OCORA

Open CCS On-board Reference Architecture

Operational & System Analysis

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Revision history

Version	Change Description	Initial	Date of change
1.00	Official version for OCORA Release R1	MT, JL, PV, TM, AL	03.12.2021
2.00	Official version for OCORA Release R2	MT, JL, PV, TM, AL, ML	23.06.2022
3.00	Official version for OCORA Release R3	SZ ML	30.11.2022
4.00	Official version for OCORA Release R4	SZ	30.06.2023

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References

Reader's note: please be aware that the numbers in square brackets, e.g. [1], as per the list of referenced documents below, is used throughout this document to indicate the references to external documents. Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). OCORA always reference to the latest available official version of the SUBSET, unless indicated differently.

[1] OCORA-BWS01-010 – Release Notes

[2] OCORA-BWS01-020 – Glossary

[3] OCORA-BWS01-030 – Question and Answers

[4] OCORA-BWS01-040 – Feedback Form

[5] OCORA-BWS03-010 – Introduction to OCORA

[6] OCORA-BWS03-020 – Guiding Principles

[7] OCORA-BWS04-010 – Problem Statements

[8] OCORA-TWS01-030 – System Architecture

[9] ISBN 978-1-78548-169-7 – Model-based System and Architecture Engineering with the Arcadia Method – Jean Luc Voirin – ISTE Press - 01/03/2018

[10] EEIG ERTMS Users Group, 21E158, Version 1.0, 06/09/21 - CCS Use Case Specification and Basic Requirements for the Intelligent Freight Train based on the DAC

1 Introduction

1.1 Purpose of the document

The purpose of this document is to provide a high-level view of all services that an OCORA based system provides to external actors, and to prepare for Europe's Rail Joint Undertakings System- & Innovation-Pillar. The document will evolve in subsequent releases. At a later stage, modelling of system capabilities is expected to be performed using a modelling tool such as Capella. To support the modelling activities, an operational analysis was initiated, and an initial set of system capabilities were derived from the elaborated operational activities.

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA concepts for on-board CCS. The reader is invited to provide feedback to the OCORA collaboration and can, therefore, engage in shaping OCORA. Feedback to this document and to any other OCORA documentation can be given by using the feedback form [4].

1.2 Applicability of the document

The present document is currently considered informative. Subsequent releases of this document will be developed based on a modular and iterative approach, evolving within the progress of the OCORA collaboration.

1.3 Context of the document

This document is published as part of an OCORA Release, together with the documents listed in the Release Notes [1]. If you are interested in the context and the motivation that drives OCORA we recommend reading the Introduction to OCORA [5], the Guiding Principles [6], and the Problem Statements [7]. The reader should also be aware of the Glossary [2] and the Question and Answers [3].

2 Operational context

To support the operational analysis and to facilitate the identification of System Capabilities of the CCS-OB, OCORA identified the need for a high-level operational context of the different types of trains. The goal of this process is to help identifying the System Missions and high-level functional interactions of all actors of the CCS-OB.

2.1 Overview

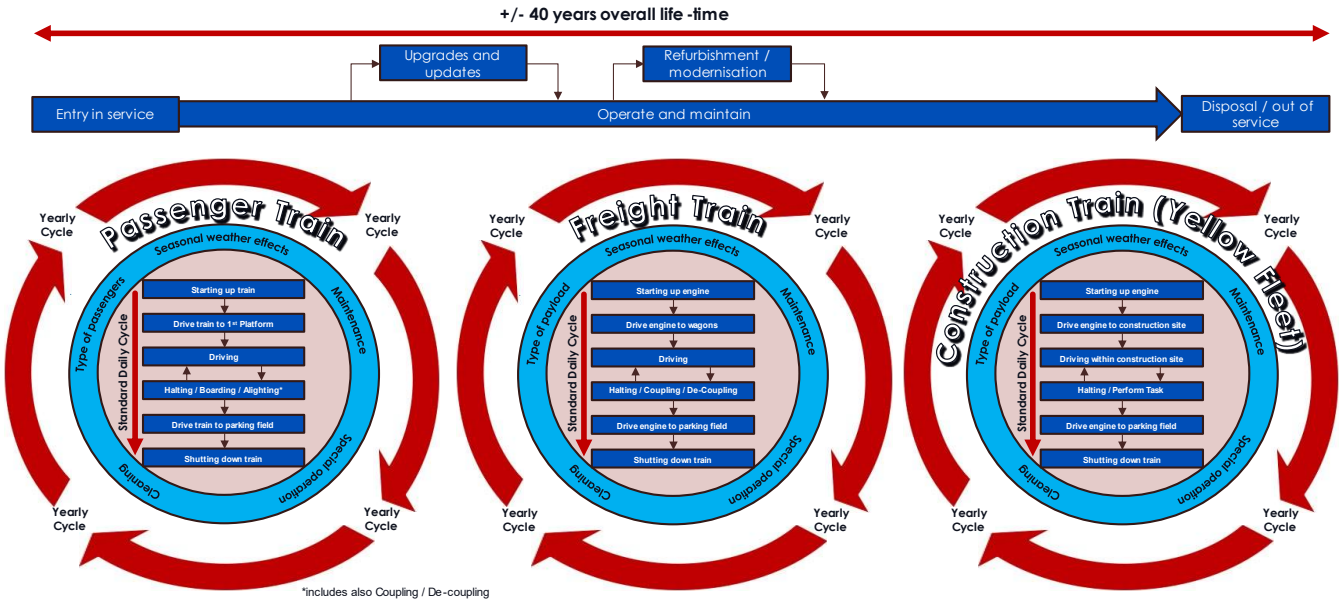


Figure 1 Operational concept overview

The high-level operational concept describes the production model of the operator: operational processes with a focus on rolling stock. The objective is to facilitate clear communication during the different project phases and provides context for expectations and user perspectives behind the formalised requirements. Within the V-model, the operational context is located at both upper ends of the V: it is an information source used when technical system requirements are written, but also the basis for validation activities. Considering the train within the context of operation, a framework of three different scales is central to this:

- A **day's cycle**: The daily cycle will cover the daily operational processes, from preparing the train for service until the end of service.
- A **yearly cycle:** The yearly cycles will zoom out further, assessing the weekly, monthly, and annual processes. This can cover both maintenance processes, atypical operational procedures, but also the influence of seasonal effects.
- The full **life cycle:** The full lifecycle covers the full life of a train from introduction up to and including the end of service and recycling. As the life cycle of the train will contain multiple life cycles of different IT systems, this perspective is the basis to prepare for regular updates and upgrades, ideally in sync with the longer maintenance cycles.

Combining the need different time frames, which will include a set of operational processes, serves as a first perspective to determine required capabilities of the CCS-OB, which is defined further in chapter 5.

3 Operational analysis

The operational analysis is conducted from the perspective of the whole train and the CCS-OB related to a standard daily cycle (refer to Figure 1). Activities covering longer term cycles like maintenance and the lifecycle are not considered at the current stage.

3.1 Overview

The following diagram shows the different states a train (respectively the CCS-OB) can be within a standard daily cycle. The operational states are described more precisely in section 3.2. The arrows between the different states define the possible transitions to reach another operational state (refer to section 3.2.7 for more details on the operational transitions). Each state encloses multiple operational activities which are elaborated and documented in the upcoming section 3.3.

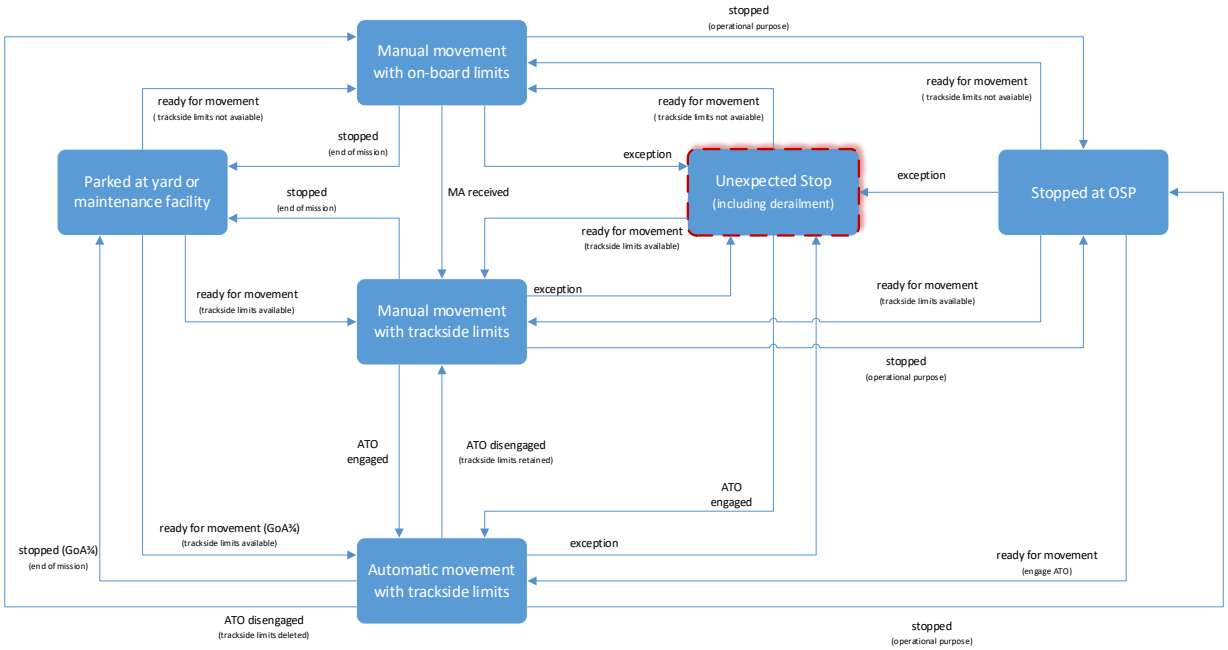


Figure 2 Operational states and transitions - overview

3.2 Operational states

3.2.1 Parked at yard or maintenance facility

The train is intentionally stopped in a yard or maintenance facility (parked at an appropriate location). The train either remains in this state for a longer period or in short it gets shut down.

3.2.2 Manual movement with on-board limits

The train is moving but has not yet received trackside information for a moving authority or this information has been deleted. The supervision of the train is limited, it is only based on some on-board parameters (e.g., ceiling speed).

3.2.3 Manual movement with trackside limits

The train is moving and has a moving authority based on information received from trackside. The position of the train is known.

3.2.4 Automatic movement with trackside limits

On the train, all operational and engagement conditions are fulfilled, and ATO-OB is engaged. The train is moving while ATO-OB automatically drives the train. A movement authority has been received from trackside.

3.2.5 Unexpected Stop

The train is stopped unexpectedly (not planned halt) due to different reasons like, emergency brake, failure on trackside, failure on the train, emergency on the train (e.g., fire), etc.

3.2.6 Stopped at Operational Stopping Point (OSP)

The train has stopped intentionally at the operational stopping point (OSP) according to the schedule.

3.2.7 Operational transitions

All operational transitions are related to the whole train from CCS on-board perspective.

Some operational transitions for ATO with GoA 3/4 are indicated for the sake of completeness to the best of one's knowledge. Nevertheless, many points remain open and are not clear and can be completed once a more detailed concept and additional information is available from the Shift2Rail group working on the ATO with GoA 3/4.

Origin state	Transition	Destination state	Description
Parked at yard or maintenance facility	Ready for movement (trackside limits not available)	Manual movement with on-board limits	The train starts moving but has not received trackside information for a moving authority or this information has been deleted. Train supervision is limited, it is only based on some on-board parameters (e.g., ceiling speed).
	Ready for movement (trackside limits available)	Manual movement with trackside limits	The train starts moving and has received a moving authority from trackside.
	Ready for movement (GoA¾) (trackside limits available)	Automatic movement with trackside limits	This is only valid for ATO with GoA 3/4. On the train all operational and engagement conditions are fulfilled and ATO-OB gets engaged. The train starts moving while ATO-OB automatically drives the train. A moving authority from trackside was received.
Manual movement with on-board limits	Stopped (end of mission)	Parked at yard or maintenance facility	The train intentionally stops in yard or in maintenance facility (parked in an appropriate location). The train either remains in this state for a longer period or in short it gets shut down.
	Moving Authority received	Manual movement with trackside limits	The train keeps moving but meanwhile it has a moving authority based on information received from trackside (e.g., first balise has been read).
	Exception	Unexpected Stop (including derailment)	The train unexpectedly stops moving (not planned halt) due to different reasons: emergency brake, failure on trackside, failure on the train, emergency on the train (e.g., fire).
	Stopped (operational purpose)	Stopped at OSP	The train intentionally stops at the next operational stopping point (OSP) according to schedule.
Manual movement with trackside limits	Stopped (end of mission)	Parked at yard or maintenance facility	The train intentionally stops in yard or in maintenance facility (parked in an appropriate location). The train either remains in this state for a longer period or in short it gets shut down.
	ATO engaged	Automatic movement with trackside limits	On the train all operational and engagement conditions are fulfilled and ATO-OB gets engaged. Now ATO-OB automatically drives the train.
	Exception	Unexpected Stop (including derailment)	The train unexpectedly stops moving (not planned halt) due to different reasons: emergency brake, failure on trackside, failure on the train, emergency on the train (e.g., fire).
	Stopped (operational purpose)	Stopped at OSP	The train intentionally stops at the next operational stopping point (OSP) according to schedule.

Origin state	Transition	Destination state	Description
Automatic movement with trackside limits	Stopped (GoA¾) (end of mission)	Parked at yard or maintenance facility	This is only valid for ATO with GoA 3/4. The train intentionally stops in yard or in maintenance facility (parked in an appropriate location). The train either remains in this state for a longer period or in short it gets shut down.
	ATO disengaged (trackside limits deleted)	Manual movement with on-board limits	On the train either any of the operational conditions but the ETCS related ones is no longer fulfilled or a condition for ATO disengaging occurs, ATO-OB no longer drives the train automatically. The train driver takes over and drives the train. Simultaneously the trackside information for a moving authority is deleted, therefore supervision is limited, it is only based on some on-board parameters (e.g., ceiling speed).
	ATO disengaged (trackside limits retained)	Manual movement with trackside limits	On the train either any of the operational conditions but the ETCS related ones is no longer fulfilled or a condition for ATO disengaging occurs, ATO-OB no longer drives the train automatically. The train driver takes over and drives the train.
	Exception	Unexpected Stop (including derailment)	The train unexpectedly stops moving (not planned halt).
	Stopped (operational purpose)	Stopped at OSP	The train intentionally stops at the next operational stopping point (OSP) according to schedule.
Unexpected Stop (including derailment)	Ready for movement (trackside limits not available)	Manual movement with on-board limits	The train starts moving but has not received trackside information for a moving authority or this information has been deleted. Train supervision is limited, it is only based on some on-board parameters (e.g., ceiling speed).
	Ready for movement (trackside limits available)	Manual movement with trackside limits	The train starts moving and has a moving authority based on information received from trackside. Train position is known.
	ATO engaged	Automatic movement with trackside limits	On the train all operational and engagement conditions are fulfilled and ATO-OB gets engaged. The train starts moving while ATO-OB automatically drives the train. The moving authority is based on information received from trackside. Train position is known.

Origin state	Transition	Destination state	Description
Stopped at OSP	Ready for movement (trackside limits not available)	Manual movement with on-board limits	The train starts moving but has not received trackside information for a moving authority or this information has been deleted. Train supervision is limited, it is only based on some on-board parameters (e.g., ceiling speed).
	Exception	Unexpected Stop (including derailment)	The train unexpectedly remains at halt (unplanned halt).
	Ready for movement (trackside limits available)	Manual movement with trackside limits	The train starts moving and has a moving authority based on information received from trackside. Train position is known.
	Ready for movement (engage ATO)	Automatic movement with trackside limits	On the train all operational and engagement conditions are fulfilled and ATO-OB gets engaged. The train starts moving while ATO-OB automatically drives the train. The moving authority is based on information received from trackside. Train position is known.

Table 1 Operational transitions

3.3 Operational activities

As a first step, the required operational activities to manage “a day in the life of a train”, are elaborated. The description (bullet points) lists the steps required, from a train drivers’ perspective, to fulfil the activity. This process provides the foundation for the next step - the identification of the system capabilities.

It must be noted that not all steps listed in the description field may involve the CCS-OB (e.g., activate compressor, activate brake system, etc.). They are listed for completeness and to support the understanding of the described operational activity. Furthermore, the list of operational activities is not complete and will evolve in the upcoming OCORA Releases.

