP systems and interfaces

Business target	Concept	Objective
		MO11@Define standard interfaces for provisioning of Map Data to RCA track-side and on-board systems
#remote and automated deployment	APS	APS@Ensure the generation of a fail-safe operating state after a reboot APS@Support independent updateability of Hardware, Software and Engineering Data
	PE	O-PE@Support independent updateability of HW and SW and Engineering Data O-PE@Guarantee high availability (99.95%)
	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces MO18@Support scalable and robust architecture
#Requests of any (by TMS) authorized system or person to change or reserve track elements shall be possible in an automated way	APS	APS@Ensure process and system independence (control safe usage of track section regardless of how the rail network topology is physically realised) APS@Enable automatic warnings areas and movement limitations without the need for manual interactions APS@Support safe entry and exit from a construction site or maintenance location for track worker and machinery APS@Interface with mobile devices in order to confirm the removal of a usage restriction area APS@Interface with mobile devices in order to represent safely the existance of a usage restriction area APS@Provide functionality to define geometrical extents for warning areas within the Area of Control APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Provide information required for the operation of the RCA system O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Request the driveability and flank protection state of field elements of the railway network to execute Operational Movements O-PE@Request Movement Permissions for Physical Train Units to execute Operational Movements O-PE@Receive and process initial and update requests for Operational Plans
#Safety is assessed and assured mainly on runtime on the basis of a generic safety function	APS	APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
	PE	O-PE@Reduce the RAMS requirements of the Planning System

Business target	Con-cept	Objective
		O-PE@Execute Operational Plans considering the operationally needed safety level and the possible risk mitigation measures O-PE@Consider safety rules of SubSys SL
	MAP	MO05@Minimize engineering efforts
#Scheduled speed mix (train mix) and form of usage of a track layout can be changed even on runtime	APS	APS@Enable implementation of APS on existing track layout without changing it APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation
#sensor-aggregation-function	APS	APS@Implement a strict object aggregation for enabling of usage of different information sources and simplification of interfaces within the system and future adjacent systems (avoid the need to implement a logic knowing exact behaviour of interfacing parts)
	PE	O-PE@Provide information required for the operation of the RCA system
#shorter headway	APS	APS@Support the securing of route paths with any geometric extension with no need having a fixed start and end point defined by lineside signals APS@Implement full supervision of all movements, also shunting APS@Enable usage of train integrity information for optimised track occupancy without the restriction of fixed signalling blocks
	PE	O-PE@Ensure the precise implementation of Operational Plans for Opera-tional Movements, Operational Restrictions and Operational Warning Measures (fully auto-mated) O-PE@Provide information required for the operation of the RCA system
#Shorter maintenance and construction pos-sessions (blocked tracks) with less im-pact on the bypassing traffic on other tracks	MAP	MO01@Provide Map Data versions for testing without impact on operation MO04@Efficient distribution of Map Data to Trackside Systems MO14@Avoid the need for end-to-end-testing from APS to trackside assets MO16@Allow partial Map Data update
	APS	APS@Enable automatic warnings areas and movement limitations without the need for manual interactions APS@Interface with mobile devices in order to confirm the removal of a usage re-striction area APS@Interface with mobile devices in order to represent safely the existance of a usage restriction area
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully auto-mated) O-PE@Provide information required for the operation of the RCA system

Business target	Concept	Objective
#simple addition of single components under production	APS	APS@Support interfacing to additional field elements during runtime APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation
	PE	O-PE@Support independent updateability of HW and SW and Engineering Data
	MAP	MO01@Provide Map Data versions for testing without impact on operation MO04@Efficient distribution of Map Data to Trackside Systems MO14@Avoid the need for end-to-end-testing from APS to trackside assets
#simple splitting point	A.P.M.	A.P.M.@Build a modular system architecture that is split according to different lifecycles
	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces MO11@Define standard interfaces for provisioning of Map Data to RCA trackside and on-board systems
	APS	APS@The building blocks and their interfaces should have as little version dependency as possible
	PE	O-PE@The building blocks and their interfaces should have as little version dependency as possible
#small safe components	A.P.M.	A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys.
	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces
	APS	APS@Enable a safe system and its safety assurance based on building blocks APS@Minimise effort for safety assurance APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance
	PE	O-PE@Support independent updateability of HW and SW and Engineering Data O-PE@The building blocks and their interfaces should have as little version dependency as possible
#smaller components have a lower complexity	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces
	APS	APS@Minimise effort for safety assurance APS@The integration of building blocks with their own safety assurance shall result in a secure system that does not require further safety assurances.
#software upgradeability for central and decentral components	MAP	MO13@Frequently provide Map Data to ensure safety and high-cadence asset modification MO04@Efficient distribution of Map Data to Trackside Systems
	APS	APS@Support independent updateability of Hardware, Software and Engineering Data