		Initiating Actor(s)										Operational States						
		Train Driver	Train Attendant	Passenger	Physical Train Unit	OCS-IM	OCS-RU	Eurobalise	Euroloop	Light Signal	Environment	Parked	Manual Movement OB limits	Manual Movement TS limits	Automatic Movement TS limits	Stopped at OSP	Unexpected Stop	
ID	**Operational Activity**																	**Description (bullet points)**
OpA001	Start-up train	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	**Leading** ▪ turn on control power (Battery) ▪ systems are initialising and performing health checks ▪ activate cabin ▪ check and confirm train composition (TCMS) ▪ raise pantograph or start diesel engine ▪ power train (main switch) - electric train only ▪ activate compressor ▪ activate brake system ▪ activate comfort system (e.g., air-conditioning, heating, etc.) ▪ activate passenger info system ▪ activate CAB radio (voice communication) ▪ check smoke detector system ▪ perform ETCS system test (EB test) ▪ perform dead man's switch test (Driver Safety Device (DSD)) ▪ turn lights on (inside and outside) ▪ test close & lock doors **Non-Leading** ▪ turn on control power (Battery) ▪ systems are initialising and performing health checks ▪ activate cabin ▪ check and confirm train composition (TCMS) ▪ raise pantograph or start diesel engine ▪ power train (main switch) - electric train only ▪ activate compressor ▪ activate comfort system (e.g., air-conditioning, heating, etc.) – if not controlled by leading engine ▪ activate passenger info system – if not controlled by leading engine ▪ activate CAB radio (voice communication) ▪ check smoke detector system – if not controlled by leading engine ▪ perform ETCS system test (EB test) ▪ perform dead man's switch test (Driver Safety Device (DSD)) ▪ turn lights on (inside and outside) – if not controlled by leading engine ▪ test close & lock doors – if not controlled by leading engine

		Initiating Actor(s)										Operational States						
ID	Operational Activity	Train Driver	Train Attendant	Passenger	Physical Train Unit	OCS-IM	OCS-RU	Eurobalise	Euroloop	Light Signal	Environment	Parked	Manual Movement OB limits	Manual Movement TS limits	Automatic Movement TS limits	Stopped at OSP	Unexpected Stop	Description (bullet points)
OpA002	Compose train	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	-	**Couple train engine to composition of coaches / wagons:** ▪ activate parking brake ▪ deregister CAB radio (voice) - if required ▪ main switch off ▪ lower pantograph stop diesel engine ▪ attach or detach coaches / wagons ▪ deactivate cabin ▪ walk to the other cabin ▪ activate cabin ▪ check and confirm train composition (TCMS) ▪ raise pantograph / start diesel engine ▪ power train (main switch) - electric train only ▪ activate compressor ▪ activate brake system ▪ activate comfort system (e.g., air-conditioning, heating, etc.) ▪ activate passenger info system ▪ deactivate parking brake ▪ check smoke detector system ▪ turn lights on inside/outside ▪ test close & lock doors **Attach additional coaches / wagons to train:** ▪ lower pantograph or stop diesel engine ▪ attach or detach coaches / wagons ▪ check and confirm train composition (TCMS) ▪ raise pantograph or start diesel engine ▪ power train (main switch) - electric train only ▪ activate compressor ▪ activate brake system ▪ activate comfort system (e.g., air-conditioning, heating, etc.) ▪ activate passenger info system ▪ check smoke detector system ▪ turn lights on inside/outside ▪ test close & lock doors
OpA003	Prepare train for mission	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	**Leading** ▪ enter/update CAB (voice) radio data ▪ enter/confirm passenger info data ▪ enter/confirm ETCS data (register with trackside) ▪ brake tests (incl. passenger emergency hand brake) **Non-Leading** ▪ enter/update CAB (voice) radio data ▪ enter/confirm passenger info data – if not controlled by leading engine ▪ select non leading mode (NL) on ETCS DMI
OpA004	Prepare train for departure	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	▪ approaching departure time ▪ authorization to move (MA from track signal or on DMI (cab signalling) or on-board limits (SR or RS) ▪ departure time reached (dwell time expired) ▪ authorisation from train attendant (if required) ▪ enforce closure & locking of doors (driver or attendant) ▪ all doors are locked
OpA005	Drive to operational stopping point	x	-	-	-	-	-	-	-	-	-	-	x	x	x	-	-	▪ accelerate and brake or coasting ▪ comply with trackside / on-board signals (e.g., stop at light signals, adapt speed, etc.) ▪ comply to journey profile (schedule) ▪ observe outside environment ▪ observe PTU (TCMS, manometers, emergency brake, smoke alarm, etc.) ▪ check train consistency (driving mirror) before entering longer tunnels (smoke, open doors, loose parts, etc.) ▪ repeatedly press dead man pedal ▪ release doors on correct side (on platform side) ▪ stop at platform (taking into account the train length)
OpA006	Communicate with passengers	x	-	-	-	x	x	-	-	-	-	-	x	x	x	x	x	▪ driver makes ad-hoc voice announcements ▪ driver plays pre-recorded announcements ▪ observe passenger information system (to ensure that correct announcements are made)
OpA007	Communicate with off-board staff	x	-	x	-	-	-	-	-	-	-	x	x	x	x	x	x	▪ passenger talks to off-board staff (emergency GoA3/4) ▪ driver talks to off-board staff (e.g., traffic controller, maintenance manager, etc.) ▪ driver interacts with selected track workers using sign language
OpA008	Communicate with on-board staff	x	x	x	-	-	-	-	-	-	-	x	x	x	x	x	x	▪ driver talks to train attendant ▪ train attendant talks to driver ▪ train attendants talk to each other ▪ passenger talks to train attendant (only in person communication)
OpA009	Passenger requests stop	-	-	x	-	-	-	-	-	-	-	-	x	x	x	x	-	▪ passenger presses stop-on-request button on-board ▪ driver is informed via indicator light ▪ driver observes if there are passengers on platform waiting for this train and decides to stop
OpA010	Passengers embark & disembark	-	x	x	-	-	-	-	-	-	-	-	-	-	-	x	-	▪ door open request ▪ driver observes if doors are opening ▪ passengers enter / leave train ▪ train attendant manages proper embarking/disembarking of passengers
OpA011	Load and unload cargo	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	▪ load master signals manually that loading/unloading has been completed

ID	Operational Activity	Initiating Actor(s)										Operational States						Description (bullet points)
		Train Driver	Train Attendant	Passenger	Physical Train Unit	OCS-IM	OCS-RU	Eurobalise	Euroloop	Light Signal	Environment	Parked	Manual Movement OB limits	Manual Movement TS limits	Automatic Movement TS limits	Stopped at OSP	Unexpected Stop	
OpA012	Joining trains	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	**Train at standstill**: ▪ prepare train for coupling (open hatch, if necessary, etc.) ▪ set couple mode (parking mode or parking mode and coupling mode) ▪ put cabin in standby mode (if this cabin will not be leading the coupled train) ▪ **If this cabin remains the leading cabin:** ▪ driver waits for completion of coupling ▪ deactivate parking mode ▪ check and confirm train composition (TCMS) ▪ enter/confirm passenger info data ▪ modify ETCS data ▪ brake tests (incl. passenger emergency hand brake) ▪ deactivate parking brake **Moving train**: prepare train for coupling (open hatch, if necessary, etc.) check if "Train to be attached" is in coupling mode couple change cabin
OpA013	Splitting train	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	**Train to be split**: ▪ activate parking mode ▪ select correct splitting point ▪ decouple ▪ retract coupling and close hatch if required **If this cabin remains a leading cabin:** ▪ deactivate parking mode ▪ enter/confirm passenger info data ▪ modify ETCS data ▪ deactivate parking brake ▪ if necessary, turn off lights in passenger coaches **If this cabin is no longer leading:** ▪ unregister CAB Radio ▪ deactivate cabin **Decoupled Train no longer in use:** ▪ remains in parking mode **Decoupled Train remains in use:** ▪ activate correct cabin ▪ deactivate parking mode ▪ activate brake system ▪ enter CAB (voice) radio data ▪ enter/confirm passenger info data ▪ enter/confirm ETCS data (register with trackside) ▪ brake tests (incl. passenger emergency hand brake) ▪ deactivate parking brake
OpA014	Change cabin	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	**In mode parking:** ▪ activate parking brake ▪ deregister CAB radio (voice) - if required ▪ activate parking mode ▪ deactivate cabin ▪ walk to the other cabin ▪ activate cabin ▪ deactivate parking mode ▪ activate brake system ▪ enter CAB (voice) radio data ▪ enter/confirm passenger info data ▪ enter/confirm ETCS data (register with trackside) ▪ brake tests (incl. passenger emergency hand brake) ▪ deactivate parking brake ▪ check smoke detector system ▪ test close & lock doors **Without parking mode:** ▪ activate parking brake ▪ deregister CAB radio (voice) - if required ▪ main switch off ▪ lower pantograph ▪ deactivate cabin ▪ walk to the other cabin ▪ activate cabin ▪ raise pantograph ▪ turn main switch on ▪ activate brake system ▪ enter CAB (voice) radio data ▪ enter/confirm passenger info data ▪ enter/confirm ETCS data (register with trackside) ▪ brake tests (incl. passenger emergency hand brake) ▪ deactivate parking brake ▪ check smoke detector system ▪ test close & lock doors

ID	Operational Activity	Initiating Actor(s)										Operational States						Description (bullet points)
		Train Driver	Train Attendant	Passenger	Physical Train Unit	OCS-IM	OCS-RU	Eurobalise	Euroloop	Light Signal	Environment	Parked	Manual Movement OB limits	Manual Movement TS limits	Automatic Movement TS limits	Stopped at OSP	Unexpected Stop	
OpA015	Change driver	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	**National value (N_NVDERUN) allows changing driver ID:** ▪ new driver enters cabin ▪ new driver enters new driver ID ▪ new driver checks ETCS data **National value (N_NVDERUN) prohibits changing driver ID:** ▪ current driver deactivates cabin ▪ new driver enters cabin ▪ new driver activates cabin ▪ execute system tests (initiate stationary brake test, check dead man switch, etc.) ▪ visual system check ▪ enter train data ▪ initiate voice radio communication ▪ register with trackside
OpA016	Drive to yard or maint. Facility (GoA 1/2) (shunting)	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	▪ select mode shunting ▪ wait for MA at the shunting signal ▪ accelerate and brake or coasting ▪ comply with track-side signals (e.g., shunting signals, adapt speed, etc.) ▪ observe outside environment (there might be obstacles on the way!) ▪ observe PTU (TCMS, manometers, emergency brake, smoke alarm, etc.) ▪ repeatedly press dead man pedal ▪ release doors (at maintenance facility) ▪ stop at yard / maint. facility (taking into account the train length)
OpA017	Drive to yard or maint. Facility (GoA3/4) (shunting)	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	▪ based on the mission profile mode ATO shunting is selected ▪ wait for MA from MT ▪ accelerate and brake or coasting ▪ perception system observes the track (obstacles), shunting signals and other signs, etc. ▪ react to track-side signals, signs, obstacles, etc. ▪ operator traffic control centre (TCC) observes PTU (TCMS, emergency brake, smoke alarm, etc.) ▪ release doors (at maintenance facility) according to mission profile ▪ stop at yard / maint. facility (taking into account the train length)
OpA018	End Mission	x	-	-	-	x	-	-	-	-	-	x	-	-	-	x	x	▪ deregister CAB Radio ▪ activate parking brake ▪ activate vehicle mode depending on local operational procedures e.g., parking mode, sleeping mode etc. ▪ deactivate cabin ▪ check full train to ensure nobody is left behind
OpA019	Shutdown train	x	-	-	x	-	-	-	-	-	-	x	-	-	-	x	x	▪ activate cabin (if not yet activated) ▪ deactivate parking mode or sleeping mode ▪ ensure that parking brakes are active ▪ Diesel engine: ▪ turn off diesel engines ▪ power off train ▪ Electric engine: ▪ turn off main switch ▪ lower pantograph ▪ power off train
OpA020	Manoeuvre at operational stopping point	x	-	-	x	-	-	-	-	-	-	-	x	-	-	-	-	▪ switch to manual movement with on-board limits (shunting mode) ▪ switch voice radio registration for shunting ▪ request and receive permission for manoeuvre ▪ communicate with shunter in case the sight onto the tracks is blocked ▪ accelerate and brake ▪ comply with track-side manoeuvre signals (e.g., stop at light signals) ▪ observe outside environment ▪ observe PTU ▪ stop at stopping point (taking into account the train length) ▪ deactivate shunting mode ▪ --> continue e.g., with OpA003 Prepare Train for Mission
OpA021	Manoeuvre in maintenance yard (non-centralized interlocking)	x	-	-	x	-	-	-	-	-	-	-	x	-	-	-	-	▪ switch to manual movement with on-board limits (shunting mode) ▪ switch voice radio registration for shunting ▪ set and verify correct position of switches ▪ communicate with shunter in case the sight onto the tracks is blocked ▪ accelerate and brake or coasting ▪ comply with track-side manoeuvre signals (e.g., stop at light signals) ▪ observe outside environment ▪ observe PTU ▪ stop at final position ▪ deactivate shunting mode

ID	Operational Activity	Initiating Actor(s)										Operational States						Description (bullet points)
		Train Driver	Train Attendant	Passenger	Physical Train Unit	OCS-IM	OCS-RU	Eurobalise	Euroloop	Light Signal	Environment	Parked	Manual Movement OB limits	Manual Movement TS limits	Automatic Movement TS limits	Stopped at OSP	Unexpected Stop	
OpA022	Manoeuvre in construction site (track barred to traffic)	x	-	-	x	-	-	-	-	-	-	-	x	-	-	-	-	This activity covers only the movement inside the construction area. Yellow fleet vehicles are usually not equipped with a CCS-OB. ▪ accelerate and brake ▪ observe outside environment ▪ observe PTU ▪ stop at final position **Vehicles with CCS-OB** ▪ switch to manual movement with on-board limits (shunting mode) ▪ accelerate and brake ▪ comply with on-board limits and track-side manoeuvre signals, if available ▪ observe outside environment ▪ observe PTU ▪ stop at final position ▪
OpA023	Evacuate passengers	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	x	**Complete train stopped at platform** ▪ Advise passengers to leave the train ▪ Unlock/open doors to platform **Partial train stopped at platform or on track** ▪ Communicate with traffic control centre ▪ Agree on evacuation concept ▪ Inform passengers ▪ Prepare evacuation ▪ Advise passengers according to evacuation concept ▪ Unlock/open required doors
OpA024	Drive reverse (reversing)	x	-	-	-	-	-	-	-	-	-	-	x	x	x	-	-	**ETCS L2 (only in tunnels)** ▪ Operation control centre initiates the reversing process ▪ CCS-OB receives “RV” mode ▪ Train driver set the direction control to backwards and confirms RV mode on CCS-OB (DMI or ETCS confirmation button) ▪ accelerate and brake ▪ comply with trackside limits (speed and distance) ▪ stop after RV end signal or trackside limit ▪ Communicate with OCC **ETCS L0/L1** ▪ Reversing does not exist - only in shunting mode
OpA025	Drive reverse (GoA3/4)	x	-	-	-	-	-	-	-	-	-	-	x	x	x	-	-	▪ TBD
OpA026	Drive non-leading	x	-	-	-	-	-	-	-	-	-	-	x	x	x	-	-	Train driver on non-leading engine ▪ Communicate by CAB voice with leading train driver ▪ Control traction according to instructions by leading train driver
OpA027	Drive non-leading (GoA3/4)	x	-	-	-	-	-	-	-	-	-	-	x	x	x	-	-	▪ TBD
OpA028	ATP isolation	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	▪ Train driver isolates the ATP system due to a system failure ▪ Continuation of trip is only allowed after oral authorization from OCS-IM (traffic controller) by Cab Voice Radio or Phone ▪ accelerate and brake ▪ comply with limits (speed and distance according to rules for movement in isolated mode)
OpA029	Prepare train to be rescued	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	▪ TBD
OpA030	Join train to be rescued	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	▪ TBD
OpA031	Install software update	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	▪ TBD
OpA032	Install configuration update	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	▪ TBD
OpA033	Maintenance	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	x	▪ TBD
OpA034	Diagnostics	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	x	▪ TBD
OpA035	Rescue train (tow train)																	▪ TBD

Table 2 Operational Activities

3.4 Initiating Actors

For the description of the initiating refer to the OCORA System Architecture Document [8].

4 System analysis

Once the system under consideration is defined (scope and boundaries), the most natural way to compile the full set of system capabilities is to follow a top-down approach and start by identifying actors interacting with the system and missions the system shall perform (see 4.2 System scope and actors and 4.3 Missions).

Knowing the missions of a system is prerequisite to identify the system capabilities necessary to accomplish those missions.

Again, capabilities facilitate the identification of system functions. Capabilities are described using one or multiple functional chain(s), scenario(s) and mode/state diagram(s).

Functional chains assist the RAMSS analysis, scenarios describe the sequence of functions and their data exchanged. All resulting artefacts support the verification and validation process.

4.1 Definition of system capabilities

4.1.1 System capabilities in context of the Arcadia method

Ever-increasing expectations regarding functionality, safety, security, and performance of today's railway CCS systems, originating from different stakeholders, need to be managed and implemented in a structured and traceable way. The strength of any system is rooted in its architecture. The Arcadia method supports all required engineering activities that include analysing operational needs, structuring, and decomposing the system and considering constraints of existing standards and legislation as well as domain specific design objectives.

System capabilities are a core element of the Arcadia methodology and defined [9] as follows:

"*A system capability is the system's expected ability to supply a service contributing to fulfilling one or more missions. A system capability represents a system usage context. It is characterized by a set of functional chains and scenarios that it references, and which more precisely describe the conditions for performing the system functions that contribute to it. A capability can also reference a function that contributes to it by itself.*

A capability can use one or more other capabilities that it will reference."

4.1.2 OCORA interpretation

For a better understanding, especially for people who are not familiar with the Arcadia method, capabilities may be considered services of the system provided to external actors. Capabilities are characterized, described, and illustrated using functions, scenarios, modes, and states.

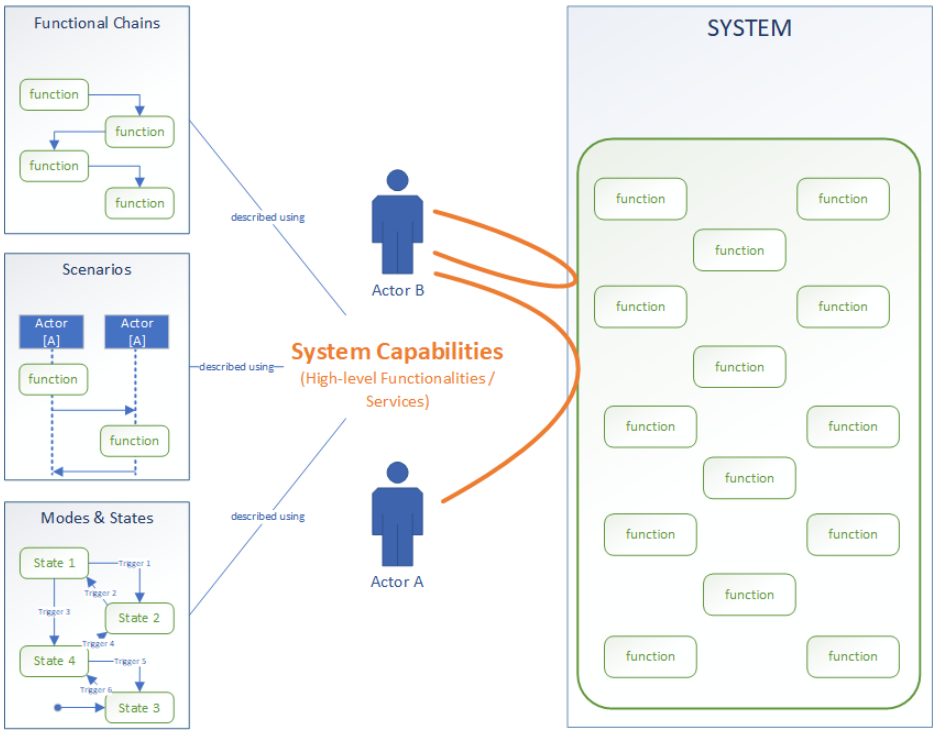


Figure 3 OCORA Perspective of System Capabilities

4.1.3 Arcadia approach

Arcadia stipulates a viewpoint-driven approach (as described in ISO/IEC 42010) and emphasizes a clear separation of need and solution.

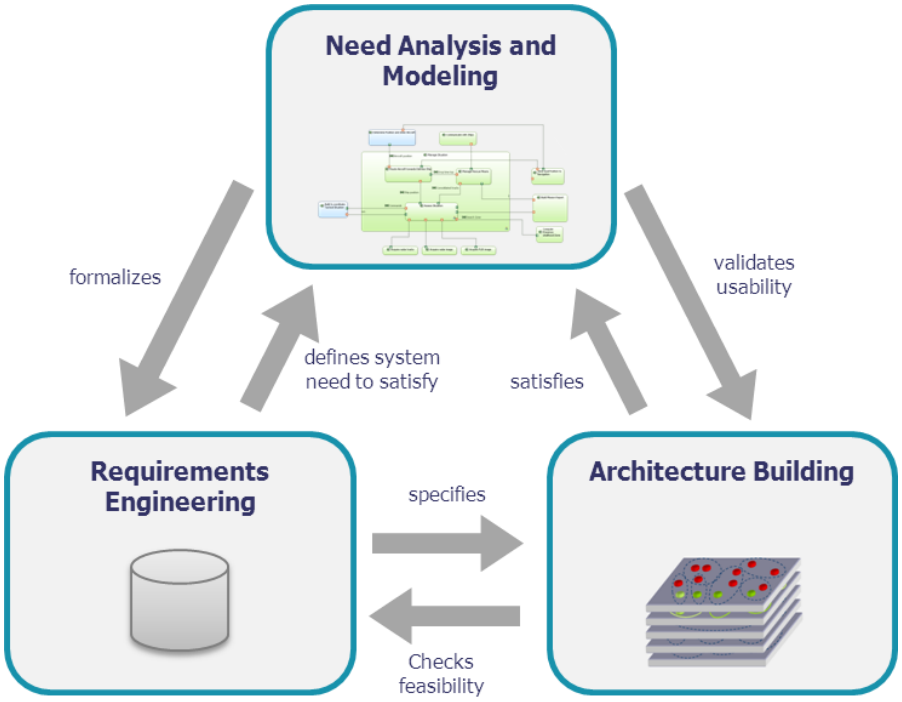


Figure 4 Viewpoint driven approach[1]

Arcadia promotes four[2] distinct perspectives:

- **Customer Operational Need Analysis** - definition of the Problem
  Focuses on analysing the customer needs and goals, expected missions and activities. It structures the need in terms of actors/users, their operational capabilities, and activities.

  Note: *Linx4Rail conducts an overall Operational Analysis. Synchronization shall happen at a later stage.*

- **System Need Analysis** - formalization of system requirements
  Focuses on the System itself, to define how it will satisfy the compiled operational need - zeroing in on functions and its related exchanges, non-functional constraints (e.g., safety, security, etc.) as well as role sharing between system and actors.

- **Logical Architecture (Notional Solution)** - definition of solution architecture
  Aims at building a coarse-grained component breakdown of the system. This involves taking important engineering decisions which are unlikely to be challenged at a later stage. The system is decomposed into logical components, functions are allocated to components. This building process is where the majority of the OCORA design objectives and design rules will be considered.

- **Physical Architecture** - definition of solution architecture
  Makes the logical architecture vision evolve according to implementation, technical and technological constraints, and choices.

[1] Source : https://www.eclipse.org/capella/arcadia.html
[2] Arcadia includes a fifth perspective regarding the Building Strategy. However, this perspective is currently considered to be out of scope of OCORA.

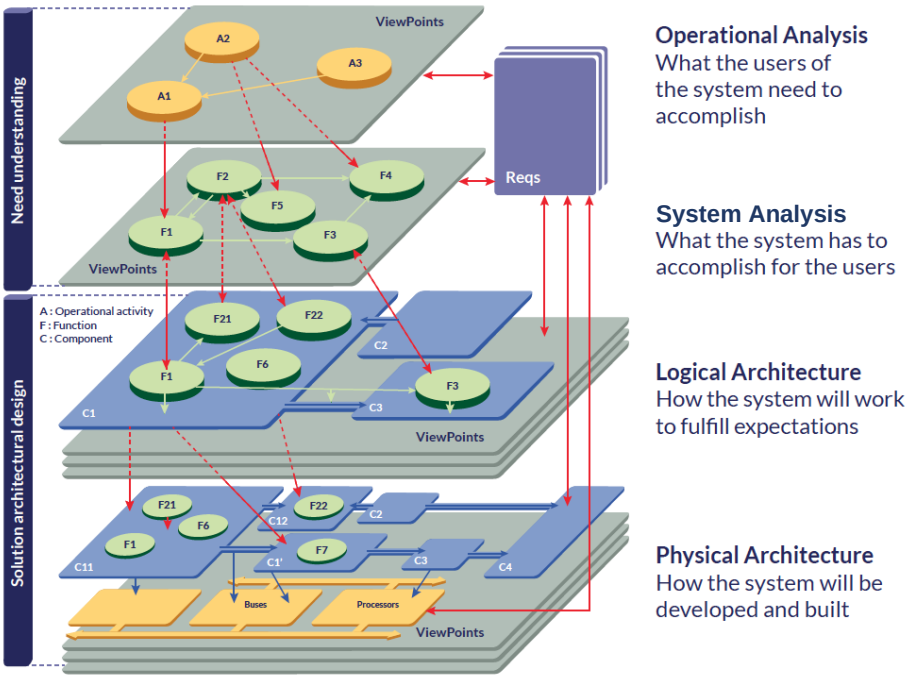


Figure 5 The four perspectives of Arcadia[1]

The Arcadia approach has been synchronized with the OCORA tailored V-model development process (see also Requirement - Management Guideline [9]).

Important Arcadia artefacts are:

Artefact	Description
System	The system is an ordered set of elements functioning as a whole, responding to customer and user demand and needs, and subject to engineering supported by Arcadia.
Actor	An actor is an entity that is external to the system (human or not), interacting with it, especially via its interfaces.
Mission	A mission is a high-level goal to which the system should contribute. To be fulfilled, a mission should use a number of system functions, regrouped within one or more system capabilities.
Capability	A system capability is the system's expected ability to supply a service contributing to fulfilling one or more missions.
Scenario	A function scenario is a time-ordered dynamic flow, on a temporal axis (conventionally vertical from top to bottom), of exchanges between different functions in the context of implementing a capability.
Functional Chain	A functional chain is an ordered set of references to functions and the functional exchanges that link them, describing one possible path among all the paths forming the dataflow.
Mode	A mode is a behaviour expected of the system, a component or also an actor or operational entity, in some chosen conditions.
State	A state is a behaviour undergone by the system, a component, an actor or an operational entity, in some conditions imposed by the environment.
Mode/state diagram	A mode(s) machine (or respectively, state(s) machine) is a set of modes (or, respectively, states) linked to one another by transitions. Modes and states cannot cohabit in the same machine.

Table 3 Arcadia Artefacts explained

[1] Source : https://www.eclipse.org/capella/arcadia.html

The following figure shows the relationship between Capabilities and other Arcadia modelling artefacts:

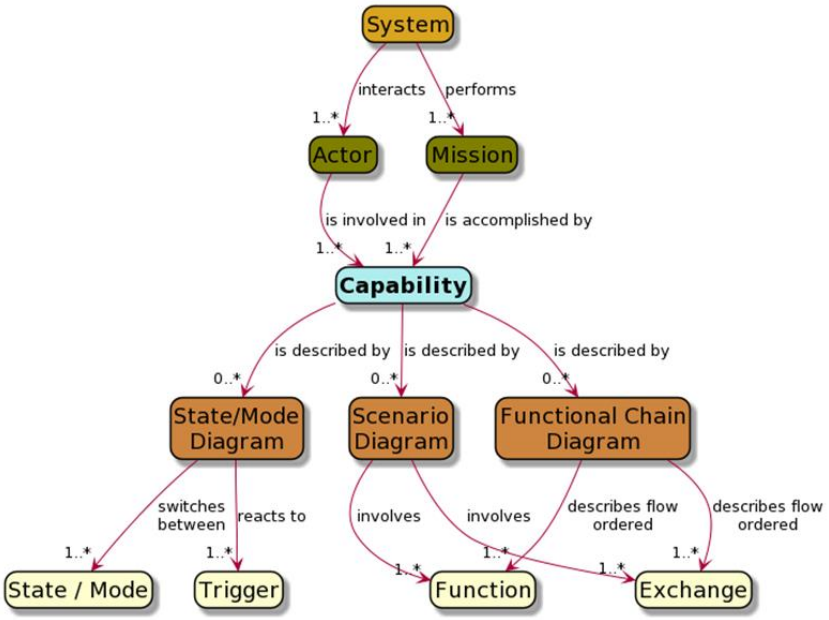


Figure 6 Artefacts of the System Analysis perspective

4.2 System scope and actors

As a first step for defining the Missions and System Capabilities, the scope and corresponding actors are identified.

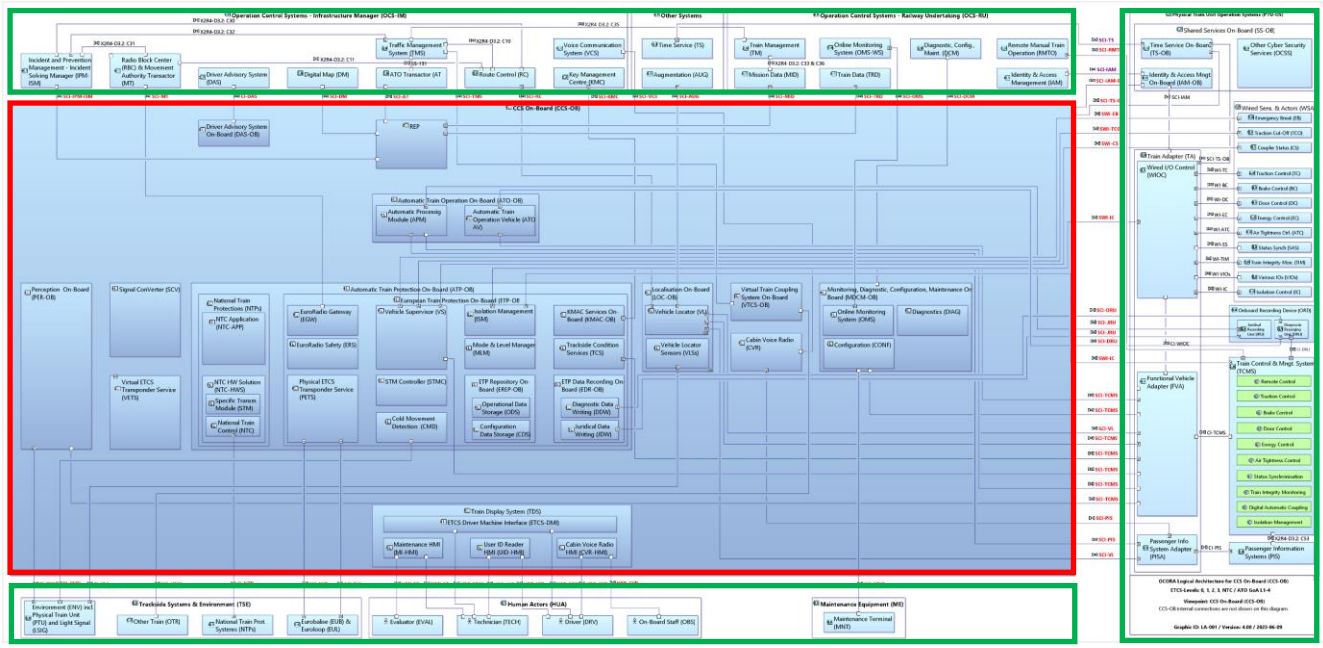


Figure 7 System under consideration (red) and Actors (green)

Note: The System under Consideration (SuC) is CCS On-Board only e.g., excluding the Train Adaptor. Nevertheless, OCORA aims to standardize the interface to the Physical Train Unit by leveraging existing standards and proposing improvements where necessary. Legacy trains require a Train Adaptor that translates legacy interfaces and behaviour; future trains, however, will implement the standardized interfaces natively, and will no longer need a Train Adaptor.

4.3 Missions

OCORA has identified the following missions the CCS-OB has to fulfil.

Ref.	Mission	ERTMS Level	GoA [1]	Comments
Mission 1	Control safe train movement.	0 1 2 3 NTC	1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4	This mission is related to Automatic Train Protection (ATP). Supervise safe train movement according to train configuration, track configuration, speed profile, permitted travel distance, assigned mode, current speed, and current position. This mission includes the triggering of EB and TCO.
Mission 2	Optimise (energy, capacity, comfort) train movement (command train or signal to driver).	0[2] 1 2 3 NTC	1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4	Command train movement and release door opening according to train configuration, segment profile (topology), journey profile (schedule), mission profile, perceived environment information (e.g., clearance profile), speed profile, permitted travel distance, assigned GoA level, current speed, and current position (GoA2-4). Signal information to the driver about actual speed, the optimal speed profile (GoA1 only), additional advisory information and track description.
Mission 3	Signal information to ensure safe and appropriate driving.	0 1 2 3 NTC	1, 2 1, 2 1, 2 1, 2 1, 2	This mission is related to ATP Cabin Signalling. Signal the mode of the ATP System and provide information to the driver about actual speed, maximum speed profile and the position within the permitted travel distance.
Mission 4	Provide voice communication means	0 1 2 3 NTC	1, 2 1, 2 1, 2 1, 2 1, 2	This mission is related to Cabin Voice. ▪ Voice communication between the Operations Control Systems personnel of the Infrastructure Manager and the Train Driver (TRDR). ▪ Voice communication between driver and train attendant ▪ Voice communication between driver and passenger
Mission 5	Provide information to the train system	0 1 2 3 NTC	1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4 1, 2, 3, 4	Provide communication means between trackside and the train systems ▪ Data communication between the Operations Control Systems of the Infrastructure Manager (OCS-IM) and the Physical Train Unit (PTU). ▪ Data communication between the Trackside Equipment (TSE) and the Physical Train Unit (PTU). ▪ Data communication between the Trackside Equipment (TSE) and the applications outside of ERTMS Provide information computed by the CCS (odometry, speed) Provide information entered by the driver (e.g., ID, Train running number)

Remark: The maintenance of the system under consideration (CCS-OB) is not considered to be a mission of the system. For Level 0, Level 1, and Level NTC a system (e.g., perception, Euro-Loop, TVM, LZB) capable to provide track side signal information is needed to run in GoA3 and GoA4.

[1] The applicability of GoA with the ERTMS level needs to be verified by the ATO team (OCORA internal GitHub issue #259)
[2] The applicability of ERTMS Level 0 for this mission needs to be verified and will be updated in an upcoming OCORA Release

4.4 CCS-OB modes

By refining the operational states of the whole train (refer to 3.2) and setting the focus closer onto the CCS-OB the following CCS-OB operational modes have been identified.