Business target	Concept	Objective
	PE	O-PE@Support independent updateability of HW and SW and Engineering Data
#split/copy/distribute a single command from the Safety Logic to several receivers	APS	APS@Implement a strict object aggregation for enabling of usage of different information sources and simplification of interfaces within the system and future adjacent systems (avoid the need to implement a logic knowing exact behaviour of interfacing parts)
#Standard interface for connecting trackside assets based on EULYNX	APS	APS@Use standard interface towards Field Elements to separate the lifecycles of hardware and software components APS@Develop and commission standard interfaces APS@Support EULYNX standards for interfacing with field elements via Object Controller
	MAP	MO07@Define standard interface for engineering data according RCA specifics MO04@Efficient distribution of Map Data to Trackside SystemsMO11@Define standard interfaces for provisioning of Map Data to RCA trackside and on-board systems
#Standard interface for trackworker safety systems and mobile safety devices	APS	APS@Develop and commission standard interfaces APS@Interface with mobile devices in order to confirm the removal of a usage restriction area APS@Interface with mobile devices in order to represent safely the existance of a usage restriction area
#standard interfaces to reduce integration effort	MAP	MO07@Define standard interface for engineering data according RCA specifics MO11@Define standard interfaces for provisioning of Map Data to RCA trackside and on-board systems
	APS	APS@Develop and commission standard interfaces APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components
#Strong architectural rules to increase the interface release compatibility	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces
	PE	O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems
	APS	APS@The building blocks and their interfaces should have as little version dependency as possible
#Strong functional and technical decoupling	A.P.M.	A.P.M.@Architecture design reduces the functional and non-functional dependencies between the SubSys and thus reduces the functional and non-functional requirements (especially RAMS) for the individual SubSys.
	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces
	PE	O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units

Business target	Con-cept	Objective
		O-PE@Support independent updateability of HW and SW and Engineering Data
	APS	APS@Support independent updateability of Hardware, Software and Engineering Data APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
#strong independency management	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces
	PE	O-PE@Support migration for existing CTC Systems O-PE@Support migration for different expansion stages of Planning Systems O-PE@Provide functionality to operate APS fully automated, half automated or manually O-PE@Support the adaptability of business logic to national specific operating rules O-PE@Support standalone usage of ATO without A.P.M. O-PE@The building blocks and their interfaces should have as little version de-pendency as possible
	APS	APS@The building blocks and their interfaces should have as little version depend-ency as possible
#strong split between functions needed in safety systems and operational functions to be placed in the field of TMS is needed	APS	APS@Apply a generic safety approach in encapsulating smallest possible safety relevant functions in building blocks that allow a separate safety assurance APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic APS@Build a system that doesn't consider in its logic operational implications but only checks for safe operation (separate business logic and safety logic)
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully auto-mated) O-PE@Provide information required for the operation of the RCA system
#The APS shall sup-port TMS with a de-tailed information how every part of the net-work can be used (precise topology state)	MAP	MO08@Provide reliable Map Data reflecting the actual topology MO04@Efficient distribution of Map Data to Trackside Systems MO11@Define standard interfaces for provisioning of Map Data to RCA trackside and on-board systems
	PE	O-PE@Provide information required for the operation of the RCA system O-PE@Support efficient and safe update of Map Data Version during runtime
	APS	APS@Support published changes in Map Data (new, change, delete) during runtime without impact on operation APS@Provide real-time Operating State
#The safe combina-tion of specific track-side assets or train is assessed and decided on runtime	APS	APS@Consider train specific characteristics when granting movements
	PE	O-PE@Provide information required for the operation of the RCA system O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures