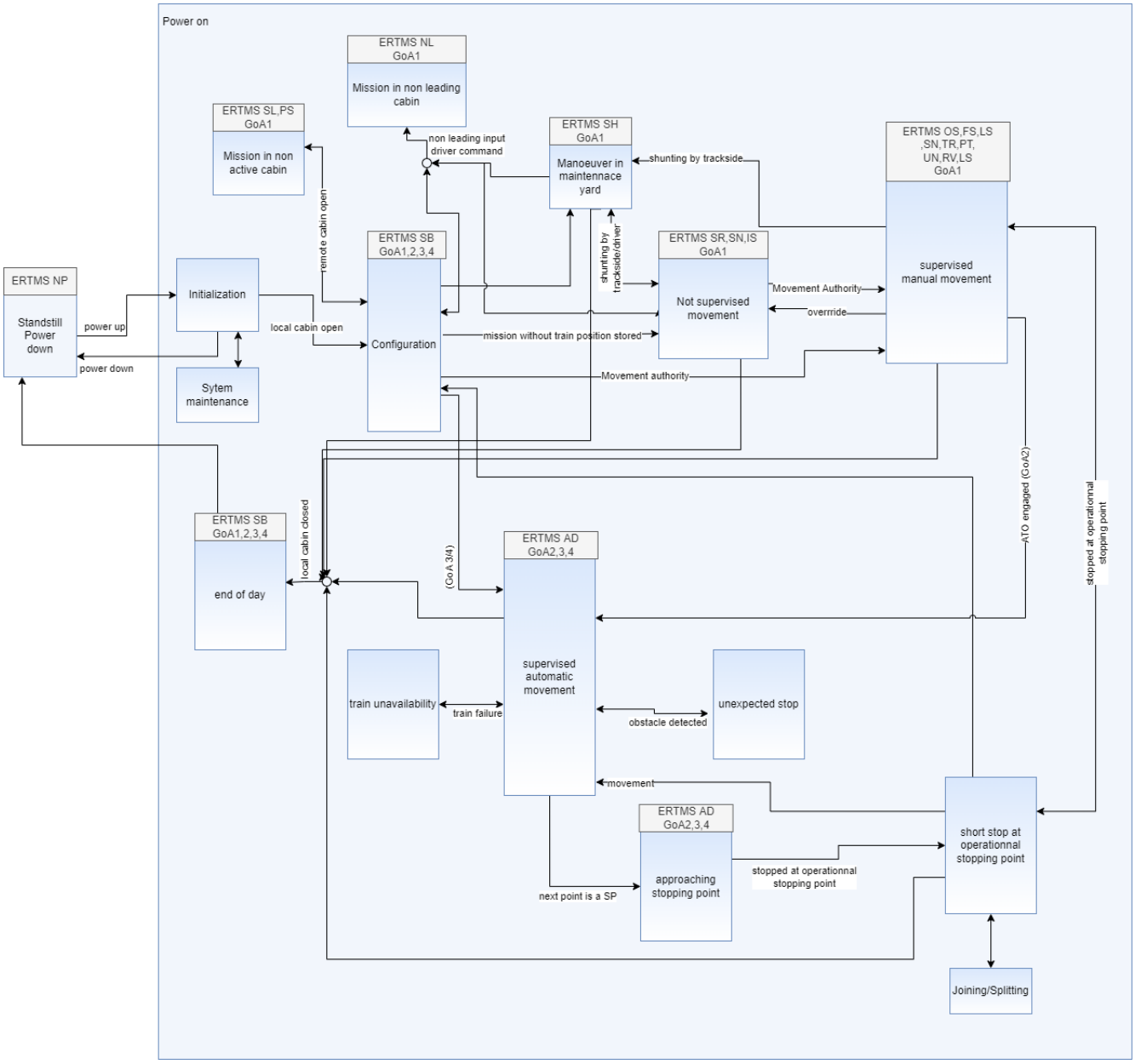


Figure 8 CCS-OB modes

The following table describes the different CCS-OB modes and an initial mapping to the ERTMS modes and operational states elaborated in the operational analysis (3.2).

CCS-OB mode	ERTMS modes	Description	Related operational state
System maintenance	-	A technician connects his maintenance terminal to the CCS in order to check internal state of the system. It performs update of software and configuration. It calibrates sensor. The system maintenance online can be performed on the train or in a test bench. In that case, each subsystem can be tested separately. CCS can have a specific technical mode in order to enable specific maintenance function.	▪ Parked at yard or maintenance facility
Standstill power down	NP	The system is not powered and does not provide any functionality	▪ Parked at yard or maintenance facility ▪ Unexpected Stop ▪ Stopped at OSP
Initialization	-	CCS performs its self-test. Subsystems connect and synchronize to each other. CCS evaluates, if new parameter or new software are available and performs the update. Stored configuration parameters are loaded and broadcasted to all consumers.	▪ Parked at yard or maintenance facility
Configuration	SB	CCS waits for configuration information from external system. Driver enters its ID and the train running number, enters the train data and configure the system (radio parameter e.g.). The train also transmits information (driver ID, train running number). CCS tries to connect with trackside systems. Driver selects the mode of the mission.	▪ Parked at yard or maintenance facility
Not supervised movement	SR, SN, IS	CCS doesn't know the position of the train. No movement authority is supervised. The train is running under the driver's responsibility.	▪ Manual movement with on-board limits
Supervised manual movement	OS, FS, LS, SN, TR, PT, UN, RV	CCS supervised static speed restriction and end of movement based on stored information which are frequently refreshed by RBC or infill equipment. It is located by referring to the group of beacons it crosses. CCS displays driving information (signalling and planning) to the driver and requests acknowledgement. Driver interacts with CCS to acknowledge or activates function. CCS manages transition to not supervised movement and to automatic movement (GoA2). CCS requests activation of train functions (e.g., lower/raise pantograph)	▪ Manual movement with trackside limits
Supervised automatic movement	AD	CCS performs same action as in supervised manual movement. In addition, CCS receives mission characteristic, computes an optimal driving profile and requests traction/brake to the train. The driving profile is based on timing points. In GoA4, the scope CCS supervises the environment through perception system and the set of train function managed is larger.	▪ Automatic movement with trackside limits
Approaching a stopping point	AD	CCS switches from timing point targets to location-based target. It aims to stop precisely to operational stopping point (station e.g.).	▪ Automatic movement with trackside limits
End of day	SB	CCS set the train for the "end of day" configuration.	▪ Parked at yard or maintenance facility
Short stop at operational stopping point	-	CCS manages the doors and control the train immobilization. It manages train change of configuration (cabin status, direction controller).	▪ Stopped at OSP
Joining/splitting	-	CCS supervises the train joining and command the traction/brake (precise speed and positioning). CCS configures the train (open coupler flap). And update its internal data	▪ Stopped at OSP
Train unavailability	-	CCS detects failure and takes immediate action ensuring safety. CCS command train function as a remediation of the situation (isolation for e.g.).	▪ Unexpected Stop
Unexpected stop	-	CCS detects trackside (obstacle for e.g.) disturbance and acts accordingly (stop for e.g.)	▪ Unexpected Stop

CCS-OB mode	ERTMS modes	Description	Related operational state
Manoeuvre in maintenance yard	SH	CCS supervises train movement according to speed restriction and list of allowed encountered balises. The movement occurs in maintenance yard/depot or work area.	▪ Manual movement with on-board limits
Mission in non-leading cabin	NL	CCS displays driving information (speed, track condition) to the driver and performs request to the train to enable specific functions (panto, main switch, etc.).	▪ Manual movement with trackside limits
Mission in rear cabin	SL/PS	CCS manages information and configuration in order to keep the capacity to ensure supervised movement (train position, RBC handover)	▪ Manual movement with trackside limits

Table 4 CCS-OB modes

4.5 System capabilities

For each operational activity identified during the operational analysis, the system capabilities were elaborated by walking through all the steps (bullet points) noted in the operational activity table and then by determining, if the CCS-OB is involved and what capability it needs to provide for this step.

The following table contains an initial set of system capabilities and the mapping with the operational activity.

#	System Capability	OpA001 Start-up train	OpA002 Compose train	OpA003 Prepare train for mission	OpA004 Prepare train for departure	OpA005 Drive to operational stopping point	OpA006 Communicate with passengers	OpA007 Communicate with off-board staff	OpA008 Communicate with on-board staff	OpA009 Passenger requests stop	OpA010 Let passengers embark & disembark	OpA011 Load and unload cargo	OpA012 Joining trains	OpA013 Splitting train	OpA014 Change cabin	OpA015 Change driver	OpA016 Drive to p/m Facility (GoA1/2)	OpA017 Drive to p/m Facility (GoA3/4)	OpA018 End of Mission	OpA019 Shutdown train	OpA020 Manoeuvre at operational stopping	OpA021 Manoeuvre in maintenance yard	OpA022 Manoeuvre in construction site	OpA023 Evacuate passengers	OpA024 Drive reverse	OpA025 Drive reverse (GoA3/4)	OpA026 Drive non-leading	OpA027 Drive non-leading (GoA3/4)	OpA028 ATP isolation	OpA029 Prepare train to be rescued	OpA030 Join train to be rescued	OpA031 Install software update	OpA032 Install configuration update	OpA033 Maintenance	OpA034 Diagnostics
SysC01	Allow local system configuration and software update	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
SysC02	Allow remote system configuration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
SysC03	Manage train door operation	x	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC04	Allow mode selection by trackside	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	x	x	-	-	-	-	x	-	-	-	-	-	-
SysC05	Drive train between two operational timing points (ATO over ETCS)	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC06	Manage operational stopping points	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC07	Perform transition between GoA levels *	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC08	Manage track conditions	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-
SysC09	Command train function (GoA3/4)	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
SysC10	Perform train coupling *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC11	Deactivate systems *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC12	Manage unattended stop *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC13	Provide driving advisory	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC14	Provide allowed speed and distance information	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-
SysC15	Allow RBC to command emergency stops	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-	x	x	x	-	x	x	x	-	-	-	-	-	-	-
SysC16	Provide status information (ATP -ATO status)	x	x	x	-	x	-	-	-	-	-	x	x	x	x	x	x	-	-	x	x	x	x	x	x	-	x	-	-	x	x	-	-	-	-
SysC17	Supervise train speed and distance	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-	x	x	x	-	x	x	-	-	-	-	-	-	-	-	-
SysC18	Manage train integrity	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	x	-	x	x	-	-	-	-	-	-	-	-	-

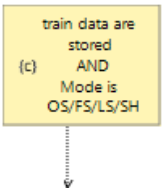
#	System Capability	OpA001 Start-up train	OpA002 Compose train	OpA003 Prepare train for mission	OpA004 Prepare train for departure	OpA005 Drive to operational stopping point	OpA006 Communicate with passengers	OpA007 Communicate with off-board staff	OpA008 Communicate with on-board staff	OpA009 Passenger requests stop	OpA010 Let passengers embark & disembark	OpA011 Load and unload cargo	OpA012 Joining trains	OpA013 Splitting train	OpA014 Change cabin	OpA015 Change driver	OpA016 Drive to p/m Facility (GoA1/2)	OpA017 Drive to p/m Facility (GoA3/4)	OpA018 End of Mission	OpA019 Shutdown train	OpA020 Manoeuvre at operational stopping	OpA021 Manoeuvre in maintenance yard	OpA022 Manoeuvre in construction site	OpA023 Evacuate passengers	OpA024 Drive reverse	OpA025 Drive reverse (GoA3/4)	OpA026 Drive non-leading	OpA027 Drive non-leading (GoA3/4)	OpA028 ATP isolation	OpA029 Prepare train to be rescued	OpA030 Join train to be rescued	OpA031 Install software update	OpA032 Install configuration update	OpA033 Maintenance	OpA034 Diagnostics
SysC19	Protect against undesirable train movement	x	x	x	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	-	-	-	x	-	-	-	-	-	x	x	-	-	-	-
SysC20	Allow driver to initiate specific modes	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	x	-	-	-	-	x	x	-	-	-	-	-	-	-
SysC21	Acquire mission specific parameter	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC22	Manage trackside disturbance *	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-	x	x	x	-	x	x	x	-	-	-	-	-	-	-	-
SysC23	Manage Passengers incident *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC24	Manage rolling stock failures *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	x	x	x	-	x	x	x	-	-	x	x	-	-	x	x
SysC25	Provide juridical record	x	x	x	x	x	-	-	-	-	-	-	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	-	-	x	x
SysC26	Manage application outside of ERTMS system	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-	x	x	x	-	x	x	x	x	-	-	-	-	-	-	-
SysC27	Ensure passenger communication without staff on board *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC28	Inform about on-board, trackside and train failure	-	-	x	x	x	-	-	-	-	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	-	x	x	x	x	x	x
SysC29	Supervise allowed running distance	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	x	x	-	-	-	-	-	-	-	-	-
SysC30	Publish information to the PTU-OS	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	x	-	-	-	-	-	-
SysC31	Publish information to RBC for radio based train protection	x	x	x	-	x	-	-	-	-	-	-	-	x	x	x	x	x	x	-	x	x	x	-	x	x	x	-	-	-	-	-	-	-	-
SysC32	Manage balises to be ignored by CCS-OB	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-	x	x	x	-	x	x	x	-	-	-	-	-	-	-	-
SysC33	Allow to perform maintenance task and system test *	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC34	Provide stop instruction to the driver	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC35	Ensure communication between driver and other staff	-	-	-	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC36	Manage stop request from passenger *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC37	Manage radio connection	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	x	-	x	-	x	-	-	-	-	-	-	-	-
SysC38	Provide additional track description to the driver	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC39	Allow reverse movement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
SysC40	Allow to cross non-authorised location	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-
SysC41	Restrict operational mode SR or SH to the allowed area	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-
SysC42	Manage system version	-	-	-	-	x	-	-	-	-	-	-	x	x	-	-	x	x	-	-	x	x	x	-	x	x	x	x	-	-	-	-	-	-	-
SysC43	Provide geographical position	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-

#	System Capability	Start-up train	Compose train	Prepare train for mission	Prepare train for departure	Drive to operational stopping point	Communicate with passengers	Communicate with off-board staff	Communicate with on-board staff	Passenger requests stop	Let passengers embark & disembark	Load and unload cargo	Joining trains	Splitting train	Change cabin	Change driver	Drive to p/m Facility (GoA1/2)	Drive to p/m Facility (GoA3/4)	End of Mission	Shutdown train	Manoeuvre at operational stopping	Manoeuvre in maintenance yard	Manoeuvre in construction site	Evacuate passengers	Drive reverse	Drive reverse (GoA3/4)	Drive non-leading	Drive non-leading (GoA3/4)	ATP isolation	Prepare train to be rescued	Join train to be rescued	Install software update	Install configuration update	Maintenance	Diagnostics
		OpA001	OpA002	OpA003	OpA004	OpA005	OpA006	OpA007	OpA008	OpA009	OpA010	OpA011	OpA012	OpA013	OpA014	OpA015	OpA016	OpA017	OpA018	OpA019	OpA020	OpA021	OpA022	OpA023	OpA024	OpA025	OpA026	OpA027	OpA028	OpA029	OpA030	OpA031	OpA032	OpA033	OpA034
SysC44	Allow to operate ETCS L2 without physical balise	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	x	x	x	-	-	-	-	-	-	-
SysC45	Allow ETCS supervision with light signal	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	x	-	x	-	-	-	-	-	-	-
SysC46	Request movement authority	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SysC47	Select requested level	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-	x	x	-	-	-	-	-	-	-
SysC48	Manage text message display	-	-	x	x	x	-	-	-	-	-	-	x	x	-	-	-	-	-	x	x	x	-	-	x	x	x	x	-	-	-	-	-	-	-

* : not included in this release as the contents of these capabilities are still in review and not mature enough for the publication

Appendix A System Capabilities template

OCORA is planning to use the following template for identifying and describing, on a high level, the capabilities. Mandatory fields are marked with an (M) and attributes also foreseen in Capella are identified with an *.

Name*	(M)	Name of the Capability. The following pattern is required: SysC<*capability number*>: <*capability name*> <*capability number*> is a unique integer number. <*capability name*> begin with an action verb which has optionally an object.
Operational Need*		Operational need of the Capability from a stakeholder perspective. Can be expressed as a user story. For example: As <*stakeholder name*>, the system helps me to <*system capability*> in order to carry out <*mission*>. As <*stakeholder name*>, I want to <*receive benefit*> from the system, when <*precondition*>, so that I can <*mission*>.
Summary*		Detailed description of the Capability. Can be expressed as a user story. For example: As <*actor name*>, the system helps me to <*system capability*> in order to carry out <*mission*>. As <*actor name*>, I want to <*receive benefit*> from the system, when <*precondition*>, so that I can <*mission*>.
Mission	(M)	Mission(s) related to the Capability as defined in the chapter 4.3.
Involved actors*		It includes human, non-human actors, and the system itself. Actors are defined in the chapter 4.2. Minimum one actor is referenced.
ERTMS Level*	(M)	Applicable ERTMS Level: 0, 1, 2, 3 or NTC.
ERTMS Mode*	(M)	Applicable ERTMS Mode (e.g., NP, OS, LS, FS, etc.)
GoA*	(M)	Applicable level of automation: 1, 2, 3 or 4.
Pre-condition*		Conditions necessary for the Capability to be performed. Must be selected from the list of Constraints and/or States in the System Analysis. It can be expressed as: a constraint that evaluates to TRUE or, an entering state of the system. A constraint is a Capella element which allow to formalize list of conditions carried by an element (function, a functional exchange). E.g.: 
Condition during execution		
Post-Condition*		Conditions verified after the Capability has been performed. Must be selected from the list of Constraints and/or States in the System Analysis. It can be expressed as: a constraint that evaluates to TRUE or, an existing state of the system.

		It is a measurable or observable result delivered by the system to an actor.
Non-Functional Requirement		Non-functional requirement applicable to the capability.
Functional Chain*	(M)	Functional chain(s) describing the Capability. Functional chain is an ordered sequence of functions linked with directional functional exchange or sequence link. Minimum one functional chain referenced. Generally, one functional chain by system mode where the capability is operating.
Scenario	(M)	Scenario describes a time sequence of exchange between actors (exchange scenario) or functions (functional scenario).
CCS-OB mode	(M)	Reference to an CCS-OB mode, as identified in chapter 4.4.
Type of train*	(M)	Type of train to which this capability is applicable (e.g., Passenger, Freight, Construction, All)
Remark		

Appendix B System Capabilities

Hereunder are system capabilities that have been specified with the above template, which will be used as input documents for the modelling of the system in Capella.

SysC01 – Allow local system configuration and software update

Name*	(M)	**SysC01 - Allow local system configuration and software update**
Operational Need*		As an RU, I want to be able to apply CCS related configurations to a train while being on-site in order to configure a train in case remote configuration is not possible. As an RU, I want to be able to update CCS related software to a train while being on-site in case remote software update is not possible.
Summary*		As technician, I want the CCS-OB system to allow the application of configuration or software update onsite on the train
Mission	(M)	▪ Mission 1: Control safe train movement ▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver). ▪ Mission 3: Signal information to ensure safe and appropriate driving. ▪ Mission 4: Provide voice communication means ▪ Mission 5: Provide communication means between trackside and the train systems
Involved actors*		Technician
ERTMS Level*	(M)	Not relevant
ERTMS Mode*	(M)	Not relevant
GoA*	(M)	Not relevant
Pre-condition*		▪ The configuration file has been prepared ▪ The software file has been prepared ▪ Maintenance terminal connected to the CCS-OB
Condition during execution		
Post-Condition*		CCS-OB is configured/updated and ready to start
Non-Functional Requirement		Centralized configuration management: One access point to upload the configuration of the different sub-systems. (ATO, PER, ATP, DMI, …).
Functional Chain*	(M)	▪ The technician uploads the configuration data via Maintenance Terminal ▪ CCS-OB applies configuration data ▪ The technician uploads the software data via Maintenance Terminal ▪ CCS-OB applies new software data
Scenario	(M)	▪ System configuration in the commissioning of CCS-OB for the first time ▪ Change of system configuration due to modification of vehicle configuration ▪ Apply new software version due to software update
CCS-OB mode	(M)	System maintenance
Type of train*	(M)	Passenger, Freight, Construction

SysC02 – Allow remote system configuration and software update

Name*	(M)	**SysC02 - Allow remote system configuration and software update**
Operational Need*		As an RU, I want to be able to remotely apply CCS related configurations to a train to reduce the maintenance effort. As an RU, I want to be able to update remotely CCS related software to a train to reduce the maintenance effort.
Summary*		As OCS-RU DCM, the system helps to perform remote configuration and software update.
Mission	(M)	▪ Mission 1: Control safe train movement ▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver). ▪ Mission 3: Signal information to ensure safe and appropriate driving. ▪ Mission 4: Provide voice communication means ▪ Mission 5: Provide communication means between trackside and the train systems
Involved actors*		OCS-RU DCM
ERTMS Level*	(M)	Not relevant
ERTMS Mode*	(M)	Not relevant
GoA*	(M)	Not relevant
Pre-condition*		Connection between OCS-RU DCM and CCS-OB is established
Condition during execution		
Post-Condition*		▪ CCS-OB is configured and ready to start. ▪ CCS-OB software is updated and ready to start.
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS periodically checks with the OCS-RU if a new configuration / software version is available. ▪ CCS-OB downloads the new configuration file when CCS is powered and connected to OCS-RU ▪ CCS-OB downloads the software in case a new version is available while being powered and connected to OCS-RU DCM ▪ CCS-OB detects new configuration / software during initialization ▪ CCS-OB updates configuration / software data in case the scheduled date is reached
Scenario	(M)	▪ CCS-OB updates the configuration / software during initialization ▪ CCS-OB downloads configuration / software
CCS-OB mode	(M)	All modes where the CCS is powered (update during initialization)
Type of train*	(M)	Passenger, Freight, Construction

SysC03 – Manage train door operation

Name*	(M)	**SysC03 - Manage train door operation**
Operational Need*		As a driver, I want to see if all doors are locked to ensure a safe departure and driving. As a driver, I want to see if passengers may open the doors to ensure an efficient passenger exchange. As a driver, I want to be advised when and on which side of the train to release the doors to allow passengers to open the doors. As a driver, I want to be advised when to close & lock the doors for an on-time safe departure. As an IM, I want the doors to be released or closed & locked automatically to ensure on-time departure. As a driver, I want to be informed if the doors are automatically being closed to understand what the system is doing.
Summary*		As a driver, I want the system to display the state of the doors (open, closed) As a driver I want the system to advise me about expected manual actions related to the doors. As a driver, I want the system to automatically operate the doors As a driver I want the system to display all automatically performed actions related to the doors (doors are being closed by ATO).
Mission	(M)	▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver).
Involved actors*		▪ Driver ▪ ATO Transactor ▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Technician
ERTMS Level*	(M)	1,2,3
ERTMS Mode*		FS, AD
GoA*	(M)	1, 2
Pre-condition*		▪ The physical train unit is capable to provide the current state of the doors to the CCS-OB. AND ▪ CCS-OB is equipped with ATO AND ▪ ATP-OB is in FS or AD Mode
Condition during execution		
Post-Condition*		▪ Door information is displayed ▪ Door operation is performed
Non-Functional Requirement		ERA 15560 (CR1238)
Functional Chain*	(M)	▪ ATO transactor provides journey profile to CCS-OB ▪ PTU-OS provides the states of the doors ▪ CCS-OB (ATO) determines the required door states ▪ CCS-OB (ATO) computes the door information to be displayed ▪ CCS-OB displays the door information to the driver. ▪ CCS-OB requests door operation ▪ PTU-OS commands door operation
Scenario	(M)	▪ Train stops at station and the driver commands manually the door control ▪ Train stops at station and the ATO commands automatically the door control
CCS-OB mode	(M)	▪ Supervised manual movement ▪ Supervised automatic movement ▪ Short stop at operational stopping points ▪ Approaching stopping point
Type of train*		Passenger

Remark		This capability is only active with ATO as it requires door information in Journey Profile from ATO transactor. Door information is displayed also in mode FS, when the ATO is not engaged when the train stops at station.

SysC04 – Change mode as requested by trackside

Name*	(M)	**SysC04 - Change mode as requested by trackside**
Operational Need*		As IM I want to be able to request a train to perform an ERTMS mode change (SH, OS, LS, FS) immediately or at a defined location in accordance with the track situation (track occupancy, shunting exploitation, work area, parking field, etc...). As a driver, I want to be informed when the trackside requires me to perform an announced ERTMS mode change; As a driver, I want to know when an automatic mode transition occurs.
Summary*		As RBC or Eurobalise or Euroloop or Radio infill or Digital Map, I want the CCS-OB to help me setting the Onboard supervision mode (shunting, on-sight, limited supervision or full supervision). As a driver, I want the CCS-OB to inform me when the trackside requires me to perform an announced ERTMS mode change. As a driver, I want the CCS-OB to inform me when an automatic mode transition occurs.
Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [*in case of virtual balise*] ▪ Radio In-fill Unit (RIU) ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Driver
ERTMS Level*	(M)	0,1,2,3, NTC (for shunting) 1,2,3 (for on-sight, limited supervision, full supervision)
ERTMS Mode*	(M)	FS, OS, SR, LS, UN, PT, SB, SN, AD
GoA*	(M)	1, 2
Pre-condition*		Mode is FS, LS, OS, SR, PT, SN, UN, SB or AD
Condition during execution		
Post-Condition*		Train is in mode SH or OS or LS or FS
Non-Functional Requirement		
Functional Chain*	(M)	▪ Eurobalise, Euroloop, Digital map, Radio infill or RBC generates movement authority with or without mode profile. ▪ CCS-OB changes the mode to SH or OS or LS or FS according to trackside parameters (applicable point) and possible requested driver acknowledgement ▪ CCS-OB manages acknowledgment (request, monitor, service brake command) (for SH, OS or LS transition mode) ▪ Driver acknowledges the mode transition (for SH, OS or LS transition mode)
Scenario	(M)	▪ train entering a yard (FS->OS->SH) ▪ train entering station for coupling (FS->OS) ▪ train entering in an occupied section (AD->OS) announced in advanced ▪ train entering in an occupied section (FS->OS) without mode transition announcement. ▪ train receiving its first MA (SR->FS) ▪ train entering Limited Supervision area (SR->LS) ▪ start of mission (SB->OS) ▪ train receiving MA in PT (PT->OS) ▪ Exit unfitted area (UN -> LS) ▪ Train entering ERTMS area (SN->FS)

CCS-OB mode	(M)	▪ Supervised manual movement ▪ Supervised automatic movement ▪ Not supervised movement
Type of train*	(M)	All

SysC05 – Drive train between two operational timing points

Name*	(M)	**SysC05 - Drive train between two operational timing points (ATO over ETCS)**
Operational Need*		As an IM I want the train to drive automatically between two operational timing points whilst complying with the operational timetable to save energy and to improve passenger comfort.
Summary*		As a train, I want the system to provide me with traction/brake commands in order to move according to the operational timetable.
Mission	(M)	▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver).
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ ATO transactor ▪ MT
ERTMS Level*	(M)	1,2,3, NTC
ERTMS Mode*		ERTMS mode AD
GoA*	(M)	2,3,4
Pre-condition*		▪ Journey profile and at least first segment profile have been received from ATO AND ▪ Movement authority has been received from MT AND ▪ ATO-OB is engaged
Condition during execution		
Post-Condition*		▪ The train reached last passing point before a stopping point
Non-Functional Requirement		Timing point accuracy - subset 125
Functional Chain*	(M)	▪ CSS-OB periodically checks with AT for updated journey profile ▪ CCS-OB (VL) determines train position ▪ CCS-OB (ATO-OB) calculates the most efficient speed profile ▪ CCS-OB (ATO-OB) sends traction and brake commands to the train. ▪ PTU provides information about train status (brake/traction) ▪ CCS-OB requests next segment profile Note: CCS(ATO-OB) ensures the required stopping accuracy (max overshoot, max undershoot)
Scenario	(M)	▪ nominal following JP setpoint ▪ nominal following ERTMS curves ▪ profile update during mission
CCS-OB mode	(M)	▪ Supervised automatic movement
Type of train*		All

SysC06 – Manage operational stopping points

Name*	(M)	**Sys06 - Manage operational stopping points**
Operational Need*		As an IM I want the train to stop automatically at the defined stopping points according to the operational timetable and exactly at the predefined position on the respective platform. As an IM I want to be able to instruct an automatically operated train to skip stopping points by means of updating the operational timetable. As a driver I want to know about the stopping accuracy of an automatically operated train to be able to manually adjust the stopping position if necessary. As a driver I want to be able to instruct the automatically operated train to skip the next stopping point.
Summary*		As a train, I want the system to provide the traction/brake commands to stop me at the stopping points provided by journey profiles along the mission. As a driver, I want the system to allow me to skip operational stopping points when the train is operated automatically. As a driver, I want the system to inform me about the stopping accuracy to take appropriate actions if necessary.
Mission	(M)	▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver).
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ ATO transactor ▪ Driver
ERTMS Level*	(M)	1,2,3,4, NTC
ERTMS Mode*	(M)	Mode AD
GoA*	(M)	2,3,4
Pre-condition*		▪ Journey profile including stopping points ▪ AND ▪ Next timing point is a stopping point
Condition during execution		
Post-Condition*		Train is stopped at the stopping point
Non-Functional Requirement		▪ Stopping point precision ▪ Parameters: presence of platform doors
Functional Chain*	(M)	▪ CCS displays the stopping points ▪ CCS computes the optimal speed profile ▪ Driver evaluates the stopping point (skipped or not) ▪ CCS (ATO-OB) send T/B command according to the next stopping point position ▪ CCS (VL) elaborates train position ▪ CCS(ATO-OB) commands the “standstill” brakes (e.g., by applying full service brake, holding brake…) ▪ CCS(ATO-OB) evaluates and displays the stopping accuracy (overshoot, undershoot)
Scenario	(M)	▪ GoA2/3/4 stopping point ▪ GoA2/3/4 stopping point skipped by driver
CCS-OB mode	(M)	Approaching a stopping point
Type of train*	(M)	All

SysC08 – Manage track conditions

Name*	(M)	**SysC08 - Manage track conditions**
Operational Need*		As an IM I want to be able to communicate track conditions to running trains to trigger (manually/automatically) the necessary actions when approaching or reaching a certain point. As a driver I want to see an indication about upcoming track conditions that require an action or attention. As a driver I want to be informed when I need to consider a track condition or execute an action based on a track condition. As a driver I want to be informed about track conditions that trigger an automatic action to be able to supervise automatic actions.
Summary*		As a Train, I want the system to help me perform actions based on received track condition As a driver, I want the system to help me perform and supervise actions based on received track conditions. ***Note***: Track condition = p68, p69 and “national” track conditions received from an NTP
Mission	(M)	▪ Mission 3: Signal information to ensure safe and appropriate driving ▪ Mission 5: Provide information to the train system
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio In-fill Unit (RIU) ▪ National Train Protection Systems (NTPs) ▪ Driver
ERTMS Level*	(M)	1, 2, 3, NTC
ERTMS Mode*		▪ FS, LS, OS, NL, TR, PT (for track condition sent by the ETCS trackside) ▪ SN (for national track condition sent by an NTP) ▪ SR, SH, PS, UN, SB (big metal masses only)
GoA*	(M)	1, 2, 3, 4
Pre-condition*		▪ CCS-OB is configured to handle each track condition (manual or automatic)
Condition during execution		
Post-Condition*		▪ Track condition is handled
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS trackside (MT / RBC, EUB, EUL, Radio infill, NTPs) provides track conditions ▪ CCS-OB determines the action(s) to be performed based on the received track conditions and the train location. ▪ CCS-OB displays track conditions information to the driver ▪ CCS-OB sends track conditions commands to the PTU ▪ PTU performs the actions based on the track conditions ▪ Driver supervises action(s) executed based on the track conditions ▪ Driver performs action(s) based on track conditions
Scenario	(M)	▪ Track conditions received from ETCS trackside. ▪ Track conditions received from NTC. ▪ Reception of a new track conditions list when a previously one is stored on-board but not yet executed. ▪ Reception of a new track conditions list when a previously one is stored on-board and being executed. ▪ Shortening track descriptions when the train is inside a track condition ▪ Reset to initial state ▪ Train receives track conditions when there are already 3 icons displayed on the DMI
CCS-OB mode	(M)	▪ Mission in NL cab. ▪ Not supervised movement (big metal masses TC) ▪ Shunting in maintenance yard (big metal masses TC) ▪ Supervised manual movement ▪ Supervised automatic movement

		▪ Approaching stopping point ▪ Short stop at operational stopping point
Type of train*		All

SysC09 – Command train function (GoA3/4)

Name*	(M)	**SysC09 - Command train function (GoA3/4)**
Operational Need*		As a RU, I want to able to prepare a driverless train.
Summary*		As trackside (ATO-TS), I want the CCS-OB to help me control train functions. This capability deals with commanding train functions by ATO when operated in GoA3/4 in normal operation only. It is not related to remote control where we consider that IM-TM (train management) is linked directly to the Train without involvement of the CCS. Based on shift2rail specification for GoA3/4
Mission	(M)	Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver).
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ ATO-TS
ERTMS Level*	(M)	0,1,2,3, NTC
ERTMS Mode*		AD
GoA*	(M)	3,4
Pre-condition*		▪ Mode is AD *AND* ▪ Automatic driving level is 3 or 4 *AND* ▪ Train functions are configured and available
Condition during execution		
Post-Condition*		Train function has been executed
Non-Functional Requirement		
Functional Chain*	(M)	▪ ATO-TS sends mission profile ▪ CCS-OB commands train function: - Switch battery breaker - Rise/lower panto - Open/close main switch - switch on/off engine - Switch engine heater - Switch headlight - Start auxiliaries - Command horn - Command heat coupler ▪ Command open coupler flap
Scenario	(M)	▪ train preparation in GoA3/4
CCS-OB mode	(M)	▪ Supervised automatic movement ▪ Configuration
Type of train*		All

SysC13 – Provide driving advisory

Name*	(M)	**SysC13 - Provide driving advisory**
Operational Need*		As an RU, I want my driver to receive advisory information to drive the train in a time & energy efficient way.
Summary*		As a driver, I want the system to provide me advisory information to help me drive the train in a time & energy efficient way.
Mission	(M)	Mission 3: Signal information to ensure safe and appropriate driving
Involved actors*		▪ Driver ▪ ATO Transactor
ERTMS Level*	(M)	1, 2, 3
ERTMS Mode*		Mode FS
GoA*	(M)	1
Pre-condition*		▪ Train is equipped with ATO *AND* ▪ The CCS OB is in mode FS *AND* ▪ The CCS OB receives from IM (ATO Transactor) JP and SP.
Condition during execution		
Post-Condition*		DAS trajectories are displayed to the driver
Non-Functional Requirement		The requested information shall be displayed within 0.4s, and shall be refreshed at least every 0.5s.
Functional Chain*	(M)	▪ CCS OB calculates the ATO operational speed profile each time JP is updated ▪ CCS OB computes continuously the DAS trajectory (Target Advisory Speed, Coasting advice, next advice change) and displays it continuously to the driver. ▪ Driver evaluates displayed information
Scenario	(M)	▪ Manual driving with ATO equipped train on ATO line ▪ Manual driving with ATO equipped train on non ATO line ▪ Manual driving with autonomous DAS ▪ Cross border between autonomous DAS and ATO
CCS-OB mode	(M)	▪ Supervised manual movement
Type of train*		All

SysC14 – Provide allowed speed and distance information

Name*	(M)	**SysC14 - Provide allowed speed and distance information**
Operational Need*		As a driver, I want to receive information about the speed and distance supervision to be able to drive within the permitted limits.
Summary*		As a driver, I want the system to show me information about the speed and distance supervision (permitted speed, warning speed, sbi & ebi speed, target speed and distance, planning target…).
Mission	(M)	Mission 3: Signal information to ensure safe and appropriate driving
Involved actors*		▪ Driver ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio In-fill Unit (RIU) ▪ Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level*	(M)	0, 1, 2, 3 or NTC
ERTMS Mode*		Mode SH, FS, AD, OS, LS, SR, RV, UN, PT, SN
GoA*	(M)	1,2
Pre-condition*		▪ Movement authority received from MT *AND* ▪ Train configuration received from PTU and Driver *AND* ▪ Information received from balise: localisation and MA.
Condition during execution		
Post-Condition*		Speed and distance information displayed
Non-Functional Requirement		The requested information shall be displayed within 0.4s and shall be refreshed at least every 0.5s (refer to subset-41 & subset-121 for more details).
Functional Chain*	(M)	▪ CCS computes MRSP ▪ CCS identifies the targets ▪ CCS computes brakes curves ▪ CCS computes: - supervision limits - speed limits - distance limit ▪ CCS computes STM speed and distance limits ▪ CCS manages LSSMA display ▪ CCS sends information to be displayed to Train Display System ▪ Train Display System displays received information
Scenario	(M)	▪ Movement in ceiling speed monitoring ▪ Movement approaching a decrease of speed limitation ▪ Movement approaching the end of authority ▪ Movement in SR ▪ Movement in OS ▪ Movement in RV ▪ Movement in SN ▪ Update of a target (MA, SPP, TSR)
CCS-OB mode	(M)	▪ Supervised manual movement ▪ Supervised automatic movement Not supervised movement ▪ Shunting in maintenance yard
Type of train*		All