Business target	Concept	Objective
#The safety logic of APS shall have a generic approval and authorisation in which it is proven that it just needs a reliable input of topology information and train information	APS	APS@Regard Map data as fail safe APS@Ensure safeguarding of movements for any railway network topology that is compliant to the safety relevant application conditions APS@Use the same high parameterisable safety level for any railway network topology (includes safe control at any time of existing and interfaced trackside assets) APS@Ensure process and system independence (control safe usage of track section regardless of how the rail network topology is physically realised)
	PE	O-PE@Execute Operational Plans considering the operational needed safety level and the possible risk mitigation measures O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units.
	MAP	MO08@Provide reliable Map Data reflecting the actual topology
#track workers shall be automatically detectable (if locatable)	APS	APS@Support different localisation systems and localisation technologies for trackbound and non-trackbound objects in order to represent safely non-occupied track segments
#TSI CCS compatible	APS	APS@Enable usage of mix of different ETCS OBU system versions on line (migration facilitation)
#unified operational processes	MAP	MO05@Minimize engineering efforts MO02@Efficient PREP processes and tools with highest economical grade of automation
	PE	O-PE@Ensure the precise implementation of Operational Plans for Operational Movements, Operational Restrictions and Operational Warning Measures (fully automated) O-PE@Provide information required for the operation of the RCA system O-PE@Implement all functions for the execution of energy-optimal and conflict-free Operating Plans, without support from auxiliary functions of the Planning System or APS O-PE@Execute Operational Plans considering the operationally needed safety level and the possible risk mitigation measures O-PE@Execution of Operational Plans is based on a generic business logic that can handle the specific capabilities and characteristics of the operated Field Elements and Physical Train Units. O-PE@Provide functionality to operate APS fully automated, half automated or manually
#use existing modern (safe) hardware environments that allow centralized and decentralized system topologies	PE	O-PE@Develop RCA SubSys according to EN 50128 and EN 50126-1 O-PE@Achieve the most extensive generic safety assurance possible while minimising the scope of the specific safety assurance O-PE@Support independent updateability of HW and SW and Engineering Data
	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces MO18@Support scalable and robust architecture

Business target	Concept	Objective
#provide high usability for GUI	A.P.M.	A.P.M.@Provide state of the art usability for GUI operations (incl. comfort functions such SSO) A.P.M.@Allow integration of GUI for all APM systems, which allows a cross-system overview and quick change between operated systems A.P.M.@Ensure synchronized state between GUI of all APM systems
#workload can be divided better between more and specialized partners	MAP	MO10@Ensure modularity and modifiability for MAP systems and interfaces
	PE	O-PE@Enable changes, adaptations and extensions throughout the life cycle of the building blocks O-PE@The building blocks and their interfaces should have as little version dependency as possible
	APS	APS@The building blocks and their interfaces should have as little version dependency as possible APS@Enable changes, adaptations and extensions throughout the life cycle of the building blocks
	A.P.M.	A.P.M.@Provide scalable system architecture to be used in a modular way depending on local needs A.P.M.@Standardize all main CCS processes, functionalities and interfaces A.P.M.@Design a modular system architecture with small as possible amount of safety relevant components
#reduced onsite testing	PE	O-PE@Develop RCA SubSys according to EN 50128 and EN 50126-1 O-PE@Support operation of an entire geographical rollout segment
	MAP	MO01@Provide Map Data versions for testing without impact on operation MO08@Provide reliable Map Data reflecting the actual topology MO14@Avoid the need for end-to-end-testing from APS to trackside assets
	APS	APS@Consider open interfaces to integrate as much formats as possible APS@Ensure functionality even in case of incomplete information due to limited functionality of interfaced components APS@Support published changes in Map Data (new, change, delete) during runtime without impact on system operation

4 Clarifications

Architecture vs. configuration

The objectives consider different aspects of the A.P.M architecture and configuration requirements. The two terms are distinguished as follows:

- An architecture is a set of interfaces (protocols between functions) and describe the behaviour of functions in certain situations.
- A configuration is a specific set of devices/functions that are installed.

Hence, one architecture shall allow many different configurations (scalability, migratability, upgradeability). For example, L2, L3 and mixed level operation are configurations. They must not be based on different architectures in the future. Otherwise, important business targets like the fast, cost-efficient and easy migration of fleets, infrastructures and corridors will not be met and there will be no harmonised operational rules.

Support of different operational concepts

The objectives are phrased to support existing and emerging operational concepts (e.g. Engineering GL Level 3 concepts, Level R concepts). Therefore, the term “Hybrid Train Detection” newly introduced by ERA, which includes HL3 concepts, is referred to as mixed level operation (L2/L3) or mixed level approach.

5 Open Issues

Table 2: Open Issues

Nr.	Title	Description
1	AE Objectives	Objectives for AE must be derived from business targets.