SysC15 – Allow RBC to command emergency stops

Name*	(M)	**SysC15 - Allow RBC to command emergency stops**
Operational Need*		As an IM, I want to be able to request the train to stop in dangerous situations in order to avoid an accident. As an IM, I want to be able to revoke emergency stop request as it is not needed any more due to change of situation.
Summary *		As RBC&MT, I want the CCS-OB to command an emergency stop via PTU-OS on my request. As RBC&MT, I want the CCS-OB to revoke emergency stop on my request.
Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level	(M)	2,3
ERTMS Mode		SB, FS, LS, SR, PT
GoA	(M)	GoA 1,2,3,4
Pre-condition*		Emergency stop required
Condition during execution		
Post-Condition*		Emergency stops evaluated by CCS-OB
Non-Functional Requirement		
Functional Chain*	(M)	▪ RBC sends emergency stops message ▪ CCS-OB evaluates emergency message (conditionnal or unconditionnal) ▪ CCS-OB commands emergency brake in case the condition is satisfied (received MA will be rejected) ▪ RBC sends revocation of emergency stop message ▪ CCS-OB acknowledges revocation of emergency stop (so as to receive new MA)
Scenario	(M)	▪ conditionnal emergency stop accepted ▪ conditional emergency stop rejected ▪ unconditionnal emergency stop ▪ revocation of emergency stop
CCS-OB mode	(M)	▪ Configuration ▪ Supervised manual movement ▪ Unsupervised manual movement ▪ Supervised automatic movement ▪ Unexpected stop ▪ Approaching stopping point ▪ Short stop at operational stopping point ▪ Joining / Splitting
Type of train		All

SysC16 – Provide status information (ATP - ATO status)

Name*	(M)	**SysC16 - Provide status information (ATP - ATO status)**
Operational Need*		As a driver, I want to know the status of the ATP and ATO to be able to safely drive the train and to intervene in case of anomalies.
Summary*		As a driver, I want to receive information on CCS-OB status.
Mission	(M)	Mission 3: Signal information to ensure safe and appropriate driving
Involved actors*		Driver
ERTMS Level*	(M)	0, 1, 2, 3, NTC
ERTMS Mode*		All ERTMS Modes except NP, PS, SL, SF, IS
GoA*	(M)	1, 2
Pre-condition*		CCS-OB is powered on and successfully initialized
Condition during execution		
Post-Condition*		CCS-OB status is correctly displayed
Non-Functional Requirement		▪ The requested information shall be displayed within 0.4s and shall be refreshed at least every 0.5s (refer to subset-41 & subset-121 for more details). ▪ ERA_ERTMS_015560 – ETCS Driver Machine Interface for the symbol format and display place
Functional Chain*	(M)	▪ CCS-OB determines mode and level. ▪ CCS-OB determines brake intervention status. ▪ CCS-OB determines adhesion factor value ▪ CCS-OB manages Radio network registration and safe radio connection ▪ CCS-OB manages the NTC specific data entry ▪ CCS-OB manages the train reversing ▪ CCS determines radio status (GSM-R) ▪ CCS-OB determines ATO status in case ATO is interfaced with ETCS ▪ CCS-OB converts UTC to local time ▪ CCS-OB displays status information on Train Display System: - mode & level - brake intervention - adhesion factor - safe radio connection - reversing permitted - System is processing (hourglass) - Cab radio status - ATO status - Local time
Scenario	(M)	▪ ERTMS Start of Mission ▪ Vehicle exceeds the SB/EB intervention speed ▪ Vehicle enters Reversing mode ▪ NTC specific data entry
CCS-OB mode	(M)	▪ Configuration ▪ Not supervised movement ▪ Supervised manual movement ▪ Supervised automatic movement ▪ Approaching stopping point ▪ Short stop at operational stopping point ▪ Joining/splitting ▪ Movement in maintenance yard ▪ Mission in non-leading
Type of train*		All

SysC17 – Supervise train speed

Name*	(M)	**SysC17 - Supervise train speed**
Operational Need*		As an IM, I want to ensure the safety of all trains running on my network, to avoid accidents and damage to my infrastructure.
Summary*		As a driver, I want the system to help me supervise the speed of the vehicle, so that I can control safely the train movement and adapt the speed for the supervised target: - the locations corresponding to a speed decrease of the MRSP - the Limit of Authority (LOA) - the End of Authority (EOA) and the Supervised Location (SvL) - the location deduced from the maximum permitted distance to run in Staff Responsible, with a target speed zero
Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Driver ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio In-fill Unit (RIU) ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level*	(M)	0, 1, 2, 3, NTC
ERTMS Mode*		All ERTMS Modes except NP, PS, SL, SF, IS
GoA*	(M)	1, 2
Pre-condition*		▪ Train configuration and train data are received *AND* ▪ Trackside related inputs are received
Condition during execution		
Post-Condition*		Supervision limits are computed, and speed and distance monitoring commands are sent when necessary
Non-Functional Requirement		▪ Refer to subset-041 and subset-091 for performance requirements ▪ The train position stored onboard shall remain valid if train has not moved since last Power Off (so as to obtain MA asap)
Functional Chain*	(M)	▪ CCS-OB determines train related inputs (from data storage, the driver or external device). ▪ CCS-OB receives trackside related inputs (Gradients, Reduced Adhesion, Track conditions, Speed and distance limits (LoA, EoA/SvL, SR distance), Trackside speed restrictions, National values, Inhibition of revocable TSRs from balises in L2/3, Route Suitability Data) ▪ CCS-OB determines MRSP ▪ CCS-OB updates MA with the expiration of section timer, new MA, repositioning information, infill information, or MA shortening from RBC ▪ CCS-OB checks the route suitability with stored Train Data ▪ CCS-OB determines the supervised targets ▪ CCS-OB determines train speed and location ▪ CCS-OB computes brakes curves ▪ CCS-OB computes supervision limits - speed limits - distance limits ▪ CCS-OB sends speed and distance monitoring commands: - EB command - SB command - TCO command ▪ PTU commands EB, SB, TCO
Scenario	(M)	▪ Movement in ceiling speed monitoring ▪ Movement approaching a decrease of speed limitation ▪ Movement approaching the end of authority ▪ Movement in SR ▪ Movement in OS ▪ Movement in RV ▪ Update of a target (MA, SPP, TSR)

CCS-OB mode	(M)	▪ Not supervised movement ▪ Supervised manual movement ▪ Supervised automatic movement ▪ Manoeuvre in maintenance yard ▪ Approaching stopping point
Type of train*		All

SysC18 – Manage train integrity

Name*	(M)	**SysC18 - Manage train integrity**
Operational Need*		As an IM, I want to avoid collisions with lost train consists/wagons.
Summary*		As RBC, I want the CCS-OB to help me know the integrity (integrity and safe consist length) of a train considering its entire train length in order to validate the min safe rear end of the train.
Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Driver ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level*	(M)	3
ERTMS Mode*		SB, FS, LS, SR, OS, AD, PT, RV (in case of loss of train integrity)
GoA*	(M)	1,2,3,4
Pre-condition*		PTU evaluates train integrity.
Condition during execution		
Post-Condition*		Train integrity information is sent
Non-Functional Requirement		
Functional Chain*	(M)	▪ PTU sends train integrity status to CCS-OB ▪ Driver confirms train integrity status (except GoA3/4) ▪ CCS-OB sends position report including train integrity information to the RBC
Scenario	(M)	▪ Movement sending position report with train integrity ▪ Movement sending position report losing train integrity
CCS-OB mode	(M)	▪ Configuration ▪ Not supervised movement ▪ Supervised manual movement ▪ Supervised automatic movement
Type of train*		All

SysC19 – Protect against undesirable train movement

Name*	(M)	**SysC19 - Protect against undesirable train movement**
Operational Need*		A) As an IM, I want that trains remain at standstill until their movement can be supervised. B) As an IM, I want trains to only move in the permitted direction. C) As an IM, I want trains to be protected against rolling in the opposite direction than selected by the direction controller of the active cabin. D) As an IM, I want trains to remain immobilized for passenger exchange, operational reasons, signalling reasons in case of automatic driving.
Summary*		A) As the train, I want the CCS-OB to ensure that the train remains standstill as long as it can't supervise movement (standstill supervision). B) As the train, I want the CCS-OB to prevent me from moving in the opposite direction to the permitted one (reverse movement protection). C) As the train, I want the CCS-OB to prevent me from moving in a direction which conflicts with the current position of the direction controller in the active desk (rollaway protection). D) As the train, I want the CCS-OB to ensure that the train remains immobilized for passenger exchange, operational reasons, signalling reasons (automatic driving).
Mission	(M)	▪ Mission 1: control safe movement ▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver)
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ ATO transactor
ERTMS Level*	(M)	0,1,2,3
ERTMS Mode*		A) SB, B, C) FS, LS, SR, OS, PT, RV C) UN, SH D) AD
GoA*	(M)	1,2,3,4
Pre-condition*		(A) CCS-OB is powered and mode is SB (B) MA stored on board (C) Direction controller status available (backward/forward) (D) Automatically standstill commanded
Condition during execution		
Post-Condition*		Emergency brake in case of undesirable train movement
Non-Functional Requirement		A) A short movement is allowed: distance threshold (D_NVROLL) to take into action little movement occurred during coupling D) accuracy of detected movement
Functional Chain*	(M)	▪ CCS acquires travelled distance (A,D) ▪ CCS detects overrunning of a distance threshold (A) ▪ CCS detects inconsistency between MA orientation and movement orientation (B) ▪ CCS detects inconsistency between direction controller and movement orientation (C) ▪ CCS detects movement (D) ▪ CCS command emergency brakes (A, B, C, D)
Scenario	(M)	▪ Movement of the train while not supervised for movement (A) ▪ Movement in the opposite direction from the MA (B) ▪ Movement in the opposite direction from the direction controller (C) ▪ Movement when automatically standstill is commanded (D)
CCS-OB mode	(M)	▪ Configuration (A) ▪ Supervised manual movement (B, C) ▪ Supervised automatic movement (B) ▪ Stop at an operational stopping point (D)
Type of train*		All

SysC20 – Allow driver to initiate specific modes

Name*	(M)	**SysC20 - Allow driver to initiate specific modes**
Operational Need*		As a driver, I want the CCS to supervise the movement of the train during shunting operation. As a driver, I want the CCS to supervise manoeuvre without signals on the track. As a driver, I want the CCS to manage the slave engine during Tandem operation, i.e., on-board equipment is not remote controlled and there is an active cab. As a driver, I want the CCS to avoid entering the SoM procedure while performing consecutive shunting movement with change of cab.
Summary*		As a driver, I want the CCS to allow me to select shunting supervision mode. As a driver, I want the CCS to allow me to select Shunting supervision mode. As a driver, I want the CCS to allow me to select Supervised Manoeuvre mode. As a driver, I want the CCS to allow me to select Non Leading mode. As a driver, I want the CCS to allow me to change to Passive Shunting mode when the desk is closed, and the on-board equipment is not remote controlled.
Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Driver ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Physical Train Unit Operation Systems (PTU-OS) (driver selection to NL, PS)
ERTMS Level*	(M)	0,1,2,3, NTC **(driver selection to SH)** 2,3 **(driver selection to SM)** 0,1,2,3, NTC **(driver selection to NL)** 0,1,2,3, NTC **(driver selection to PS)**
ERTMS Mode*		FS, LS, OS, SR, AD, SM, PT, SN, UN or SB **(driver selection to SH)** FS, AD, OS, LS, SR, PT, SB or SM **(driver selection to SM)** SB, SH, FS, AD, LS, SR or OS **(driver selection to NL)** SH **(driver selection to PS)**
GoA*	(M)	1
Pre-condition*		**Driver selection SH:** Train is at standstill *AND* Mode is FS, LS, OS, SR, AD, SM, PT, SN, UN or SB **Driver selection SM:** Train operates at level 2/3 *AND* the “safe consist length” information is available on-board *AND* (Mode is SM *OR* (Mode is FS, AD, OS, LS, SR, PT or SB *AND* Driver ID is known *AND* no RBC transition order is stored on-board)) **Driver selection NL:** Train is at standstill *AND* Mode is SB, SH, FS, AD, LS, SR or OS **Driver selection PS:** Mode is SH
Condition during execution		
Post-Condition*		Train is in the selected mode

Non-Functional Requirement		
Functional Chain*	(M)	▪ PTU-OS generates input signal for mode transition (NL, PS) ▪ CCS-OB manages Driver's selection (SH / SM / NL / PS) and Cab closure (PS) ▪ CCS-OB requests SH / SM authorisation to the RBC ▪ RBC sends SH / SM authorisation to CCS-OB ▪ CCS-OB changes the mode to NL / PS / SH / SM ▪ CCS-OB recalculates train position and deletes location related info in case of train orientation change after transition to SM ▪ CCS-OB reports position to RBC after mode transition when the level is 2/3 ▪ CCS-OB terminates communication session (SH)
Scenario	(M)	▪ Initiate shunting by driver in level1 ▪ Initiate shunting by driver in level2 ▪ Initiate Passive shunting by driver ▪ Initiate Non-leading by driver ▪ Initiate Supervised manoeuvre by driver
CCS-OB mode	(M)	▪ Mission in non active cabin (PS) ▪ Mission in non leading cabin (NL) ▪ Manoeuvre in maintenance yard (SH, SM) ▪ Supervised manual movement (SM)
Type of train*		All

SysC21 – Acquire mission specific parameters

Name*	(M)	**SysC21 - Acquire mission specific parameters**
Operational Need*		As a driver, I want to be able to set mission specific and radio parameters.
Summary*		As driver, I want the CCS-OB system to help me enter the mission specific parameters. As driver, I want the CCS-OB to offer the possibility to view the mission specific parameters.
Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Driver ▪ Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level*	(M)	0, 1, 2, 3 or NTC
ERTMS Mode*		SB, FS, LS, SR, OS, UN, SN
GoA*	(M)	1
Pre-condition*		▪ Cabin is activated AND (▪ CCS-OB is in mode SB OR ▪ CCS-OB is in mode FS, LS, SR, OS, UN or SN and data already valid (update))
Condition during execution		
Post-Condition*		The mission specific parameters are updated
Non-Functional Requirement		ERA_ERTMS_015560
Functional Chain*	(M)	▪ Driver enters driverID ▪ Driver enters Train Running Number ▪ Driver enters Virtual Balise Cover ▪ Driver enters radio parameters ▪ Driver enters train integrity ▪ Driver enters reduced adhesion ▪ Driver enters the SR parameters ▪ Driver selects level ▪ Driver enters/revalidates train data - CCS-OB requests the train data entry from driver - CCS-OB receives train data from external device - Driver enters train data - CCS-OB checks train data ▪ Driver enters/revalidates NTC specific data in case of NTC level ▪ Driver enters/revalidates ATO specific data in case ATO is available ▪ Driver views the data
Scenario	(M)	▪ Driver changes mission specific parameters in modes other than SB ▪ Driver enters mission specific parameters during SoM including: - Driver enters fixed train data - Driver enters flexible train data - Driver enters switchable train data
CCS-OB mode	(M)	▪ Configuration ▪ Supervised manual movement ▪ Not supervised manual movement
Type of train*		All

SysC25 – Provide juridical records

Name*	(M)	**SysC25 - Provide juridical records**
Operational Need*		As an IM/RU I want the train to record juridical information to be analysed in case of accidents or other issues regarding the interaction between trackside and on-board that need investigation, etc.
Summary*		As RU, I want the CCS-OB to provide juridical information.
Mission	(M)	▪ Mission 1: Control safe train movement. ▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver).
Involved actors*		Train Recording Unit (TRU)
ERTMS Level*	(M)	0,1,2,3
ERTMS Mode*		All
GoA*	(M)	1,2,3,4
Pre-condition*		▪ CCS-OB is initialized *AND* ▪ CCS-OB is connected to the TRU
Condition during execution		
Post-Condition*		Juridical data transmitted to TRU recording device
Non-Functional Requirement		Subset 027
Functional Chain*	(M)	▪ CCS-OB prepares and sends information to TRU ▪ TRU records the received juridical information
Scenario	(M)	▪ juridical recording
CCS-OB mode	(M)	All except power down and maintenance modes
Type of train*		All

SysC26 – Manage application outside of ERTMS system

Name*	(M)	**SysC26 – Manage application outside of ERTMS system**
Operational Need*		As an IM, I want to implement applications outside of ERTMS/ETCS by using the ERTMS transmission channel.
Summary*		As the PTU-OS, I want that CCS-OB reads data to be used by applications outside of ERTMS transmitted by trackside over the ERTMS transmission channel and forward it to the specific application.
Mission	(M)	▪ Mission 5: Provide information to the train system
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Driver ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ National Train Control system
ERTMS Level	(M)	0, 1,2,3, NTC
ERTMS Mode		All Modes except NP, SF and IS
GoA	(M)	1,2,3,4
Pre-condition*		Data to be used by applications outside of ERTMS is available
Condition during execution		
Post-Condition*		Data is transmitted to specific application outside of ERTMS system
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB receives data to be used outside of ERTMS from trackside ▪ CCS-OB decodes data ▪ CC-OB forwards data to the specific application outside of ERTMS system according to NID_XUSER in the message
Scenario	(M)	▪ Movement in infrastructure with specific application data implemented in balise ▪ Movement in infrastructure with specific application data stored in RBC
CCS-OB mode	(M)	All modes where the CCS is powered (update during initialization)
Type of train		All

SysC28 – Inform about CCS on-board, CCS trackside and TCMS failures

Name*	(M)	**SysC28 - Inform about CCS on-board, CCS trackside and TCMS failures**
Operational Need*		As an RU, I want to be informed about CCS on-board and TCMS failure and key performance indications in order to plan corrective and predictive maintenance. As an IM, I want to be informed about CCS on-board and TCMS failure and key performance indications in order to anticipate/prevent traffic management issue (rerouting, scheduling, …). As an IM, I want to be informed about CCS trackside failure and key performance indications in order to plan corrective and predictive maintenance.
Summary*		As the OMS wayside (OMS-WS), I want the CCS-OB informing me about CCS on-board, CCS trackside and TCMS failures in order to dispatch the information to the right consumer/subscriber.
Mission	(M)	Mission 1: Control safe train movement* Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver)* Mission 3: Signal information to ensure safe and appropriate driving* Mission 4: Provide voice communication means* Mission 5: Provide information to the train system* *: this capability is to support the achievement of these missions by improving availability and maintainability of the system with the additional actions based on the failure information
Involved actors*		▪ Online Monitoring System (OMS-WS) ▪ Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level	(M)	NTC, 0, 1, 2, 3
ERTMS Mode		All, except NP, SF and IS
GoA	(M)	1, 2, 3, 4
Pre-condition*		The CCS-OB is connected to the OMS-WS.
Condition during execution		
Post-Condition*		On-board, trackside and train failure messages sent to the OMS-WS.
Non-Functional Requirement		As specified in Subset-149: ▪ The CCS-OB shall be able to buffer all failure messages **during 24 hours** in case of loss of radio connection. ▪ The CCS-OB shall be able to store failure messages in a local memory **for a period of 20 days**. ▪ The latency between having a packet prepared from ETCS and the GNSS tag added by MDCM-OB shall be less than 1 sec (magnitude 1-3sec).
Functional Chain*	(M)	▪ CCS-OB generates failure messages in case of CCS on-board, CCS trackside or TCMS failures. ▪ CCS-OB generates Data Collections which contains failure message(s) and Data Collection Header information. ▪ CCS-OB associates GNSS coordinates to each Data Collection for CCS on-board, CCS trackside and TCMS failures. ▪ CCS-OB stores Data Collection which contains failure messages in a local memory. ▪ CCS-OB sends Data Collection which contains failure messages to the OMS-WS. ▪ CCS-OB buffers Data Collection which contains failure messages in case of loss of radio connection.
Scenario	(M)	▪ Failure reporting in normal operation (with radio connection available). ▪ Failure reporting in case of loss of radio connection.
CCS-OB mode	(M)	All, except “Standstill power down”
Type of train		All

SysC29 – Supervise allowed running distance

Name*	(M)	**SysC29 – Supervise allowed running distance**
Operational Need*		As an IM, I want to react in case the train overpasses end of movement authority. As an IM, I want to react in case the train overpasses the authorized backward distance. As an IM, I want to react in case the train overpasses the SR distance.
Summary*		A) As the train, I want the CCS-OB to react if the train overpasses the end of movement authority. B) As the train, I want the CCS-OB to react if the train overpasses the authorized backwards distance. C) As the train, I want the CCS-OB to react if the train runs more than the allowed distance in mode Staff Responsible.
Mission	(M)	Mission 1: control safe movement
Involved actors*		Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level*	(M)	1,2,3
ERTMS Mode*		Mode A) FS, LS, OS B) RV, PT C) SR
GoA*	(M)	1,2,3,4

Pre-condition*		Train position is known and
		{
		(A) MA stored on board
		(B) Train orientation is available and authorized backward distance is known
		(C) SR distance is known
		}

Condition during execution		
Post-Condition*		Emergency brake in case of overpassing allowed distance
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB detects that the end of movement authority is overpassed (A) ▪ CCS-OB detects that the train overpasses the distance allowed to run in the direction opposite to the train orientation (B) ▪ CCS-OB detects that the train overpasses the allowed distance to run in the mode Staff Responsible(C) ▪ CCS-OB trips and commands emergency brakes (A, B, C)
Scenario	(M)	▪ movement of the train in the end of MA(A) ▪ Movement in the opposite direction from the train orientation (B) ▪ Movement in the mode Staff Responsible (C)
CCS-OB mode	(M)	▪ Not supervised manual movement (B, C) ▪ Approaching a stopping point (A) ▪ Supervised manual movement (A) ▪ Supervised automatic movement (A) ▪ Approaching a stopping point (A)
Type of train*		All

SysC30 – Publish information to the PTU-OS

Name*	(M)	**SysC30 – Publish information to the PTU-OS**
Operational Need*		A) As a RU, I want CCS-OB to provide interfaces to exchange information with PTU-OS to minimize the amount of equipment in the train (to avoid the duplication of systems with the same functionality). B) As RU, I want the CCS-OB to provide diagnostic information. C) As the PTU-OS, I want the CCS-OB to provide information about gradient in order to improve traction/brake command.
Summary*		As PTU-OS, I want to receive additional information from the CCS-OB
Mission	(M)	Mission 5: Provide information to the train system
Involved actors*		Physical Train Unit Operation Systems (PTU-OS)
ERTMS Level*	(M)	0,1,2,3, NTC
ERTMS Mode*		All
GoA*	(M)	GoA 1,2,3,4
Pre-condition*		Connection between CCS-OB and PTU-OS is established
Condition during execution		
Post-Condition*		Information is published to PTU-OS
Non-Functional Requirement		
Functional Chain*	(M)	Time triggered information: ▪ CCS-OB (VL) computes odometry data (A) CCS-OB publishes cyclically the above information to PTU-OS Event triggered information: ▪ CCS-OB (MLM) manages isolation status (B) ▪ CCS-OB (Data Storage) manages track gradient (C) ▪ CCS-OB (MLM) manages ETCS on board status (B) ▪ CCS-OB (HMI) manages Driver ID and train running number (A) ▪ CCS-OB (ATO-OB) manages automatic driving mode (B) ▪ CCS-OB manages national function (packet44) (A) CCS-OB publishes the above information punctually PTU processes above information received from CCS-OB (Source: FVA specification v3.0) Note: this information is used by the train in order to take specific measure or optimize the brake and traction control.
Scenario	(M)	▪ isolation of VS ▪ update of gradient ▪ change of ETCS mode ▪ change of ATO mode ▪ ID and TRN entered by driver ▪ Reception of packet 44
CCS-OB mode	(M)	All except: Power down, initialization, system maintenance offline
Type of train*		All

SysC31 – Publish information to RBC for radio based train protection

Name*	(M)	**SysC31 - Publish information to RBC for radio based train protection**
Operational Need*		As IM, I want to receive information from the train needed for radio based train protection.

Summary*		As RBC, I want to receive information from the CCS-OB in order to:
		- Compute the movement authority based on
		  o The state of the track reported by the CCS-OB (free or not)
		  o The position of train
		- Adapt the information sent to the train according to the system version
		- Monitor the balise consistency and failure
		- Generate adapted track profile for the CCS-OB
		- Manage route

Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Radio Block Center (RBC) & Movement Authority Transactor (MT)
ERTMS Level*	(M)	2, 3
ERTMS Mode*		FS, OS, LS, SR, TP, PT, PS, SB, RV, SL, NL, SH (only in case of transition from PS)
GoA*	(M)	GoA 1,2,3,4
Pre-condition*		▪ Information is available ▪ Radio connection with RBC (Level2/3)
Condition during execution		
Post-Condition*		Information is available to the RBC
Non-Functional Requirement		

Functional Chain*	(M)	▪ CCS-OB computes information:
		  - position report (based on the conditions in SS-026 §3.6.5.1.4 and Position Report Parameters received from RBC)
		  - onboard supported system version
		  - error reporting
		  - level2/3 transition
		  - track ahead free granted
		  - train running number
		  - validated train data
		▪ CCS-OB sends above information to RBC
		▪ RBC processes above information received from CCS-OB

Scenario	(M)	▪ Start of mission (OB system version, TRN, DriverID) ▪ Balise error ▪ Radio error ▪ safety failure ▪ level 2/3 transition
CCS-OB mode	(M)	All except: Power down, initialization, maintenance offline
Type of train*		All

SysC32 – Manage balises to be ignored by CCS-OB

Name*	(M)	**SysC32 - Manage balises to be ignored by CCS-OB**
Operational Need*		As RU (only maintenance yard is concerned) / IM, I want specific balises to be ignored by the CCS-OB without physically intervening on the track, because the data stored in balises is not yet valid, the line is not yet in operation, or the line is being updated during the operation, e.g., during the construction, maintenance, etc.
Summary*		As balise or driver, I want the CCS-OB to help me to set / remove balises to be ignored.
Mission	(M)	Mission 1: Control safe train movement
Involved actors*		▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Driver
ERTMS Level*	(M)	0,1,2,3, NTC
ERTMS Mode*		All except NP, SF, IS
GoA*	(M)	GoA 1,2,3,4
Pre-condition*		CCS-OB is at standstill and in mode SB when this is set by the driver or The train crosses the balise which contains the list of balises to be ignored
Condition during execution		
Post-Condition*		The CCS-OB filters the read balise according to settings
Non-Functional Requirement		
Functional Chain*	(M)	▪ Balise sends identification of balises to be ignored ▪ Driver enters identification of balises to be ignored ▪ CCS-OB maintains the list of identifications of balises to be ignored ▪ CCS-OB reads balises and evaluates if it ignores them or not
Scenario	(M)	▪ Update the identification of balises to be ignored (by the driver or via balise) ▪ Mission with identification of balises to be ignored
CCS-OB mode	(M)	All except: Power down, initialization, maintenance offline
Type of train*		All

SysC34 – Provide stop instruction to the driver

Name*	(M)	**SysC34 – Provide stop instruction to the driver**
Operationnal need*		As IM, I want to inform the driver on the time that the train will dwell in the station. As IM, I want to inform the driver that the Train Hold is requested.
Summary*		As a driver, I want the system to display the stop instruction (dwell time, Train Hold).
Mission	(M)	▪ Mission 2: Optimise (energy, capacity, comfort) train movement (command train or signal to driver).
Involved actors*		▪ Driver ▪ ATO Transactor
ERTMS Level	(M)	1,2,3
ERTMS Mode		FS, AD
GoA	(M)	1, 2
Pre-condition*		▪ CCS-OB is equipped with ATO *AND* ▪ ATP-OB is in FS or AD Mode
Condition during execution		
Post-Condition*		▪ Stop instruction is displayed
Non-Functional Requirement		ERA 15560 (CR1238)
Functional Chain*	(M)	▪ ATO transactor provides journey profile to CCS-OB ▪ CCS-OB detects condition for displaying the stop instruction: - Dwell time if stopping point is reached - Train hold in case it is requested by ATO-TS by means of JP update ▪ CCS-OB displays the stop instruction ▪ TRDR evaluates the stop instruction
Scenario	(M)	▪ Train stopped at station ▪ Train Hold is requested by means of JP update
CCS-OB mode	(M)	▪ Short stop at operational stopping points
Type of train		Passenger

SysC35 – Ensure voice communication between driver and other staff

Name*	(M)	**SysC35 -** Ensure voice communication between driver and other staff
Operational Need*		As IM, I need to communication with the driver to inform about the degraded situation (e.g., manual route change), or to send driving instruction for traffic regulation. As IM, I need to stop the traffics in specific area in case of radio alert. As driver I need to communicate with infrastructure manager in case of abnormal operational situation (e.g., operational and signalling inconsistency). As RU, I want that driver and train attendant communicate with each other to inform about operation context (reason of unattended stop, reason of delayed departure). As a driver, I need to communicate with passenger in case they signal an emergency, and any train attendant is present. As driver I need to communicate with the driver of the slave engine to coordinate the movement of train.
Summary*		As driver, I want the system to ensure voice communication link with off-board staff As PTU-OS (off-board staff), I want the system to ensure voice communication link with the driver
Mission	(M)	Mission 4: Provide voice communication mean
Involved actors*		▪ Driver ▪ Voice Communication System (VCS) ▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Other Driver * * Driver in another train or in the slave engine
ERTMS Level*	(M)	N/A
ERTMS Mode*		N/A
GoA*	(M)	1, 2
Pre-condition*		Compatible network is connected
Condition during execution		
Post-Condition*		Voice communication is performed
Non-Functional Requirement		
Functional Chain*	(M)	▪ Initiate voice communication ▪ Call indication ▪ Call arbitration ▪ Perform conversation ▪ Call termination
Scenario	(M)	▪ Voice call between driver and off board staff ▪ Voice announcement ▪ Voice call between passenger and train attendant ▪ Voice call between drivers in different cab or train ▪ Voice call between driver and train attendant
CCS-OB mode	(M)	All power-on modes
Type of train*		All

SysC37 – Manage radio connection

Name*	(M)	**SysC37 – Manage radio connection**
Operational Need*		As IM, I want that CCS-OB establishes connection with relevant RBC(s) or RIU, i.e. the RBC / RIU which is responsible of the area, so as to perform radio based train protection.
Summary*		As RIU, I want the CCS-OB to ensure the radio communication at Radio In-fill area. As RBC, I want the CCS-OB to ensure the radio communication during the mission.
Mission	(M)	Mission 1: control safe movement
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Driver ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Radio In-fill Unit (RIU)
ERTMS Level*	(M)	1 (RIU or Level transition) 2,3 (RBC)
ERTMS Mode*		Mode SB*, PS*, SH*, FS, LS, SR, OS, SL, NL, UN*, TR, PT*, SN*, RV* *Modes only for communication session management
GoA*	(M)	1,2,3,4
Pre-condition*		CCS-OB is equipped with radio *AND* Radio network is available *AND* RBC / RIU is reachable
Condition during execution		
Post-Condition*		Radio connection with relevant RBC / RIU is established
Non-Functional Requirement		The change of RBC shall be done dynamically in nominal condition
Functional Chain*	(M)	▪ Driver enters radio network identity *OR* ▪ CCS-OB receives radio network registration order from trackside ▪ CCS-OB is registered to the radio network with data received from Driver or trackside ▪ Driver enters RBC data *OR* ▪ CCS-OB receives radio connection order from trackside ▪ CCS-OB establish communication session with RBC or RIU ▪ CCS-OB receives RBC transition order from trackside ▪ CCS-OB establish communication session with accepting RBC ▪ CCS-OB sends position report to accepting RBC when it passes the border ▪ CCS-OB terminates communication session with handing-over RBC
Scenario	(M)	▪ Establish communication session with RBC during SOM ▪ Establish communication session RBC with order from trackside ▪ Establish communication session RIU with order from trackside ▪ Driver changes manually the level to 2 or 3 ▪ Train enters another RBC area
CCS-OB mode	(M)	▪ Not supervised movement ▪ Supervised manual movement ▪ Supervised automatic movement ▪ Approaching stopping point
Type of train*		All

SysC38 – Provide additional track description to the driver

Name*	(M)	**SysC38 - Provide additional track description to the driver**
Operational Need*		As a driver, I want to be informed about the upcoming track characteristics to adapt and anticipate my driving behaviour as soon as possible. List of track description: - distance scale - orders and announcements of track conditions (excluding tunnel stopping areas) - gradient profile - speed profile discontinuity information - Planning Area Speed Profile (PASP) - indication marker
Summary*		As a driver, I want the system to display planning information to adapt and anticipate my driving behaviour based on the received track description.
Mission	(M)	Mission 2 - Optimise (energy, capacity, comfort) train movement (command train or signal to driver). Mission 3 - Signal information to ensure safe and appropriate driving.
Involved actors*		▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Radio In-fill Unit (RIU) ▪ Driver
ERTMS Level*	(M)	1, 2, 3
ERTMS Mode*		FS, OS
GoA*	(M)	1, 2
Pre-condition*		When the CCS-OB is in OS mode, the speed and distance monitoring information is toggled on.
Condition during execution		
Post-Condition*		Track description is displayed to the driver
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS trackside (MT / RBC, EUB, EUL, Radio infill) provides track description. ▪ CCS OB determines MRSP and targets. ▪ CCS OB computes **speed profile discontinuity information**, **planning area speed profile** and **indication marker**. ▪ CCS OB computes **gradient profile** to be displayed. ▪ CCS OB computes **orders and announcements of track conditions (excluding tunnel stopping areas)** to be displayed. ▪ CCS OB displays all planning information to the driver.
Scenario	(M)	▪ CCS-OB is running in FS mode with no more than 3 speed discontinuities more restrictive than the ceiling permitted speed at the current train front position and with a speed value greater than zero. ▪ CCS-OB is running in FS mode with more than 3 speed discontinuities more restrictive than the ceiling permitted speed at the current train front position and with a speed value greater than zero. ▪ CCS-OB is running in FS mode with speed discontinuities more restrictive and then less restrictive. ▪ CCS-OB is running in FS mode and reaching a speed discontinuity. ▪ CCS-OB is running in FS mode and MA and MRSP are updated. ▪ CCS-OB is running in FS mode with track condition(s) (excluding tunnel stopping areas). ▪ CCS-OB is running in OS mode and the speed and distance monitoring information is modified from toggled on to toggled off. ▪ CCS-OB is running in OS mode and the speed and distance monitoring information is modified from toggled off to toggled on.
CCS-OB mode	(M)	▪ Supervised manual movement ▪ Supervised automatic movement ▪ Approaching a stopping point ▪ Short stop at operational stopping point

Type of train*		All

SysC39 – Allow reverse movement

Name*	(M)	**SysC39 - Allow reverse movement**
Operational Need*		As an IM, I want to be able to inform the CCS-OB about the reverse area, to allow the reversal of movement of a train, to run away from a danger up to a safe location.
Summary*		As trackside, I want to inform the CCS-OB about the reverse area. As a driver, I want the CCS-OB to allow me to reverse the train in case of an emergency.
Mission	(M)	Mission 1: control safe movement
Involved actors*		▪ Driver ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise]
ERTMS Level*	(M)	1,2,3
ERTMS Mode*		FS, LS, OS
GoA*	(M)	1
Pre-condition*		The train is in mode FS, LS or OS
Condition during execution		
Post-Condition*		CCS-OB changes to RV mode
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB receives reversing area information from trackside ▪ CCS-OB informs the driver if the reversing of movement is permitted while the train at standstill ▪ The driver reverses the direction of movement while the train is inside the area ▪ CCS-OB requests the driver to acknowledge transition to RV mode ▪ CCS-OB switches to RV mode if the driver acknowledges
Scenario	(M)	movement of the train in reverse direction from a danger up to a safe location
CCS-OB mode	(M)	Supervised manual movement
Type of train*		All

SysC40 – Allow to cross non-authorised location

Name*	(M)	**SysC40 – Allow to cross non-authorised location**
Operational Need*		As an IM (Traffic management entity), I want to allow a train to pass its End of Movement Authority without train trip in specific degraded situations. As an IM (Traffic management entity), I want to avoid emergency brake when passing a balise group - Transmitting 'Stop if in SR mode' - Not contained in the list of expected balises in SR mode - Transmitting 'Stop if in SH mode' - Not contained in the list of expected balises in SH mode. As an IM (Traffic management entity), I want to allow a train in SR mode to reach the end of the SR distance to proceed.
Summary*		As driver, I want the CCS-OB to avoid emergency brake when the train crosses the non-authorised location.
Mission	(M)	Mission 1: control safe movement
Involved actors*		▪ Driver ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise]
ERTMS Level*	(M)	1,2,3
ERTMS Mode*		Mode SH, SR, UN, SN
GoA*	(M)	1
Pre-condition*		((The mode is FS, LS, OS, AD, SR, UN, PT, SB (levl 2/3) or SN) AND (Validated train data and Train running number are available) OR The mode is SH) AND (The train speed is under or equal to the speed limit for triggering the "override" function (national value)) * * *Conditions to enable Override*
Condition during execution		
Post-Condition*		Non-authorised location is crossed without emergency brake
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB evaluates conditions to enable Override ▪ Driver selects Override ▪ CCS-OB changes the operational mode according to the current one ▪ CCS-OB indicates the status 'override active' to the driver ▪ CCS-OB manages mode (inhibition of train trip)
Scenario	(M)	▪ Movement of the train to pass the end of MA ▪ Cross the balise 'Stop if in Shunting' in the mode SH ▪ Cross a balise which is not contrained in the list of expected balises in SH mode ▪ Cross the balise 'Stop if in SR' in the mode SR ▪ Cross a balise which is not contrained in the list of expected balises in SR mode ▪ Movement in the mode SR to reach the end of SR distance
CCS-OB mode	(M)	▪ Not supervised manual movement ▪ Supervised manual movement ▪ Manoeuvre in maintenance yard
Type of train*		All

SysC41 – Restrict operational mode SR or SH to the allowed area

Name*	(M)	**SysC41 – Restrict operational mode SR or SH to the allowed area**
Operational Need*		As IM, I want to prohibit the train to operate in Staff Responsible / Shunting beyond a certain location defined by balise on trackside.
Summary*		As PTU-OS, I want the CCS-OB to trigger emergency brake if the expected mode (SR, SH) is not the one allowed by trackside. As Driver, I want to prevent CCS-OB from awaking in SH after previous Passive Shunting operation if this is forbidden by trackside.
Mission	(M)	Mission 1: control safe movement
Involved actors*		▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise]
ERTMS Level*	(M)	1,2,3
ERTMS Mode*		SH, SR
GoA*	(M)	1, 2
Pre-condition*		▪ CCS-OB mode is SH OR ▪ CCS-OB mode is SR
Condition during execution		
Post-Condition*		CCS-OB trigger emergency brake (mode TRIP)
Non-Functional Requirement		The list of balise is optional The expected area for SH/SR will be defined through: - A list of balise which are allowed to be crossed in mode SH and SR - A point (packet in a balise) beyond which a specific mode is forbidden For SH area, the list of balise (packet 49) shall be transmitted: - with the definition of the area (start and length – mode profile packet 80) (subset 040 §4.2.4.3) if transmitted by balise - at the same time of the authorization, if transmitted by the MA transactor
Functional Chain*	(M)	▪ MA transactor sends a list of balise for Shunting ▪ Balise sends a list of balise for Shunting ▪ MA transactor sends a list of balise for Staff responsible ▪ Balise sends “Stop Shunting on desk opening” ▪ CCS-OB checks that identity of Eurobalise is not in the list ▪ CCS-OB checks if balise telegram contains information which order to stop if in specific mode (SR or SH) ▪ CCS-OB checks if there is “Stop Shunting on desk opening” information stored onboard when the desk is opened ▪ CCS-OB performs mode transition
Scenario	(M)	▪ Movement in SH mode in SH area ▪ Movement in SR mode in SR area ▪ Movement in SH mode outside SH area ▪ Movement in SR mode outside SR area ▪ Awake of train after Passive Shunting
CCS-OB mode	(M)	▪ Not supervised manual movement ▪ Configuration ▪ Mission in non active cabin
Type of train*		All

SysC42 – Manage system version

Name*	(M)	**SysC42 – Manage system version**
Operational Need*		As an IM, I want to allow the train to run on the track with compatible system version. As an IM, I want to forbid the train to run on the track with incompatible system version.
Summary*		As EUB&EUL, DM, RIU or RBC, I want the CCS-OB to determine the operated system version according to the system version of trackside or the system version ordered by eurobalise. As EUB&EUL, DM, RIU or RBC, I want the CCS-OB to decode the message according to the operated system version.
Mission	(M)	▪ Mission 1: control safe movement
Involved actors*		▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio In-fill Unit (RIU) ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT)
ERTMS Level	(M)	0, 1, 2, 3, NTC
ERTMS Mode		All modes except NP, SF, IS
GoA	(M)	1,2,3,4
Pre-condition*		On-board supported system versions are configured
Condition during execution		
Post-Condition*		CCS-OB operates with correct system version CCS-OB decodes messages according to the operated system version
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB determines the operated system version based on: - CCS-OB supported system version stored in configuration - RBC system version in case communication session is established - System version number transmitted by any balise, loop or RIU - System version order received from balise group ▪ CCS-OB checks the system version of message received from balise, loop, RIU or RBC and reacts accordingly ▪ CCS-OB decodes the message according to the operated system version
Scenario	(M)	▪ Train receives balise/loop/RIU message with a system version lower than the operated one ▪ Train receives balise/loop/RIU message with a system version supported by the CCS-OB but higher than the operated one ▪ Train receives system version order from balise ▪ Train runs with RBC connection ▪ Train runs on track with system version not supported by on-board system
CCS-OB mode	(M)	All modes where the CCS is powered
Type of train		All

SysC43 – Provide geographical position

Name*	(M)	**SysC43 – Provide geographical position**
Operational Need*		As IM, I want to help the driver to localize the train to trackside reference, so as to report its location to the Dispatcher, to the maintainer, or to drive safely the train in case of operational rules (national writing order) at certain specific locations.
Summary*		As Driver, I want the CCS-OB to provide geographical position information.
Mission	(M)	▪ Mission 3: Signal information to ensure safe and appropriate driving
Involved actors*		▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio In-fill Unit (RIU) ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Driver
ERTMS Level	(M)	0, 1, 2, 3
ERTMS Mode		SB, FS, LS, SM, AD, SR, OS, NL, UN, TR, PT
GoA	(M)	1, 2
Pre-condition*		Geographical position information is available from trackside
Condition during execution		
Post-Condition*		Geographical position is displayed to the driver
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB receives geographical position information from trackside ▪ CCS-OB calculates the geographical position in taking into account: - Geographical position reference balise group - Track kilometer reference - Offset to track kilometer reference - Counting direction of the track kilometre in relation to the geographical position reference balise group orientation - Distance travelled from the reference balise group ▪ Driver requests the display of geographical position ▪ CCS-OB displays the geographical position information
Scenario	(M)	▪ Train receives geographical position information from balise ▪ Train receives geographical position information from RBC
CCS-OB mode	(M)	▪ Not supervised movement ▪ Supervised manual movement ▪ Supervised automatic movement ▪ Approaching a stopping point ▪ Short stop at operational stopping point ▪ Unexpected stop ▪ Mission in non-leading cabin
Type of train		All

SysC44 – Allow to operate ETCS L2 without physical balise

Name*	(M)	**SysC44 – Allow to operate ETCS L2 without physical balise**
Operational Need*		As an IM, I want the train to operate ETCS L2 without physical balise to reduce physical asset on track.
Summary*		As Digital Map, I want the CCS-OB to receive ETCS telegrams from virtual balise deployed on DM, so as to generate position report based on LRBG and location information in virtual ballise.
Mission	(M)	▪ Mission 1: control safe movement
Involved actors*		▪ Digital Map
ERTMS Level	(M)	2, 3
ERTMS Mode		SR, FS, LS, OS, AD, NL. UN, TR, PT, SN, RV
GoA	(M)	1,2,3,4
Pre-condition*		Virtual balises are deployed on the DM and the DM data is accessible by the CCS-OB.
Condition during execution		
Post-Condition*		CCS-OB applies ETCS telegram from virtual balise.
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB downloads the DM ▪ CCS-OB detects that the train is crossing a virtual balise ▪ CCS-OB compiles/retrieves virtual ETCS telegrams ▪ CCS-OB generates position report at passage of LRBG compliant virtual balise
Scenario	(M)	▪ Train operates ETCS L2 with virtual balise ▪ Train crosses a LRBG compliant virtual linked at level 2
CCS-OB mode	(M)	All modes except Standstill power down, Initialization, Configuration and End of day
Type of train		All

SysC45 – Allow ETCS supervision with light signal

Name*	(M)	**SysC45 – Allow ETCS supervision with light signal**
Operational Need*		As an IM, I want to allow the train to be supervised by ETCS by reading the light signal on the track which is not physically equipped with ETCS.
Summary*		As Light Signal (LSIG), I want the CCS-OB to identify my signal state. As Digital Map (DM), I want the CCS-OB to generate virtual ETCS telegrams/messages based on the perceived signal state.
Mission	(M)	▪ Mission 1: control safe movement
Involved actors*		▪ Light Signal (LSIG) ▪ Digital Map (DM)
ERTMS Level	(M)	0, 1, 2, 3, NTC
ERTMS Mode		All modes except NP, SF, IS
GoA	(M)	1,2,3,4
Pre-condition*		Virtual balises and light signal information are configured in the DM. The DM is accessible by the CCS-OB.
Condition during execution		
Post-Condition*		CCS-OB operates over ETCS.
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB identifies the signal state showed by a lateral light signal. ▪ CCS-OB detects the crossing of virtual balise or entry of infill area. ▪ CCS-OB retrieves the relevant information from the DM. ▪ CCS-OB builds the corresponding virtual ETCS packets/telegrams/messages. ▪ CCS-OB applies the virtual ETCS information.
Scenario	(M)	▪ The train approaches a lateral light signal and is already supervised by ETCS. ▪ The train approaches a lateral light signal but not yet supervised by ETCS. ▪ The train crosses a lateral light signal and is already supervised by ETCS. ▪ The train crosses a lateral light signal but not yet supervised by ETCS. ▪ The train enters an area allowing ETCS supervision with lateral light signal. ▪ The train exits an area allowing ETCS supervision with lateral light signal. ▪ Transition from an area allowing ETCS supervision with lateral light signal to an area physically equipped with ETCS. ▪ Transition from an area physically equipped with ETCS to an area allowing ETCS supervision with lateral light signal. ▪ The Perception system OB is defect.
CCS-OB mode	(M)	▪ Configuration ▪ Manoeuvre in maintenance yard ▪ Not supervised movement ▪ Manual supervised movement ▪ Supervised automatic movement ▪ Approaching stopping point ▪ Short stop at operational stopping point
Type of train		All

SysC46 – Request movement authority

Name*	(M)	**SysC46 – Request movement authority**
Operational Need*		As an IM, I need to ensure the availability of Movement Authority when it is needed by the CCS-OB.
Summary*		As RBC, I want that CCS-OB requests MA when it is not available and I am not able to determine the condition to send it to CCS-OB.
Mission	(M)	▪ Mission 1: control safe movement
Involved actors*		▪ Radio Block Center (RBC) & Movement Authority Transactor (MT)
ERTMS Level	(M)	0, 1, 2, 3, NTC
ERTMS Mode		SB, FS, AD, LS, SR, OS, UN, TR, PT, SN
GoA	(M)	1,2,3,4
Pre-condition*		Communication session is established
Condition during execution		
Post-Condition*		MA request is sent
Non-Functional Requirement		
Functional Chain*	(M)	▪ RBC sends MA request parameters to CCS-OB ▪ CCS-OB requests a new Movement Authority from the RBC in the following case: - Start selection by driver - Time before reaching perturbation location reached - Time before a section timer or the LOA speed timer expires reached - The track description has been deleted - Track ahead free up to level 2/3 transition location
Scenario	(M)	▪ Driver selects Start at level 2/3 ▪ Train reaches the perturbation location ▪ Section timer is expired ▪ LOA speed timer is expired ▪ Track description has been deleted ▪ The information "Track ahead free up to level 2/3 transition location" is received when a transition to level 2/3 is announced and communication session is established
CCS-OB mode	(M)	▪ Configuration ▪ Not supervised movement ▪ Supervised manual movement ▪ Supervised automatic movement ▪ Approaching stopping point ▪ Short stop at operational stopping point
Type of train		All

SysC47 – Select requested level

Name*	(M)	**SysC47 – Select requested level**
Operational Need*		A) As an IM, I want that train runs on the appropriate level as requested by the trackside. B) As a RU, I want that driver selects the appropriate level.
Summary*		A) As EUB&EUL, RIU or RBC, I want that CCS-OB operates at the appropriate level. B) As driver, I want that CCS-OB operates at the requested level.
Mission	(M)	▪ Mission 1: control safe movement
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio In-fill Unit (RIU) ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT) ▪ Driver
ERTMS Level	(M)	0, 1, 2, 3, NTC
ERTMS Mode		A) SB, SH, PS, FS, AD, LS, SR, OS, SL, NL, UN, TR, PT, SN (Trackside order) B) SB, FS, AD, LS, SR, OS, NL, UN, SN (Driver selection)
GoA	(M)	1,2,3,4
Pre-condition*		A) Default list of available level is configured on-board B) (train is at standstill) AND (Driver ID is valid) AND (mode is SB/FS/LS/SR/OS/NL/UN/SN) AND Default list of available level is configured on-board
Condition during execution		
Post-Condition*		CCS-OB is at the requested level
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB determines and displays the available ERTMS/ETCS level(s). (B) ▪ Driver selects ERTMS/ETCS level (B) ▪ CCS-OB receives level transition order from trackside (A) ▪ CCS-OB manages level ▪ CCS-OB manages level transition announcement (A) ▪ Driver acknowledges level transition in case it is requested (A) ▪ CCS-OB commands service brake in case the driver doesn't acknowledges within the timer (A) ▪ CCS-OB releases service brake after the acknowledgement (A)
Scenario	(M)	▪ Driver selection of level ▪ Receive level transition order ▪ Receive conditional level transition order
Operational Phase	(M)	▪ Configuration ▪ Not supervised movement ▪ Manual supervised movement ▪ Mission in non leading cabin ▪ Manoeuvre in maintenance yard ▪ Supervised automatic movement ▪ Unexpected stop ▪ Approaching stopping point ▪ Short stop at operational stopping point
Type of train		All

SysC48 – Manage text message display

Name*	(M)	**SysC48 – Manage text message display**
Operational Need*		As a RU, I want to inform the system status to the driver via text message. As an IM, I want that the train displays the plain/fixed text messages received from trackside.
Summary*		As the driver, I want the CCS-OB to display the system status text message. As the EUB, EUL or RBC, I want the CCS-OB to display the plain/fixed text messages to the driver. As the EUB, EUL or RBC, I want the CCS-OB to manage the acknowledgement of the text message by the driver.
Mission	(M)	▪ Mission 1: control safe movement ▪ Mission 3: Signal information to ensure safe and appropriate driving
Involved actors*		▪ Physical Train Unit Operation Systems (PTU-OS) ▪ Driver ▪ Eurobalise (EUB) & Euroloop (EUL) ▪ Digital Map (DM) [in case of virtual balise] ▪ Radio Block Center (RBC) & Movement Authority Transactor (MT)
ERTMS Level	(M)	0, 1, 2, 3, NTC
ERTMS Mode		Mode SB, SH, FS, LS, AD, OS, NL, UN, TR, RV, PT, SR, SN
GoA	(M)	1,2
Pre-condition*		TDS is available
Condition during execution		
Post-Condition*		Text message is displayed with corresponded acknowledgement if requested
Non-Functional Requirement		
Functional Chain*	(M)	▪ CCS-OB receives plain/fixed text message from trackside ▪ CCS-OB manages text message display (start / end condition, type of message, etc.) ▪ CCS-OB displays text message and acknowledgement if requested ▪ Driver acknowledges text message if requested ▪ CCS-OB manages the acknowledgement of text message (start / end condition, driver confirmation, brake application, sending to RBC at level 2 about deriver acknowledgement, etc.) ▪ PTU-OS commands brake in case of non-acknowledgement of text message
Scenario	(M)	▪ Display of system status messages ▪ Display of plain / fixed message received from trackside without acknowledgement ▪ Display of plain / fixed message received from trackside with acknowledgement confirmed by the driver ▪ Brake application due to non-confirmation of acknowledgement of the plain / fixed message received from trackside
CCS-OB mode	(M)	▪ Configuration ▪ Mission in non-leading cabin ▪ Manoeuvre in maintenance yard ▪ Not supervised movement ▪ Supervised manual movement ▪ Supervised automatic movement ▪ Approaching a stopping point ▪ Short stop at operational stopping point ▪ Unexpected stop ▪ Joining/splitting
Type of train		All